Phytochemical and TLC Profiling of *Oroxylum indicum* and *Milletia pachycarpa*

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**Abstract**

The humans have used medicinal plants for healthcare since the time immemorial. The systematic phytochemical analysis of traditionally used medicinal plants is needed to establish their use as medicine. *Oroxylum indicum* and *Milletia pachycarpa* have been used in India and China to treat various health related disorders. Therefore it was decided to undertake phytochemical and Thin Layer Chromatography (TLC) profiling of different extracts of *Oroxylum indicum* and *Milletia pachycarpa* using standard procedures. The dried powder of stem bark of *Oroxylum indicum* and root bark of *Milletia pachycarpa* was sequentially extracted in chloroform, ethanol and water. The dried extract of each plant was phytochemically analyzed for the presence of alkaloids, flavonoids, cardiac glycosides, phytosterols, saponins, tannins sterols and phlobatannins. Each extract from both plants was processed for TLC profiling on silica gel using various solvent combinations as mobile phase. The phytochemical analysis showed the presence of alkaloids in chloroform and ethanol extracts, whereas alkaloids were absent in aqueous extract of both *Oroxylum indicum* and *Milletia pachycarpa*. The flavonoids were observed in all extracts of both plants. However, cardiac glycosides were absent in the aqueous extract of *Milletia pachycarpa*. The saponins were detected in all the extracts of both plants except the chloroform extract of *Oroxylum indicum*. The tannins could not be detected in the aqueous extract of *M. pachycarpa*. The phlobatannins were absent in all extracts of both plants. Steroids were present in the ethanol extract of both plants. The TLC profiling confirmed the presence of different phytochemicals as evidenced by different Rf values. The present study indicates that the properties of both *O. indicum* and *M. pachycarpa* may be due to presence of alkaloids, flavonoids, cardiac glycosides, saponins, tannins and phytosterols.

**Keywords**: *O. indicum; M. pachycarpa; Alkaloids; Flavonoids; Cardiac glycosides; Tannins*

**Introduction**

The plants usually synthesize many chemicals, which are either product of metabolism or intentionally for nutrition, defence, pollination and against stress and predators [1]. The phytochemicals synthesized by plants can be mainly grouped into primary and secondary metabolites [2]. The primary metabolites include phytoestrogens, acyl lipids, amino acids and organic acids that have shared biological function across all plant species [3]. The primary metabolites are responsible mainly for growth, development and other metabolic activities of the plants [4]. The metabolism of primary metabolites generates secondary metabolites, which are not involved in any of the metabolic activity of plants [2]. The properties of these phytochemicals have been under investigation since the 1850s and they have been used as dyes, polymers, fibers, glues, oils, waxes, flavoring agents, perfumes, and even as drugs [4]. It is now fairly well established that the synthesis of secondary metabolites plays an important role in the survival of plants and other activities [5]. The plants usually synthesize these phytochemicals in specialized cells during particular developmental phase making their extraction and purification difficult [6]. The various phytochemicals synthesized by plants as secondary metabolites have been found to exert various physiological effects in mammals including humans and hence they are also called the active principle of that plant [6]. The phytochemicals produce various biological activities, and this has been the reason that plants have been used to treat several ailments in traditional medicine since the time immemorial. It is also known that almost 70% of the modern medicines have a direct or indirect origin in plants [7]. The phytochemicals derived from plants include antibiotic, antifungal and antiviral, antitumor and antigenervative compounds, which helps plants to protect from plant pathogens, insects and predators. The plants also synthesize important UV absorbing compounds, to safeguard the leaves against the damaging effect of UV light from sunlight [5,8]. The phytochemicals synthesized by plants are usually complex and it is sometimes difficult to synthesize them in the laboratory therefore phytochemicals will continue to play crucial role in the new drug discovery. *Milletia pachycarpa Benth* (family: Fabaceae) is a deciduous climbing shrub, which grows up to a height of 6 meters. It has a lilac coloured flower that forms in a large pea-shaped cluster. It usually flowers during July-August and has a brown or grey stem with dark brown seeds [9]. *M. pachycarpa* is used as blood tonic and to induce the growth of red blood cells in Chinese traditional medicine and the preparation is called as ‘Jixueteng’ [10]. *M. pachycarpa* has been found to have a significant cytotoxic effect in Brine shrimp assay [11] and is also known to have anti-inflammatory activity [12]. It is used as fish poison, pesticide, blood tonic and in the treatment of cancer and infertility traditionally in India and China [11,13,14]. Some of the compounds isolated from *M. pachycarpa* have been reported to be cytotoxic and induce apoptosis in HeLa cells [15]. *Oroxylum indicum* (family Bignoniaceae), sapa natha is a deciduous tree distributed throughout Asia and grows at an altitude of 1200 m mainly in ravines, in damp region and moist places in the forests. In India, it is distributed in the Himalayan foothills, Eastern and Western Ghats and North East India [16]. *O. indicum* lives in relationship with an actinomycete *Pseudonocardia oroxyli*, a gram positive bacterium [17] that has the capacity to produce many secondary metabolites.

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exhibiting a wide variety of biological activity [8]. Almost every part of this tree possesses medicinal properties and has been used in several traditional Ayurvedic and folk medicines [18]. *O. Indicum* has been reported to possess several medicinal properties including analgesic, antibacterial, anti-inflammatory, anticancer, antioxidant [19-23]. Therefore, an attempt has been made to study the phytochemical constituents of *Milletia pachycarpa* and *Oroxylum indicum*.

**Materials and Methods**

**Preparation of the extract**

The non-infected stem bark of *O. indicum* was collected from Champhai whereas root bark of *Milletia pachycarpa* was collected from Kolasib district of Mizoram, India during the dry season in the month of January. The identification of plant was done by the Department of Horticulture and Aromatic and Medicinal Plants, Mizoram University, Aizawl, India. The barks of both plants were washed thoroughly with clean water and allowed to shade dry at room temperature in the dark in clean and hygienic conditions. The dried barks of both plants were separately powdered using an electrical grinder at room temperature. The powdered bark of *O. indicum* stem or root bark of *M. pachycarpa* was sequentially extracted with petroleum ether, chloroform, ethanol and distilled water according to increase in polarity using a Soxhlet apparatus until the solvents became colourless [24]. The liquid extracts were concentrated by evaporating their liquid contents using rotary evaporator. Each extract, except petroleum ether was concentrated in vacuo and stored at -70°C until further use.

**Preliminary phytochemical analysis**

The chloroform, alcoholic and aqueous extracts of *O. indicum* and *M. pachycarpa* were subjected to different phytochemical tests for the presence of tannins, alkaloids, steroids and flavonoids by using standard phytochemical procedures [25-27].

**Alkaloids**

The presence of alkaloids in *O. indicum* and *M. pachycarpa* was confirmed by employing the Dragendorff’s test. Briefly, 0.1 g of different extracts of *O. indicum* or *M. pachycarpa* was mixed with 0.5 ml of Dragendorff’s reagent. The development of reddish brown precipitate indicates the presence of alkaloids [25-27].

**Flavonoids**

The flavonoids were qualitatively estimated using alkaline reagent test, where 0.1 g of each extract of *O. indicum* and *M. pachycarpa* was dissolved in appropriate solvents and mixed with a few drops of sodium hydroxide solution. The formation of intense yellow colour, which turned colourless on addition of a few drops of dilute acid indicated the presence of flavonoids [25-28].

**Cardiac glycosides (Keller-Killani test)**

0.1 g of *O. indicum* or *M. pachycarpa* was treated with 2 ml of glacial acetic acid containing one drop of ferric chloride solution with an under layering of 1 ml of concentrated sulphuric acid. The appearance of brown ring at the interface indicated the presence of deoxysugar, which is a characteristic of cardenolides [25,27].

**Saponins**

Usually 0.1 g of the extracts of *O. indicum* or *M. pachycarpa* was mixed with 3 drops of olive oil and shaken vigorously for a few minutes. The formation of a fairly stable emulsion indicated the presence of saponins [25,27,29].

**Steroids**

The presence of steroid in various extracts of *O. indicum* and *M. pachycarpa* was determined by Salkowski’s test. Briefly 0.1 g of various extracts of *O. indicum* and *M. pachycarpa* dissolved in different solvents were mixed with a few drops of concentrated sulphuric acid. The development of red colour at lower layer indicated the presence of steroids, whereas the formation of yellow colour indicated the presence of triterpenoids [25-27].

**Tannins**

The presence of tannin was determined by Ferric chloride test. Usually 0.1 g of dried samples of each extract of *O. indicum* or *M. pachycarpa* was dissolved in their respective solvents and a few drops of 0.1% ferric chloride were added. The formation of brownish green or a blue-black colour indicated the presence of tannins [25-27].

**Phlobatannins**

The different extracts of *O. indicum* or *M. pachycarpa* were boiled in 1% aqueous hydrochloric acid and deposition of a red precipitate indicated the presence of phlobatannins [25,27].

**Thin layer chromatography**

Thin layer chromatography (TLC) was performed on the different extracts to visualize the separation of various phytochemical components as it is a simple, less cumbersome and rapid technique. The TLC can identify and separate a number of components present in any extract/organic mixtures and it also helps in finding a suitable solvent/s for separating the components by column chromatography as well as for monitoring reactions progress. Pre-coated TLC plates (Silica gel 60 F<sub>254</sub>) procured from Merck India, Mumbai were used as an adsorbent. A small amount of each of the different extracts was applied as 1 mm diameter, 5 mm above the bottom of the plates. The TLC plates were transferred into the mobile phase consisting of numerous combinations of solvent systems of different polarity such as chloroform:methanol (9:1, 8:2) benzene:chloroform (1:1), pure chloroform, chloroform: ethyl acetate (1:1) and methanol:hydrochloric acid (9:1) and allowed to move on the adsorbent silica gel. The resultant spots were observed under visible and ultra-violet light, dilute acid (H<sub>2</sub>SO<sub>4</sub>), anisaldehyde, aluminium chloride and Dragendorff’s stain. The measure of the distance a compound traveled is considered as the retention factor (R<sub>f</sub>), which was calculated using the following formula:-

\[ R_f = \frac{\text{Distance travelled by solute}}{\text{Distance travelled by solvent}} \]

**Results**

The results of phytochemical analysis are shown in Tables 1-3 and Figures 1-7.

**Phytochemical screening**

Qualitative analysis of chloroform, ethanol and aqueous extracts of *O. indicum* and *M. pachycarpa* showed the presence of different phytochemicals listed below.

**Alkaloids**

The chloroform and ethanol extracts of *O. indicum* and *M. pachycarpa* showed the presence of alkaloids, whereas alkaloids were not detected in their aqueous extract (Table 1).

**Flavonoids**

The analysis of flavonoid revealed that chloroform, ethanol
### Table 1: Qualitative phytochemical analysis of various extracts of *O. indicum* and *M. pachycarpa*.

<table>
<thead>
<tr>
<th>Extracts</th>
<th>Solvent system</th>
<th>Normal</th>
<th>UV 254</th>
<th>UV 365</th>
<th>Dil. H₂SO₄</th>
<th>ANISAL DEHYDE</th>
<th>RF</th>
<th>Alkaloid</th>
<th>Flavonoid</th>
</tr>
</thead>
<tbody>
<tr>
<td>OIC</td>
<td>CHCl₃:CH₂OH (9:1)</td>
<td>3 light yellow</td>
<td>0.369, 0.492, 0.861</td>
<td>0.329, 0.487, 0.822, 0.878</td>
<td>0.543, 0.574, 0.659, 0.851</td>
<td>1 purple, 3 yellow</td>
<td>0.347, 0.496, 0.661, 0.826</td>
<td>1 yellow</td>
<td>0.475, 0.655, 0.852</td>
</tr>
<tr>
<td>OIE</td>
<td>CHCl₃:CH₂OH (8:2)</td>
<td>2 light yellow</td>
<td>0.639, 0.819</td>
<td>0.59, 0.77, 0.836, 0.934</td>
<td>0.591, 0.771, 0.836, 0.934</td>
<td>3 yellow</td>
<td>0.591, 0.771, 0.934</td>
<td>3 yellow</td>
<td>0.66, 0.73, 0.968</td>
</tr>
<tr>
<td>OIA</td>
<td>not visible</td>
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<td>not visible</td>
<td>0</td>
<td>not visible</td>
<td>0</td>
<td>not visible</td>
<td>0</td>
<td>not visible</td>
</tr>
<tr>
<td>OIC</td>
<td>CH₂₃-C₆H₅-C₆H₅ (1:1)</td>
<td>2 yellow</td>
<td>0.635, 0.815</td>
<td>0.59, 0.77, 0.836, 0.935</td>
<td>0.589, 0.769, 0.835, 0.932</td>
<td>3 yellow</td>
<td>0.59, 0.771, 0.832, 0.931</td>
<td>3 yellow</td>
<td>0.66, 0.73, 0.968</td>
</tr>
<tr>
<td>OIE</td>
<td>not visible</td>
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<td>not visible</td>
<td>0</td>
<td>not visible</td>
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<td>not visible</td>
<td>0</td>
<td>not visible</td>
</tr>
<tr>
<td>OIA</td>
<td>not visible</td>
<td>0</td>
<td>not visible</td>
<td>0</td>
<td>not visible</td>
<td>0</td>
<td>not visible</td>
<td>0</td>
<td>not visible</td>
</tr>
<tr>
<td>OIC</td>
<td>CHCl₃</td>
<td>not visible</td>
<td>0</td>
<td>1 black</td>
<td>0.109</td>
<td>1 deep blue, 3 uv active</td>
<td>0.115, 0.393, 0.571, 0.964</td>
<td>1 yellow, 2 black</td>
<td>0.098, 0.215, 0.980</td>
</tr>
<tr>
<td>OIA</td>
<td>not visible</td>
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</tr>
<tr>
<td>OIC</td>
<td>CHCl₃:CH₂O₂ (1:1)</td>
<td>2 yellow</td>
<td>0.596, 0.865</td>
<td>0.594, 0.885</td>
<td>0.631, 0.829, 0.885</td>
<td>yellow</td>
<td>0.842, 0.842, 0.885</td>
<td>3 yellow</td>
<td>0.270, 0.666, 0.861</td>
</tr>
<tr>
<td>OIA</td>
<td>not visible</td>
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<td>not visible</td>
<td>0</td>
<td>not visible</td>
<td>0</td>
<td>not visible</td>
<td>0</td>
<td>not visible</td>
</tr>
<tr>
<td>OIC</td>
<td>Green and brown mixed</td>
<td>0.694</td>
<td>black</td>
<td>0.846</td>
<td>2 yellow</td>
<td>0.846, 0.885</td>
<td>1 Yellow, 1 light brown</td>
<td>0.83, 0.94</td>
<td>0.661, 0.861</td>
</tr>
<tr>
<td>OIA</td>
<td>Green and brown mixed</td>
<td>0.722</td>
<td>black</td>
<td>0.82</td>
<td>2 dark brown</td>
<td>0.639, 0.869</td>
<td>no proper spots</td>
<td>0</td>
<td>yellow UV active</td>
</tr>
</tbody>
</table>

Legend: Present (+), Absent (-). OIC: *O. indicum* chloroform extract; MPC: *M. pachycarpa* chloroform extract; OIE: *O. indicum* ethanol extract; MPE: *M. pachycarpa* ethanol extract; OIA: *O. indicum* aqueous extract; MPA: *M. pachycarpa* aqueous.

### Table 2: TLC of different extracts of *O. indicum* and *M. pachycarpa*.

<table>
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<tr>
<th>Extracts</th>
<th>Solvent system</th>
<th>Normal</th>
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<th>UV 365</th>
<th>Dil. H₂SO₄</th>
<th>ANISAL DEHYDE</th>
<th>RF</th>
<th>AIChl UV</th>
<th>DRAGEN DORFF</th>
</tr>
</thead>
<tbody>
<tr>
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<td>3 light yellow</td>
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</tr>
<tr>
<td>OIA</td>
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<td>not visible</td>
<td>0</td>
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</tr>
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<td>not visible</td>
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<td>not visible</td>
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<tr>
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<td>0.639, 0.869</td>
<td>no proper spots</td>
<td>0</td>
<td>yellow UV active</td>
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<tr>
<th>Extracts</th>
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<th>NORMAL</th>
<th>UV 254</th>
<th>R_f</th>
<th>UV 365</th>
<th>R_f</th>
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<th>R_f</th>
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<td>0.659</td>
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<td>0.297</td>
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</tr>
<tr>
<td>MPC</td>
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<td>2 black</td>
<td>0.786</td>
<td>0.983</td>
<td>4 purple</td>
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<td>0.512</td>
<td>0.59</td>
<td>0.771</td>
</tr>
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<td>0</td>
<td>not visible</td>
<td>0</td>
<td>not visible</td>
<td>0</td>
<td>1 brown</td>
<td>not visible</td>
<td>not visible</td>
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<td>0</td>
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</tr>
<tr>
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<td>0.51</td>
<td>not visible</td>
<td>0</td>
<td>not visible</td>
<td>0</td>
<td>2 yellow</td>
<td>0.395</td>
<td>0.765</td>
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</tr>
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<td>0</td>
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<td>not visible</td>
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<tr>
<td>MPC</td>
<td>CHCl_3</td>
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<td>0</td>
<td>3black</td>
<td>0.097</td>
<td>0.218</td>
<td>0.390</td>
<td>4uv active</td>
<td>0.342</td>
<td>0.571</td>
<td>0.941</td>
<td>5 yellow</td>
<td>0.097</td>
<td>0.218</td>
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<tr>
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<td>0</td>
<td>1 uv active</td>
<td>0.572</td>
<td>1 yellow</td>
<td>0.572</td>
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<td>not visible</td>
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<td>0</td>
<td>not visible</td>
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<td>MPC</td>
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<td>1black</td>
<td>0.966</td>
<td>3uv active</td>
<td>0.361</td>
<td>0.722</td>
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<td>2 deep blue</td>
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<td>not visible</td>
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<tr>
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<td>not visible</td>
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<td>0</td>
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<tr>
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<td>black</td>
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<td>light green</td>
<td>0.82</td>
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<td>0.833</td>
<td>no proper spots</td>
<td>0</td>
<td>yellow UV active</td>
<td>0.778</td>
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<tr>
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<td>0.833</td>
<td>black</td>
<td>0.82</td>
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<td>0</td>
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</table>

Table 3: TLC profile of different extracts of M. pachycarpa.

and aqueous extracts of O. indicum and M. pachycarpa contained flavonoids (Table 1).

Cardiac glycosides

The phytochemical analysis of chloroform, ethanol and aqueous extracts of O. indicum showed the presence of cardiac glycosides. The cardiac glycosides were also present in the chloroform and ethanol extracts of M. pachycarpa however, these phytochemicals were completely absent in its aqueous extract (Table 1).

Saponins

Saponins were absent in the chloroform extract of O. indicum, whereas they were present in its ethanol and aqueous extracts. The analysis of chloroform, ethanol and aqueous extracts of M. pachycarpa showed the presence of saponins (Table 1).

Tannins

Analysis of tannins showed that these phytochemicals were present in all the extracts of O. indicum, whereas M. pachycarpa showed the presence of tannins in both the chloroform and ethanol extracts. Tannins were completely absent in the aqueous extract of M. pachycarpa (Table 1).

Steroids

Test for steroids showed the ethanol extract of both the O. indicum and M. pachycarpa contained steroids, however the other extracts of O. indicum and M. pachycarpa did not show any trace of steroids (Table 1).

Phlobatannins

Analysis for phlobatannins for both the O. indicum and M. pachycarpa revealed that these plants did not contain phlobatannins (Table 1).
TLC profiling

The chloroform, ethanol and aqueous extracts were subjected to TLC profiling using different solvent systems as mobile phase. The different solvent systems provided different $R_f$ values for various spots under UV and day light or with anisaldehyde or aluminum chloride indicating the presence of a number of phytochemicals in the *O. indicum* and *M. pachycarpa* (Tables 2 and 3). The TLC plates of different solvent systems are shown in Figures 1-7.

**Discussion**

The plants have attracted the attention of men since its evolution and with the elapse of time humans have discovered the medicinal value of several natural products including plants for their healthcare. Several older systems of medicine including Ayurveda, Chinese and others are principally based on the plants/natural products. The advent of allopathic system of medicine reduced the dependence of humans...
on plants and natural products for human healthcare since most of the drugs are chemically synthesized. Despite this, it is well known that many of the modern drugs are directly or indirectly derived from plants or natural products until their chemical synthesis began [7]. Further, many of the molecules synthesized by plants are very complex and difficult to synthesize in the laboratory therefore we have to still depend on nature for them. There has been a recent spurt in research in the plant/natural products as medicine since it is believed that they are either non-toxic or less toxic than the synthetic drugs, which is to some extent may be true due to their biologic origin. Since vast array of plants are used for human healthcare their systematic scientific evaluation is required. Therefore, the present study was undertaken to evaluate the phytochemical constituents of O. indicum and M. pachycarpa that are used as a traditional medicine in India and China. Out of several phytochemicals synthesized by plants alkaloids are essential for plant defense against stimulation, protection, flavouring, pigmentation, microbe infection, insects and herbivory [30,31]. The alkaloids are more commonly synthesized by angiosperms than the other plants. The alkaloids are nitrogen containing organic molecules and more than 12,000 alkaloids have been isolated from plants and many more will be extracted from plants in the years to come. Their structure is very complex and laboratory synthesis has always been challenging. The alkaloids are toxic and usually this property has been ingeniously used by humans as a medicine or poisons since time immemorial [32]. The alkaloids have been used as stimulants [33-35]. Several drugs used for treatment of cancer, neurological, cardiovascular and several other health related disorders in human are alkaloids [36]. We have detected presence of alkaloids in both O. indicum and M. pachycarpa and their medicinal use may lie in these phytochemicals. The O. indicum has shown the presence of alkaloids in the chloroform and aqueous extracts but not in the methanol extract [37]. However we have not observed the alkaloids in the aqueous extract, which may be due the nonpolar nature of the alkaloids, which may not be soluble in water. A similar observation has been made earlier [38]. The flavonoids are polyphenolic compounds and they protect plants against pathogenesis, stress and the adverse effect of UV light and also provide multitude of colours to flowers that help in pollination [39-41]. No wonder that plants produce a wide array of more than 8000 different flavonoids. Many of the medicinal activities of both O. indicum and M. pachycarpa may be attributed to the presence of polyphenolic flavonoids. Earlier O. indicum has been found to contain flavonoids in chloroform, alcohol and water extracts [42]. However, systematic report regarding the presence of flavonoids in M. pachycarpa is lacking. Flavonoid have been found to be of great medicinal value in humans as they have been found to act as antiallergic, antiatherosclerotic, antioxidants, antifungal, antimutagenic, antithrombogenic, anti-inflammatory, antiviral, anticarcinogenic, cardioprotective and radioprotective in several studies [43-55]. The flavonoids also stimulate signaling pathways required for various activities in the cells [56]. They have also been reported to modulate various transcription factors in different study systems [57]. The organisms do not waste their energy in futile exercises and plants synthesize carbohydrate glycosides for defence since some of them are poisonous [58]. Digitalis is a cardiac glycoside that has been used to protect heart [58]. However, cardiac glycosides possess numerous other activities including diuretic, expectorant, cytotoxic and anticancer (as early as 1967). The cardiac glycosides have been found to be active against numerous cancers like breast, prostate, melanoma, pancreatic and lung cancers, and leukaemia, neuroblastoma and renal adenocarcinoma [58-60]. The cardiac glycosides are helpful in treating cardiac disorders like heart failure and atrial arrhythmia [59]. The use of cardiac glycosides in clinical trials has shown that digoxin administration with chemotherapy increased the overall survival in patients suffering from breast, colorectal, head and neck, and hepatocellular carcinoma [60]. The cardiac glycosides have also been reported to induce apoptosis [61]. The cardiac glycosides have been detected in all the extracts of O. indicum and M. pachycarpa, except the aqueous extract of the latter. The presence of cardiac glycosides reafirms their use a traditional medicine. Saponins are produced by plants to protect them against pathogens and herbivory. They have been found to kill fungus, insects and molluscs that attack plants and also act as allelopathic [62-64].
Saponins also act as anticancerous, and antiangiogenic agents and have been reported to inhibit the progression of the cell cycle and induce apoptosis [65]. The other activities attributed to saponins include antioxidant, anticarcinogenic, immunostimulatory, antibacterial, antifungal, antiviral, antiprotozoal, hypoglycemic, hemolytic, immune adjuvant and membrane permeabilizing [62,63,64]. The saponins were present in all the extracts of O. indicum, and M. pachycarpa, except the chloroform extract of the former. The presence of saponins in these plants may have also contributed to their medicinal properties.

The presence of phytosterols in both O. indicum and M. pachycarpa has been confirmed by test for sterols. The plant sterols are responsible for the growth and maintenance of temperature [66]. The sterols have been found to inhibit the progression of the cell cycle and induce apoptosis [65]. The other activities attributed to saponins include antioxidant, anticarcinogenic, immunostimulatory, antibacterial, antifungal, antiviral, antiprotozoal, hypoglycemic, hemolytic, immune adjuvant and membrane permeabilizing [62,63,64]. The saponins were present in all the extracts of O. indicum, and M. pachycarpa, except the chloroform extract of the former. The presence of saponins in these plants may have also contributed to their medicinal properties.

The other activities attributed to saponins include antioxidant, anticarcinogenic, immunostimulatory, antibacterial, antifungal, antiviral, antiprotozoal, hypoglycemic, hemolytic, immune adjuvant and membrane permeabilizing [62,63,64].

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References


