Studies in pharmacognostic characters of the climber Erycibe paniculata Roxb. of Convolvulaceae

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Abstract
The present scientific investigation deals with the pharmacognosy and preliminary phytochemical screening of the leaf and stem bark of Erycibe paniculata Roxb., an ethnomedicinal climber used in curing the fever, cholera, night blindness, sprains, constipation, etc. Standard methods have been followed to study the microscopic, macroscopic, physicochemical characters and fluorescence behavior of the powdered samples of this plant. Phytochemical screening including GCMS of the stem bark has also been performed. In leaf epidermal micromorphology, it was found that stomata are anisocytic type distributed in hypostomatic leaf. Stomatal Index was 13.879. Glandular unicellular type of trichomes found in both surfaces of the leaf. Non-glandular trichomes with 2 to 6-arms were observed on the epidermal surfaces of petiole and stem. Petiole in T.S. is semi-lunar in outline housing 3 vascular bundles. Total ash of the stem bark was found 9%, of which acid insoluble ash and water soluble ash values were observed 0.092% and 7.626%, respectively. Moisture content of the bark sample was 0.5%. Out of five solvent extracts of the stem bark, methanolic extract showed highest extractive value (8.672%). Important groups of phytochemicals like tannins, alkaloids, flavonoids, etc. are detected in stem bark extract. Nine bioactive compounds have been identified through GCMS analysis from the methanolic bark extract which, in turn, indicate its therapeutic properties. Present study provides the pharmacognostic characters of both leaf and stem bark of Erycibe paniculata which will be an instrumental in authentication and quality control of the crude drugs procured from this medicinal plant.

Keywords: Ethnomedicine, crude drug, pharmacognosy, phytochemical screening, Erycibe paniculata

1. Introduction
The ancient knowledge regarding the uses of natural resources, mainly plants as food, shelter and medicine is very important from the beginning of human civilization. Exploitation of medicinal plants in human society on the basis of traditional knowledge dates back more than 60,000 years [1, 2]. Folk knowledge on uses of medicinal plants has ultimately been established as a means of disease healing through trial and errors among the people mainly those who belong to tribal communities all over the world. In course of time this traditional knowledge based on medicinal plants flourished as most vital and basic health care procedure for people from one generation to the next and for their livestock.

In recent years the reliability and demand of natural resources specially the resources of herbal origin have been increased several fold. The application of plant based medicines is now being increased in modern health care system because they are not only cost effective than modern allopathic medicines but also relatively devoid of toxicity. Day by day a general trend among the people is evident in substituting many of the allopathic medicines with the herbal ones for a long term health benefit. Thus the percentage of use of the botanicals of therapeutic importance is steadily increasing among the people all over the world [3, 4]. It is estimated that more or less 20,000 plant based products are currently available in health care domain in the world [5]. But scientific evaluation for identification of genuine herbal drugs and their toxicity indication are largely lacking. Toxicity data is very important to predict the physiological safety before the use of any medicine. In case of ethnomedicine, there is every possibility to form toxicity upon consumption of it in raw form or due to its adulteration. Adulteration of crude drugs may occur due to wrong identification of the source plants, inappropriate selection of drug parts and mixing of varied types of substances other than the
genuine drugs. Moreover, incorrect preparation and wrong administration process may also lead to inefficacy of the herbal drug and its adverse effect [4-6]. Thus the pharmacological and clinical studies with such adulterated drugs will be a flawed exercise in validating their efficacy against diseases. Recently, scientists are trying to develop allopolypoleral drugs by combining allopathic drugs with polyherbal preparations for treatment of diseases. It helps to reduce or eliminate the adverse effects of synthetic drug in human body. Therefore, there is a need of modern scientific tools and techniques for checking the authenticity of herbal drugs before it use. A big quantum of pharmacognostic research works are going on using different conventional and sophisticated techniques for standardization and quality control of herbal drugs. Pharmacognostic studies covering preliminary and advanced phytochemical screening like microchemical tests and several chromatography techniques such as Thin Layer Chromatography, GCMS, HPLC are reliable methods which provide standard information about crude drugs for its proper identification and subsequent standardization of desired bioactive phytochemicals from respective plant sources. Pharmacognostic study is also instrumental to develop the pharmacopoeial standards for successful authentication of the crude drugs. 

Survey of literature on pharmacognosy and phytochemistry has elucidated that there are several ethnomedicinal plants which have been systematically studied for their pharmacognostic and phytochemical profiles [3, 10-13]. Crude drugs of a large number of ethnomedicinal plants remain uninvestigated scientifically. Keeping this scenario in mind present study has been planned to explore scrupulous pharmacognostic characters including macro and microscopic characters, physico-chemical values and phytochemical profile of the plant Erycibe paniculata Roxb. No work has been done on pharmacognosy of this plant but it is used in ethnomedicines of different states of India for treatment of several health problems like cholera, fever, diarrhea, constipation, etc. [14-16]

2. Material and methods
2.1. Material
Erycibe paniculata Roxb. (Fig.1)

![Fig 1: Twigs of the Erycibe paniculata Roxb.](image)

a. Tribal name-Keri (Santali)
b. Botanical characters
An evergreen, large, woody climber with several young branches, branches with densely rusty brown tomentum. Stem woody, herbaceous towards tip, terete, younger parts greenish and covered with reddish-brown indument, older stem part faint-green to purple in color. Leaves 4-8 × 2.5 – 5cm, broadly elliptic or elliptic–obovate, coriaceous, apex obtusely acuminate, entire, glabrous; lateral veins 5-6 pairs; petiole very short, 0.5-1cm long. Inflorescence paniculate cymes, axillary and terminal, 10-20cm long. Flowers numerous, yellowish white, 6-8 mm across; pedicel 3-4mm; calyx tube 1.5-2mm long, lobes 5, ovate, densely brown tomentose, sepals 3mm long, suborbicular; corolla campanulate – rotate; 6mm long, yellowish white; lobes thick, fleshy, hairy on the back; stamens 10, exserted; ovary 1-celled, ovules 4; style absent; stigma subglobose. Fruits berry, subglobose, 1.2cm across, black when ripe. Seeds ovoid or elliptic, 1mm in diam.

c. Flowering and Fruiting times--April to June.
d. Medicinal uses
i) Bark is used in muscular pain and headache during menstruation cycle by the Santal tribal people of Birbhum district, West Bengal (Author’s personal observation).
ii) Stem bark paste is used as poultice on the affected body parts in case of Ricket [17].
iii) Leaf and stem syrup of this plant is used orally for treatment of sprains of the cattle by the ethnic people of Purulia district of West Bengal [18].
iv) Bark decoction is traditionally used by the people of Nawarangpur district of Odisha (India) for the treatment of fever and headache [18].

Folk people of Chhattisgarh state of India use extract of the young leaf in treatment of night blindness [19].
vi) Root extract is administered to cure fever [14].
vii) Ripe fruits are eaten in constipation whereas extract of aerial part shows diuretic activity [14].
viii) Bark is used by the tribal people of Odisha as ethnomedicine to cure diarrhea [16].

2.2 Methods
a. Plant collection
Flowering twigs of the species were collected from the forest areas of Chorchor, Birbhum district, West Bengal, India. The plant species has been identified and authenticated with the help of standard flora [20]. The herbarium specimen of the plant has been deposited at the Visva-Bharati herbarium, Department of Botany, Visva-Bharati, Santiniketan, West Bengal for future reference.

b. Foliar micromorphology
Leaf pieces were cut from apical, middle and basal portions of the lamina and pieces were cleared following the Bokhari’s method [21]. Aqueous safranin (1%) of few drops were applied to the cleared samples and mounted it with 10% glycerine on a slide for observation under compound light microscope [Olympus microscope, Model- CH-20i fitted with camera]. Photomicrographs of the leaf parts were taken by the camera attached with the microscope and measurement of the plant cells were taken with the standardized ocular micrometer.

c. Vegetative anatomy (stem and petiole)
Transverse sections (T.S.) of stem and petiole of the selected plant were stained suitably following standard staining method [22] and observed under compound light microscope. Photographs of the suitable sections were taken. Scanning Electron Microscope (SEM) photographs of the stem (T.S.) were also taken.

d. Xylem maceration
In this study, 1cm long stem pieces were macerated following
the standard wood maceration technique [23]. Small amount of boiled stem piece was washed thoroughly in distilled water and a bit of boiled sample taken on a glass slide, teased with needles, mounted with 10% glycerine and observed under microscope.

e. Organoleptic study
Study of crude drugs using sensory organs was performed following the standard methods[25] which includes basic characters of the crude drug sample like morphology, colour, odour, taste, etc.

f. Physicochemical evaluation
In this evaluation, moisture content, ash value and extractive value of the plant sample were determined as per guidelines of Indian Pharmacopoeia and WHO [18, 24].

Moisture content study
About 5g. of fresh stem weighed and subjected it to dry in shade for few days. Dried sample was then incubated at 80°-90°C for one hour. Post incubation weight of the sample was taken and calculated the percentage of moisture content.

Ash value determination
The residue left after incineration of the crude drug is designated as ash which usually represents the inorganic salts naturally occurring in the drug and adhering to it. Determination of total ash value: 5g. of air dried powdered drug was taken in a tared silica crucible and incinerated at 650°C in the muffle furnace for 6 hours to make it dull red hot until free from moisture and carbon. Ash was cooled and weighed, and the percentage of total ash was calculated with reference to the air-dried drug sample by the following formula:

\[
\text{Weight of the ash} \times 100
\]
\[
\text{Total ash value (%) = } \frac{\text{Weight of the ash}}{\text{Weight of the plant drug taken}} \times 100
\]

Determination of acid-insoluble ash value: The total ash was boiled with 30 ml of 2N HCL for 5 minutes. Diluted ash was then filtered using Whatman 41 filter paper. The insoluble matter was collected from filter paper, completely dried, weighed and calculated the percentage of acid insoluble ash with reference to the air-dried drug.

Determination of water-soluble ash value: The total ash was boiled with 30 ml of water for 5 minutes. The insoluble matter was collected on Whatman 41 filter paper. The matter was ignited for 15 minutes until loss of all moisture of it. The percentage of water soluble ash was calculated with reference to the air-dried drug.

g. Fluorescence analysis
Here in this study, different chemical reagents were mixed with the powdered drug and observed distinctive colour changes under UV light (355nm and 254nm). Very distinct color changes were recorded and compared those with the colours of powdered drugs as seen under visible light [25].

h. Determination of the extractive value
Different solvents like water, methanol, chloroform, benzene, petroleum ether separately taken in 100 ml conical flasks and with each of which 10 g dried plant powder was added. All mixture were subjected to occasional stirring with glass rod for 6 hours and left for overnight. After filtering the solvent extracts with Whatman No.41 filter paper, all the extracts were then left separately to dry at room temperature. Finally weight of each solvent extract was noted and extractive value was calculated following the formula:

\[
\text{Weight of the residue obtained} \times 100
\]
\[
\text{Extractive value (%) = } \frac{\text{Weight of the residue obtained}}{\text{Weight of the plant material taken}} \times 100
\]

i. Histochemical study
Transverse sections of the stem were made and mounted in glass slides. One to two drops of reagents like Wagners’, Dragendorff’s, Mayer’s, Lugol’s, Millon’s, 1% lead acetate, Phloroglucinol, Ferric chloride, etc. were applied to the sections. Specific reaction between reagents applied and phytochemical groups present in specific tissue locations makes the change of colour in the cells of the stem sections. The changes were observed under compound light microscope and recorded [24, 26].

2.3 Phytochemistry
j. Preliminary phytochemical screening:
Dried stem bark powder was extracted with methanol solvent and filtered it. Then different chemical reagents were added to a certain volume of bark extract separately for colour reaction tests. Different phytochemical groups present in the powdered sample were detected following standard methods [26, 27].

k. Gas Chromatography-Mass Spectrometry: Extract preparation
5g of dried bark powder was macerated in 100ml of methanol. The solution was subjected to occasional stirring for 10 days and the extract was filtered using Whatman No. 41 filter paper. Then the crude extract was completely concentrated by evaporating the methanol in a thermostat water cabinet at 40 °C for few hours. Then 1g of dried extract sample was dissolved in 10ml methanol. The stock solution of extract was then transferred to air-tight container and kept in the refrigerator at 4 °C until required for the experiment.

Gas Chromatography-Mass Spectrometry (GC-MS) analysis
This was carried out on a Mass Spectrophotometer (GCMS-model number Agilent 6890-MS). The sample solution was taken for GC-MS analysis after filtering it in sterilized milipore filter (0.22μ).1μl of the sample was injected in to a GC equipped with a MS and a non-polar capillary column HP-5 (30m × 0.25 mm; 0.25μm). The oven program had an initial temperature of 110°C for 2 min., transfer line temperature was 200°C. Then its temperature was increased to 250°C for 2 min at the rate of 5°C/min. Finally temperature was raised to 280°C at the rate of 6°C/ min for 7 min. Total run time was 50 min. The detector temperature were set at 250°C. As carrier gas Helium (purity 99.999%) was used at a flow rate of 1ml/min. The sample was injected in the split mode(1:10). The electron impact ionization (EI) mode was set in 70eV. The mass range scanned was 50- 550 m/z.

Identification of compounds
The phytochemical constituents present in the bark sample were identified consulting the mass spectral library of NIST. The spectra of reference compounds were extracted from the NIST database and then matched with the spectra of unknown phytochemical compounds present in the bark extract sample. Percentage of peak areas of the individual chemicals was
determined in respect of total peak area of all chemical compounds detected from the chromatogram.

3. Results
3.1 Foliar Micromorphology
Characteristic features along with measurement of the epidermal cells, stomata and trichomes of the investigated plant are given below.

a. **Epidermis**: Cell shapes are irregular and cell walls are straight in upper epidermis and it is slightly wavy in lower epidermis. Upper epidermal cell size is 45.38 µm × 27.33 µm and on lower surface, the size is 50.88 µm × 28.58 µm. Frequency of the epidermal cell is 784.15 /mm² and 817/mm² on the upper surface and lower surface, respectively. Palisade ratio is 6.62 (Table-1; Fig.-2A).

![Fig 2A: Upper epidermis of the leaf](image1)

**Table 1**: Foliar epidermal cell characters of the investigated species

| Leaf surface | Cell shape | Cell length (µm) | Cell width (µm) | Cell frequency (No./mm²) | Cell wall outline | Palisade ratio |
|--------------|------------|------------------|-----------------|--------------------------|------------------|---------------|
| Upper        | Irregular  | 45.384           | 27.330          | 784.15                   | More or less straight | 6.62          |
| Lower        | Irregular  | 50.881           | 28.582          | 817                      | Slightly wavy     |               |

b. **Stomatal complex**: Leaves are hypostomatic and stomata are of anisocytic type with distinct subsidiary cells. Size of the stomata is 32.747µm ×19.064µm. Stomatal frequency and stomatal index are 80.99 /mm² and 13.87%, respectively (Table- 2; Fig.-2B).

![Fig 2B: Lower epidermis with anisocytic stomata](image2)

**Table 2**: Stomatal features of the investigated plant species

| Leaf surface | Type        | Length (µm) | Width (µm) | Stomatal index (%) | Stomatal frequency (No./mm²) |
|--------------|-------------|-------------|------------|-------------------|-----------------------------|
| Upper        | -           | -           | -          | -                 | -                           |
| Lower        | Anisocytic  | 32.747 ×19.064 | 19.064       | 13.879            | 80.99                       |

c. **Trichomes**: Upper and lower epidermal surfaces of the leaf ornamented with unicellular, glandular type of trichomes. Size of the glandular trichomes of upper epidermis is 32.042 µm in diameter and it is 31.092 µm in lower epidermis. Frequency of the trichome is 5.23 /mm² on the upper surface and it is 12.70 /mm² on the lower surface. Trichome indices are 4.72 % and 3.20 % on the upper and lower surfaces, respectively (Table-3; Fig.-2C).

![Fig. 2C: Sessile glandular trichome](image3)
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Table 3: Trichome characters of the investigated plant species

| Leaf surface | Trichome type | Trichome size (µm) | Trichome Index (%) | Trichome frequency (No./mm²) |
|--------------|--------------|--------------------|-------------------|-----------------------------|
| Upper        | Glandular    | 32.042             | 4.72              | 5.23                        |
| Lower        | Glandular    | 31.092             | 3.205             | 12.704                      |

d. Crystals: Clustered crystals of calcium oxalate (Sphaeraphides) are present in upper leaf surface. The diameter of the crystals ranges from 30 to 35.36 µm (Table-4; Fig. –2D).

![Fig 2D: Crystals of calcium oxalate (Sphaeraphides)](image)

Table 4: Crystal characters of the plant species

| Leaf surface | Type                        | Diameter (µm) | Dissolved in |
|--------------|-----------------------------|---------------|--------------|
| Upper        | Calcium oxalate (Sphaeraphide) | 30 - 35.36 µm | Dil. HCl     |
| Lower        | -                           | -             | -            |

3.2 Vegetative anatomy
a. Stem:

![Fig 3A1: T.S. of stem (Light microscopic photograph)](image)

![Fig 3A2: T.S. of stem (SEM photograph)](image)

b. Petiole

The transverse section of the stem is circular to oval in outline and showed the following anatomical features (Fig.-3A1, 3A2, 3A3).

Cork layer: The cork layer is thick measuring 390 µm – 460 µm with a homogeneous zone of 2-3 rows of brownish somewhat tangentially elongated cells.

Epidermis: It consists of single layer, barrel shaped cells, with cuticularized outer wall. Cells are rectangular, compactly arranged. Non-glandular, 2-6 armed trichomes were distributed throughout the epidermis, each of 55 to 520 µm in length. Some multicellular glandular trichomes are also present on the stem epidermis, each about 220 µm in length.

Cortex: The cortex is massive and differentiated into three zones- 1) 2-3 layered collenchymatous hypodermis, 2) 4-5 layers of parenchymatous middle cortex, and 3) One cell layered discontinuous layer of starch sheath.

Sclerenchyma zone: Discontinuous patches of sclerenchyma cells are present just on periphery of the phloem. Vascular bundle: Vascular bundles are conjoint, collateral, open type and form a continuous vascular cylinder. Phloem scanty followed by xylem layer. In the phloem zone, there is a band of 3-5 layers of sclerenchyma. Xylem endarch. Cambium is not distinct.

Pith: It is large, occupying central part of the stem. It is composed of parenchymatous cells.
Description and measurement of xylem elements, their size, pit, perforation plates of vessel elements, side wall thickening of tracheids, fibre size and nature, etc. of the investigated plant have been represented in Table-5.

The vessel elements are long, cylindrical with simple, circular perforation plate oriented obliquely at the end wall. Pits are bordered and opposite on the lateral walls. Vessel elements have long pointed tails at both or in one end. Size of the vessel element is $493.974 \mu m \times 52.102 \mu m$ and frequency is $1.326/mm^2$ (Fig.-4A).

Tracheids are very long and with spiral side wall thickening. Diameter and frequency are $32.6\mu m$ and $17/mm^2$, respectively (Fig.-4B).

Fibres are typically libriform type; ends are narrow, tapering, pointed. Pits are simple, present throughout the length of the fibre. Fibre size is of $749.193 \times 23.748 \mu m$ and frequency is $10.754/mm^2$ (Fig.-4C).

| Structure    | Character                          | Type/ measurement |
|--------------|------------------------------------|-------------------|
| Vessel elements | Type of perforation plate         | Simple            |
|              | Arrangement of perforation plate   | Oblique           |
|              | Pits                               | Bordered          |
|              | Tail                               | Present           |
|              | Length ($\mu m$)                   | 493.974           |
|              | Breadth ($\mu m$)                  | 52.102            |
|              | Frequency (No./mm$^2$)             | 1.326             |
| Tracheids    | Wall thickening                    | Spiral            |
|              | Diameter ($\mu m$)                 | 32.6              |
|              | Frequency (No./mm$^2$)             | 17                |
| Fibres       | Ends                               | Pointed           |
|              | Pits                               | Present           |
|              | Length ($\mu m$)                   | 749.193           |
|              | Diameter ($\mu m$)                 | 23.748            |
|              | Frequency (No./mm$^2$)             | 10.754            |

3.4 Organoleptic features of the stem bark powder
Stem bark part: Colour- Grey; Odour-Not specific; Taste-Pungent; Texture- Finely fibrous (Table- 6; Fig.- 5A,5B)
3.5 Physicochemical analysis of the bark powder
For physicochemical characterization of the powdered plant samples moisture content, total ash content, acid insoluble ash, water soluble ash, extractive value, were determined and results are presented below (Table-7).

a. Moisture content
The moisture content of stem bark is 0.5 %.

b. Ash value
Total ash of the stem bark were recorded 9%, of which acid insoluble ash is 0.092% and water soluble ash is 7.626%.

c. Extractive value
Extractive value of the drug sample varies according to the nature of the solvent. It is found that methanol soluble extractive value is highest (8.627%) among the other solvents. Benzene soluble extractive value is 0.8 % which is found to be lowest here. The extractive values for the solvents of water, chloroform and petroleum ether are 7 %, 4.56 % and 1.856 %, respectively.

3.6 Fluorescence analysis
Drug powder of the stem bark treated with different chemical reagents emitted distinguishing colour when observed under different wave length of UV light (355nm and 254 nm). In some cases the colour changes were markedly distinct in comparison to the colours observed under ordinary light (Table-8; Fig.-6A, 6B). The natural colour of the bark powder is creamy white. When it was observed under UV light it fluoresces green. The bark powder treated with 50 percent nitric acid showed reddish orange colour and the powder treated with same reagent fluoresced black to deep green under UV light.

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**Table 6:** Organoleptic characters of the bark powder of the investigated plant

| Plant part   | Colour | Odour      | Taste | Texture       |
|--------------|--------|------------|-------|---------------|
| Stem bark    | Grey   | Not specific | Pungent | Finely fibrous |

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**Table 7:** Physico-chemical properties of powdered stem bark of the investigated plant

| S. No. | Physico-chemical parameters | Value (%) |
|--------|-----------------------------|-----------|
| 1.     | Moisture content (w/w)      | 0.5       |
| 2.     | Ash value (w/w)             |           |
| a.     | Total ash                   | 0.9       |
| b.     | Acid insoluble ash          | 0.092     |
| c.     | Water soluble ash           | 7.626     |
| 3.     | Extractive value ( w/w)     |           |
| a.     | Water soluble extract       | 0.7       |
| b.     | Methanol soluble extract    | 8.672     |
| c.     | Chloroform soluble extract  | 4.56      |
| d.     | Benzene soluble extract     | 0.8       |
| e.     | Petroleum ether soluble extract | 1.856 |

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**Fig 5A:** Dried stem bark  
**Fig 5B:** Powdered stem bark

**Fig 6:** UV- fluorescence study of powdered stem bark: A- Under visible light; B- Under UV light (355 nm)
**Table 8:** UV-Fluorescence behavior of the stem bark powder

| Material and treatment | Under UV light (355nm) | Under UV light (254nm) | Under visible light |
|------------------------|------------------------|------------------------|---------------------|
| Bark powder as such    | Fluorescent deep green | White green            | White               |
| Powder treated with 50% Nitric acid | Black                  | Deep green             | Reddish orange      |
| Treated with Acetone   | Fluorescent creamy green | Green                  | Deep brown          |
| With Methanol          | Fluorescent green       | Deep green             | Reddish brown       |
| With Ethanol           | Fluorescent green       | Deep green             | Light brown         |
| With Picric acid       | Black                   | Green                  | Creamy yellow       |
| With 80% Sulfuric acid | Blackish green          | Blackish violet        | Dark coffee         |
| With Acetic acid       | Fluorescent creamy white | Green                  | Deep brown          |
| With 1(N) Hydrochloric acid | Blackish green        | Olive green            | Pale orange         |
| With Antimony trichloride | Fluorescent deep green | Green                  | Pale brown          |
| With 5% Sodium hydroxide | Black                  | Blackish green         | Reddish black       |
| With 5% Ferric chloride | Deep green              | Greenish black         | Blackish yellow     |
| With Water             | Fluorescent green       | Green                  | Deep brown          |

3.7 Histochemical study

Different phytochemical groups like, tannins, proteins, alkaloids, flavonoids, glycosides, lignin, etc. have been detected in various tissue zones such as vascular bundles, cortex, pith, etc. through histochemical localization study of the stem part (Table -9).

**Table 9:** Histochemical localization test of the stem of the investigated species

| Test for | Test/ reagents | Histological location |
|----------|----------------|-----------------------|
| Alkaloids | Mayer’s reagent | Vascular bundles      |
|          | Wagner’s reagent | Vascular bundle, pith |
|          | Dragendroff’s reagent | Epidermis, vascular bundle |
| Flavonoids | 10% NaOH           | Phloem, cortex       |
| Reducing sugars | Fehling’s reagent | Epidermis, hypodermis, some cells of cortex, xylem and phloem |
|          | Benedict’s reagent | No tissue zone detected |
| Proteins  | Millon’s reagent  | Phloem, cortex including hypodermis |
|          | Lugol’s reagent   | Few cells of cortex   |
| Tannins   | 10% Lead acetate solution | Vascular bundles |
|          | 5% Ferric chloride solution | Hypodermis |
|          | 10% Potassium di-chromate | Epidermis, chlorenchyma, cortex and some cells of pith |
| Lignin    | Phloroglucinol    | Sclerenchyma tissue including xylem and phloem fibres |
| Glycosides| Keede reagent    | Xylem                 |
| Carbohydrates | Molish’ s test    | Xylem, phloem and pith |

3.8. Preliminary phytochemical screening of the powdered sample of bark

a. Microchemical colour reaction tests

Preliminary chemical screening of the methanol extract of the investigated plant showed presence of alkaloids, flavonoids, tannins, saponins and other major phytochemical groups. Presence of these groups in the stem bark indicates that the plant is possibly enriched with a good number of important phytochemical groups which are basically responsible for its wide range of medicinal properties (Table-10; Fig.-7).

**Table 10:** Microchemical tests of the methanolic extract of stem bark

| Test/Reagent       | Test for   | Nature of colourchange | Degree of colourchange |
|--------------------|------------|------------------------|------------------------|
| Dragendroff’s reagent | Alkaloids  | Orange brown ppt.      | ++                     |
| Wagner’s reagent   | Alkaloids  | Orange brown ppt.      | +++                    |
| Mayer’s reagent    | Alkaloids  | White/ Cream ppt.      | +                      |
| Hager’s test       | Alkaloids  | Yellow ppt.            | +++                    |
| Shinoda test       | Flavonoids | Magenta colour         | ++                     |
| 10% NaOH           | Flavonoids | Yellow colour          | +++                    |
Salkowski test & Steroids and Triterpenoids & Reddish-blue and green fluorescence & +++
Kedde reagent & Glycosides & Violet to blue colour & +++
Keller-Killiani test & Cardiac Glycosides & Reddish-brown at junction of two liquid & +++
Benedict’s reagent & Reducing sugar & Brick red ppt. & -
Fehling’s reagent & Reducing sugar & Brick red ppt. & -
Molish’s test & Gums & Red-violet ring & +++
10% aqueous potassium dichromate solution & Tannins & Yellowish-brown ppt. & +++
10% aqueous lead acetate solution & Tannins & White ppt. & ++
5% aqueous ferric chloride solution & Tannins & Greenish-black colour & ++
1% lead acetate solution & Saponins & White ppt. & +++
Bontrager’s test & Anthraquinones & Pink colour & +++
Ninhydrin test & Amino acids & Purple colour & -
Phloroglucinol test & Lignin & Red colour & +
Millon’s reagent & Proteins & White ppt. & +
Lugol’s reagent & Proteins & Faint yellow colour & +

+ = present; - = absent

b. Gas Chromatography Mass Spectroscopy

The methanolic extract of E. paniculata was subjected to GC-MS analysis for identification of different phytochemical compounds present in it. A total of nine chemical compounds have been elucidated for the first time from the bark extract of this ethnomedicinal plant. Out of nine, two compounds are of fatty acid esters viz., 10-Heptadecen-8-ynoic acid, methyl ester, (E)- and Cyclopropanododecanoic acid, 2-octyl-, methyl ester; three compounds are of carboxylic acid esters viz., 1,2-Benzenedicarboxylic acid, butyl octylester; Benzenepropanoic acid, 3,5-bis(1,1-dimethylethyl)-4-hydroxy-, methyl ester and 2-Propanoic acid, 3-(3,4,5-trimethoxyphenyl)-, methyl ester; two are coumarin derivatives (benzopyrone family member with lactone-like chain), viz., scoparone and scopalat; 2-Hexadecanol, a phenol and remaining one aromatic ketone(ether)viz., 2,4,6-Trimesitylacetoephene.

The area percent of a peak in respect of the total area of all peaks in the chromatogram represents the abundance of a particular compound in the tested extract. Thus, based on abundance, highest peak in the chromatogram has been detected for Scopoletin (31.788%) and lowest peak was recorded for 2-Hexadecanol (3.995%). Second and third highest abundances have been recorded for Benzenepropanoic acid, 3,5-bis(1,1-dimethylethyl)-4-hydroxy-, methyl ester (18.546%) and 2,4,6-Trimesitylacetoephene (14%), respectively. Rest of the five compounds which showed less than ten percent of peak area in the chromatogram viz., Scoparone (8.864%); 1,2-Benzenedicarboxylic acid, butyl octyl ester (7.181%); 10-Heptadecen-8-ynoic acid, methyl ester, (E)-(5.788%); 2-Propanoic acid, 3-(3,4,5-trimethoxyphenyl)-, methyl ester (5.102%) and Cyclopropanododecanoic acid, 2-octyl-, methyl ester (4.665%). Name of the phytochemicals along with their retention time, peak percent, molecular formula, molecular weight, chemical structures and reported biological roles have been presented in a tabular form (Table-11; Fig.-8).

Fig 8: GCMS chromatogram of the methanolic extract of stem bark.

Table 11: Gas Chromatography-Mass Spectroscopy (GCMS) analysis of stem bark extract of Erycibe paniculata

| Class of the chemical compound | Name of the compound | RT (min) | Peak area (%) | Molecular Formula; Molecular weight (g/mol) | Structure | Biological activity reported earlier |
|--------------------------------|----------------------|---------|--------------|---------------------------------------------|-----------|-------------------------------------|
| Phenol (pheromone) | 2-Hexadecanol | 10.38 8 | 3.995 | C18H35O; 242 | ![Structure](image1) | Not reported |
| Dicarboxilic acid-ester | 1,2-Benzenedicarboxylic acid, butyl octyl ester | 10.50 3 | 7.181 | C18H35O4; 334 | ![Structure](image2) | Antimicrobial, antifouling (Adeyemi M A et al., 2017) [54] |


### Table

| Ester derivative of fatty acid | 10-Heptadecen-8-ynoic acid, methyl ester, (E)- | 13.34 | 2 | C_{18}H_{30}O_2 : 278 | Anti-inflammatory (Ibraheam et al., 2017) |
| Ester derivative of fatty acid | Cyclopropanododecanoic acid, 2-octyl-, methyl ester | 17.07 | 2 | C_{28}H_{42}O_2 : 366 | Anticancer, antitumor, antiestrogenic, antimicrobial (Manjamahal, 2011) |
| Phenolic ester | Benzene propanoic acid, 3,5-bis(1,1-dimethylethyl)-4-hydroxy-, methyl ester | 17.41 | 5 | C_{25}H_{30}O_3 : 292 | Antifungal, antioxidant (Bashir et al., 2012) |
| Coumarin derivative | Scoparone | 17.90 | 1 | C_{11}H_{10}O_4 : 206 | Antiaceetylcholinesterase activity (Mogana et al., 2014) |
| Coumarin derivative | Scopoletin | 17.61 | 5 | C_{14}H_{14}O_4 : 192 | Antileishmanial activity (Mogana et al., 2014) |
| Benzene carboxylic acid ester having two ether group | 2-Proppenoic acid, 3-(3,4,5-trimethoxyphenyl)-, methyl ester | 18.82 | 2 | C_{18}H_{28}O_5 : 252 | No activity reported |
| Ether of trihydroxyacetophenone | 2,4,6-Trimethoxyacetophenone | 12.91 | 7 | C_{14}H_{14}O_4 : 210 | Antiinflammatory (Chairadia et al., 2008) |

### 4. Discussion

In the present study some characters obtained from foliar micromorphology, anatomy of petiole and stem, preliminary phytochemical screening and physicochemical evaluation, are found very distinct and can be used as marker in identification of *Erycibe paniculata* in its fresh as well as dried from. The study is the firsthand information since no pharmacognostic work has been done earlier on this plant. According to WHO (1998), the macroscopic and microscopic characterization of plants is the first and basic criterion to confirm identity and confer purity of drug of it [8]. In this study it has been observed that epidermal cells are irregular in shape. Very distinct type of cell wall outline is observed between the epidermal cells of upper and lower surfaces of leaf. Cell wall outline is straight in upper epidermis and it is slightly wavy in lower epidermal cells. The palisade ratio for this species is 6.62 which distinguishes it among the species of Convolvulaceae studied for their palisade ratio. Taxonomically and pharmacognostically the study of stomata is very important to identify the medicinal plants [24, 28, 27]. The foliar micromorphology of the present investigated plant showed anisocytic type of stomata which conforms the stomatal type reported in earlier studies in the genus *Erycibe* [28]. Although paracytic, anisocytic and anomocytic types of stomata have been found in different members of Convolvulaceae [28-34]. Similarly, Stomatal Index (SI) of *E. paniculata* was determined as 13.87 which is distinct to this species of genus *Erycibe* and makes it unique among other members of the same family [29-33].

Foliar trichome feature is considered as one of the valuable taxonomic markers as well [34-37]. It has been reported that, some species under the family Convolvulaceae showed the trichomes of unicellular, glandular type and both uni- and multicellular, non-glandular trichomes with two arms [38]. Here in case of *Erycibe paniculata*, trichomes of the leaf are of unicellular glandular type. However, typical 2-6-armed, non-glandular types were recorded in the petiole and stem epidermal surfaces of this taxon. Such type of multi armed nonglandular trichome structure has not been recorded earlier from the members of the genus *Erycibe* [28, 35, 39]. Therefore, the trichomes with many arms will serve as marker character here in identification of the shoot part of this investigated plant. Petiole anatomy is employed as an efficient tool in plant species identification as well as leaf drugs. Anatomy of petiole of this plant is found very distinct among the other taxa of the family Convolvulaceae so far studied. In our investigation, petiole showed a semi-lunar outline in its transverse section and it contains three vascular bundles, of which central one is semilunar in shape, larger than other two. Chemical analysis and biological assay are two important aspects which are employed in Pharmacognosy for proper evaluation of crude drug procured from the medicinal plants [39]. Preliminary phytochemical analysis highlights the...
chemical nature of crude drug and its valuable phytoconstituents. The important phytochemical groups detected in the stem bark of the present investigated plant are alkaloids, anthaquinones, saponins, tannins, glycosides, steroids, etc. Histochemical study gives a scientific impression about the localizations of alkaloids, saponins and tannins in the vascular bundles, sclerenchyma and cortical zone of the stem part. This information proves the therapeutic utility of shoot bark of this medicinal climber as anatomically bark includes the tissues of cork, cortex and phloem part of the vascular bundles. Compounds of various phytochemical groups are generally stored and/or synthesized mainly in the phloem, cortex, cork layers, pith zone and definitely in the leaf tissues. This scientific reality has also been realized here in histochemical study of stem where cortex, pith, vascular bundles and cork zone have been detected as active sites of many phytochemical groups localized.

Therapeutic properties of different phytochemicals have already been studied and well documented from some medicinal plants which are traditionally used for treatment of tumour, inflammation, diarrhea, diabetes, rheumatic pain, sexual diseases, etc. [35-38]. It our study, microchemical colour reaction tests confirm the presence of different phytochemical groups like alkaloids, flavonoids, saponins, steroids and triterpenoids, tannins, etc. Presence of such important phytochemical groups in E. paniculata clearly indicates its therapeutic properties and also its possibility towards scientific validation of different ethnomedicinal uses. In pharmacognosy, physicochemical characters play a crucial role in establishing fingerprint of some standards of a crude drug and it helps in detection of adulterants also. Moisture content, ash value, extractive value and UV-fluorescence characters are some of the pharmacognostic parameters commonly employed in crude drug evaluation [9, 25]. In this study, a negligible content of moisture (0.5%) was found in bark power which can be considered as an official standard of this bark drug.

Among the physical constants, ash value is considered as a fixed character which varies from one species to another. It is applied as one of the important diagnostic tools in crude drug study. The value also considered as an indicator of presence of inorganic matters in the crude drugs [44]. It has been found that the ash value of bark is 9% and it is very distinct as well which indicates that bark part of this medicinal plant consists of a good amount of inorganic minerals like carbonate, oxalate, phosphate including silica and siliceous earthy matters. Values for various parameters like acid insoluble ash and water soluble ash observed in the bark part of this plant are different and distinct from one another which can be used as identifying marker in authentication and quality control of the crude drug obtained from the bark of the plant E. paniculata.

The fluorescence analysis of the drug powder is very useful to distinguish genuine drug from the adulterated one [44, 45]. Some chemicals present in the plant drug powder fluorescence differently under different wavelength of UV-light. In present investigation, creamy white colored bark powder showed the green fluorescence under UV light. When the same powder is treated with 50 percent nitric acid it exhibited reddish orange colour under ordinary light and fluoresced black colour in UV light. These marked changes in colour are found very convincing here in identification of the bark in its powdered form. Extractive value indicates the amount of extractive substance released in a given solvent from a crude drug. This value plays a decisive role in selection of standard extractive solvent for estimation of maximum phytochemicals present in a powdered drug [24]. In our study, methanol exhibited highest extractive value (8.672%) among other solvents used like benzene, Petroleum ether, chloroform. In benzene, the plant drug yields lowest extractive value (0.8 %). So, it indicates that the chemicals present in drug sample of bark are highly dissolved in polar organic solvents like methanol than the non-polar solvents like petroleum ether, benzene, etc. The study revealed that methanol, being a highly polar solvent, extracted out the highest amount of chemical constituents from the bark of E. paniculata. The extractive values for all four solvents taken here gave a distinct pattern which will be instrumental in quality control of the bark drug.

Several standard techniques are used in qualitative and quantitative estimation of crude drugs for their various chemical constituents. GCMS is one of such important techniques for the analysis, characterization and identification of chemical compounds of low molecular weight. In present study GCMS of methanol extract of E. paniculata bark has been carried out and it revealed nine compounds which belong to the groups of phenolics, fatty acid esters, coumarins, carboxylic acid esters, and ether of trihydroxyacetophenone. The obtained chromatogram can be considered as the chemical fingerprint of the crude bark of this medicinal plant.

Perusal of literature revealed that among the nine identified phytochemical compounds from the bark extract, seven compounds show a wide range of biological actions such as anti-inflammatory, anticancer, antioxidant, antimicrobial, antiparasitic, etc. (Table -10). Out of seven phytochemicals, two compounds, viz. an aromatic carboxylic acid ester, Benzenedicarboxylic acid, butyl octyl ester (peak area = 7.181%) and a phenolic ester, Benzene propanoic acid, 3,5-bis (1,1-dimethylethyl)-4-hydroxy-, methyl ester have been reported as antimicrobial agents in earlier studies [46, 47]. Benzenepropanoic acid, 3,5-bis(1,1-dimethylethyl)-4-hydroxy-, methyl ester has also a good applications in food industry to maintain the flavor, quality, fragrance, taste. GCMS chromatogram of the investigated plant drug showed second highest concentration of this compound (peak area=18,546%). It has been reported that the crude extract of the E.paniculata is effective against some gram positive and gram negative pathogenic bacteria [48] which again supports the presence of antimicrobial agents in the plant extract. Another compound of fatty acid ester namely Cyclro panapededecanoic acid, 2- octyl-, methyl ester was reported to have both antimicrobial and anti-inflammatory activities [49]. Reports on such biological activities of these compounds identified from the bark extract support the traditional uses of root and bark decoction of this investigated plant by the people of Orissa in curing cholera, fever and diarrhea [14-16] as many microbial organisms are responsible for such disease as well as health conditions.

Other two chemical compounds identified here viz., 2,4,6-Trimethoxyacetophenone (a ether of trimethoxyacetophenone) and 10-Heptadecen-8-ynoic acid, methyl ester, (E)- (a fatty acid ester) have been reported as potent anti-inflammatory compounds [50, 51]. GCMS chromatograms showed the third and sixth highest concentrations of these two compounds in the bark extract (14% and 5.788%, respectively). Anti-inflammatory substances are very helpful in several diseases and ailments like cancer, rheumatism, cardiovascular problems, immune
related problems, etc. [52, 53] Presence of such anti-inflammatory chemicals in the bark of this plant is correlated with its ethnomedicinal uses for headache (during menstruation cycle).

Two different coumarin derivatives have been detected in this study, viz., scopoletin and scoparone. It is reported that Scopoletin shows potent antileishmanial [54] and antispasmodic activity [55]. In our study, scopoletin exhibited the highest concentration (peak area=31.788%) in the crude bark extract. Other coumarin compound, scopoletin has been established as the cures of a wide range of health disorders like mental retardation, crotchet, nerve deafness, scrotal dermatitis and different inflammatory conditions including painful sores of mouth, swelling of tongue, etc. [56] Application of scoparone (peak area=8.864%) stimulate the inhibition of synaptic transmission during muscular pain, helps to mobilize calcium in muscle and reduce skeletal-muscular problems including muscular pain and spasm [54, 56, 57]. Presence of scopoletin and scoparone in greater quantities in the bark clearly justify the traditional uses of stem bark of this plant for curing muscular spasm, headache and pain during menstruation because of the active role played by these two coumarin chemicals in inhibiting the synaptic transmission occurs in those health problems [15, 17].

It is interesting to mention here that two phytochemicals belonging to the groups of phenol and benzene carboxylic acid ester viz., 2-Hexadecanol (peak area= 3.995%) and 2-Propanoic acid, 3-(3,4,5-trimethoxyphenyl)-, methyl ester (peak area=5.102%), respectively have been detected in the GCMS study of bark of this plant for which the biological and pharmacological activities have not been reported till date. So, there is a scope to find out the biological roles of these two compounds obtained from this plant.

Presence of different types of phytochemical compounds in the crude bark of E. paniculata make this plant very promising candidate for its further chemical and biological activity studies. Systematic investigations of the parts other than bark are also to be carried out for scientific validation of ethnomedicinal claims attached to this important medicinal plant.

5. Diagnostic characters of the investigated plant

A. Foliar epidermal micromorphology :

1. Cells are irregular in shape and cell walls are more or less straight
2. Anisocytic type of stomata and stomatal index is 13.87.
3. Trichomes are unicellular, glandular type
4. Presence of clustered crystals in upper epidermal cells

B. Vegetative anatomy:

I. Multi-armed (2-6), non-glandular trichomes teeming on petiole and stem.
II. Petiole with 3 vascular bundles, the central one is larger and semi-lunar in shape

C. Physical evaluations

- Moisture content-0.5% (stem part)
- Total ash content- 9%
- Water soluble ash- 7.626%
- Acid insoluble ash-0.029%  
- Methanol soluble extractive value- 8.762%
- UV-fluorescence character- Methanol treated bark powder appears pinkish brown colour in visible light and in UV light it shows fluorescent blue colour.

6. Conclusion

The diagnostic characters on foliar epidermal micromorphology and physicochemical constants investigated here in the pharmacognostic study of E. paniculata will be very useful in proper identification of the crude drugs obtained from its different parts. The data of the pharmacognostic study will also be helpful in quality assurance of the drugs obtained from this ethnomedicinal plant. A wide range of therapeutically important phytochemical groups like alkaloids, flavonoids, fatty acids, phenolics, glycosides, etc. have been detected in methanolic extracts of stem bark powder of this medicinal climber which basically highlights its various therapeutic properties.

GCMS study of the bark extract revealed the existence of nine phyto-compounds and of which, seven chemicals have been identified by other workers as very potent in a wide panorama of pharmacological functions including antimicrobial, anti-inflammatory, antispasmodic, anticancer, etc. This information clearly focuses the promising domains of phytochemical and pharmacological studies of present investigated plant. Present investigation also highlights the scientific basis regarding traditional uses of this medicinal plant for various healing purposes. Finally, it may be concluded that E. paniculata needs further investigation in the line of phytochemistry and pharmacology for identification of the lead molecules and for development of potent bioactive natural products.

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8. References

1. Bhat ZA, Kumar D, Shah MY. Angelica archangelica L. is an Angel on earth for the treatment of diseases: A review. International Journal of Nutrition Pharmacology and Neurological Disorders, 2011; 1:35-49.
2. Heinrich M, Barnes J, Gibbons S, Williamson EM. Fundamentals of Pharmacognosy and Phytochemistry. Edn 3, Churchill Livingstone, Elsevier, 2012, 1-15.
3. Ekor M. The growing use of herbal medicines: issues relating to adverse reactions and challenges in monitoring safety. Frontiers in Pharmacognosy. 2014; 4:177.
4. Mukherjee PK. Traditional medicines and globalization – future of ancient systems of medicine. Maven Publishers, Kolkata, 2014, 12-22.
5. Ghorani-Azam A, Sepahi S, Riahizanjani B, Ghamsari AA, Mohajeri SA, Balali-Mood M. Plant toxins and acute medicinal plant poisoning in children: A systematic literature review. Journal of Research in Medical Sciences. 2018; 23:26.
6. Sreelekshmi M, Vimala KS, Paul RP, Chandran N, Shine PA, Salam NA. Drug adulteration: A threat to efficacy of Ayurveda medicine. Journal of Medicinal Plants Studies. 2017; 5(4):01-06.
7. Bisht L, Veerma R. Allopolypetalous formulations and their Strategies. Journal of Phytochemistry and Biochemistry. 2017; 1(1):1-4.
8. World Health Organization. Quality control methods for medicinal plant materials, WHO/PHARM/92.559, 1998;
9. Hasmi S, Singh VK. Importance of Pharmacognosy as an aid to drug standardization programme: A review. Singh VK, Govil JN, Hashmi S, Singh G. (eds) Ethnomedicine and Pharmacognosy, Studium Press LIC, U.S.A. 2003; II(VII):339-346.

10. Saha S, Rahaman CH. Pharmacognostic and anatomical studies of Antigonon leptopus Hook. and Arn.: A promising medicinal climber. International Journal of Research in Ayurveda and Pharmacy. 2013; 4(2):186-191.

11. Pal K, Rahaman CH. Studies on foliar epidermal micro-morphology, vegetative anatomy and xylem elements of four members of Protulaceae. International Journal of Current Research. 2014; 6(02):4968-4975.

12. Ghosh P, Rahaman CH. Pharmacognostic studies and phytochemical screening of aerial and root parts of Cyanotis tuberosa (Roxb.) Schult. & Schult. f. – an ethnomedical herb. World Journal of Pharmaceutical Research. 2016; 5(2):1580-1601.

13. Ray AS, Rahaman CH. Pharmacognostic standardization and phytochemical investigation of Cajanus scaraboides (L.) Thouars. Research Journal of Pharmacognosy and Phytochemistry. 2018; 10(1):120-131.

14. Khare C. Indian Medicinal plants- an illustrated dictionary, Springer, 2007, 244.

15. Dhal NK, Panda SS, Moduli SD. Traditional uses of medicinal plants by native people in Nawargarh district, Odisha, India. Asian Journal of Plant Science and Research. 2015; 5(2):27-33.

16. Panda SK. Ethnomedicinal uses and screening of plants for antibacterial activity from Simipal Biosphere Reserve, Odisha. Indian Journal of Ethnopharmacology. 2014; 151:158-175.

17. Pradhan B. Studies on medicinal plants of Birbhum district, West Bengal with reference to their status and ethnomedicine. Ph.D. thesis. Visva –Bharati, Santiniketan, 2013.

18. Dey A, De JN. Ethnoveterinary uses of Medicinal Plants by the Aboriginals of Purulia District, West Bengal, India. International Journal of Botany. 2010; 6(4):433-440.

19. Ekka A. Folklore Claims of Some Medicinal Plants Used by Tribal Community of Chhattisgarh, India. Research Journal of Biology. 2011; 1(1):16-20.

20. Sanyal MN. Flora of Bankura District West Bengal. Bishen Singh Mahendra Pal Singh, Dehradun, India, 1994, 439-440.

21. Bokhari MH. Morphology and taxonomic significance of foliar sclereids in Limonium. Notes from the Royal Botanical Garden. 1970; 30:43-53.

22. Johansen DA. Plant Microtechnique. McGraw-Hill, New York, 1940, 65-94.

23. Sen S, Datta PC. Pharmacognostic study of the leaf of Aganosoma dichotoma (Roth.) K. Schum. Journal of Economic and Taxonomic Botany. 1982; 3:787-794.

24. Anonymous. Indian Pharmacopoeia. Edn 3, Vol.II, Ministry of Health, Govt. of India, New Delhi, India, 1985.

25. Kokoski J, Kokoski R, Salma FJ. Fluorescence of powder vegetable drugs under ultraviolet radiation. Journal of American Pharmacist Association. 1958; 47(10):715-717.

26. Trease GE, Evans WC. Pharmacognosy. Edn 12., English Language Book Society, Bailliere Tindall, Eastbourne, 1983.

27. Inamdar JA. Epidermal structure and ontogeny of caryophyllaceous stomata in some Acanthaceae. Botanical Gazette. 1970; 131:261-268.

28. Metcalfe CR, Chalk L. Anatomy of Dicotyledons, Clarendon Press, Oxford, UK. 1950; II:954-964.

29. Pant DD, Banerji R. Epidermal structure and development of stomata in some Convulvulaceae. Ceylon Journal of Science, Biological Science. 1971; 9(2):64-74.

30. Singh V, Jain DK, Sharma M. Epidermal studies in Ipomoea (Convulvulaceae). Bangladesh Journal of Botany. 1974; 3(2):31-36.

31. Karatela YY, Gill LS. Epidermal morphology and stomatal ontogeny in some West African Convulvulaceae sps. Herba Hung. 1985; 24(2):11-18.

32. Tayade SK, Patil DA. Foliar epidermal investigations in some hitherto unstudied Convulvulaceae–II. Current Botany. 2011; 2(9):26-30.

33. Folorunso AE. Taxonomic evaluation of fifteen species of Ipomoea L. (Convulvulaceae) from South-Western Nigeria using Foliar Micromorphological characters. Notulae Scientia Biologicae. 2013; 5(2):156-162.

34. Leeavathi PM, Ramayya N. Structure, distribution and classification of plant trichomes in relation to taxonomy II. Caesalpinioideae. Indian Journal of Forestry. 1983; 6:43-56.

35. Mukherjee KK, Roy M, Saha PK, Ganguly SN. Surface morphology of tea (Camellia sinensis L.) leaves. Phytomorphology. 2000; 50:125-131.

36. Rao RS, Ramayya N. Trichome types and their taxonomic importance in the Tiliaceae. Indian Journal of Botany. 1987; 10:65-73.

37. Syahida–Emiza S, Staples G, Haron NW. Materials for a revision of Erycibe (Convulvulaceae) in Peninsular Malaysia. Gardens’ Bulletin Singapore. 2011; 63(1-2):97-103.

38. Phillipson JD. Phytochemistry and pharmacognosy. Phytochemistry. 2007; 68:2960-297.

39. Okuda HIT, Ito H. Tannins of constant structure in medicinal and food plants-hydrolyzable tannins and polyphenols related to tannins. Molecules. 2011; 16:2191-2217.

40. Siqueira CFQ, Cabral DLV, Sobrinho TJSP, Amorim ELC, Melo JG, Araújo TAS et al. Levels of tannins and flavonoids in medicinal plants: Evaluating bioprosp ecting strategies. Evidence-Based Complementary and Alternative Medicine, 2012, 1-7.

41. Aniszewski R. Alkaloids- Secrets of life: Alkaloid chemistry, bilogical significance, applications, and ecological role. Elsevier, 2007, 1-334.

42. Chandel HS, Pathak AK, Tailang M. Standardization of some herbal anti diabetic drugs in polyherbal formulation. Pharmacognosy Research. 2011; 3(1):49-56.

43. Chandel HS, Pathak AK, Tailang M, Chandra S. Importance of pharmacognostic study of medicinal plants: An overview. Journal of Pharmacognosy and Phytochemistry. 2014; 2(5):69-73.

44. Alagar RM, Shailaja V, Banji D, Rao KNV, Selvakumar D. Evaluation of standardization parameters, pharmacognostic study, preliminary phytochemical screening and in vitro anti diabetic activity of Emblica officinalis fruits as per WHO guidelines. Journal of Pharmacognosy and Phytochemistry. 2014; 3(4):21-28.
46. Adeyemi MA, Ekunseitan DA, Abiola SS, Dipeolu MA, Egbeyalte LT, Sogunle OM. Phytochemical analysis and GC-MS determination of Lagenaria breviflora (Benth.) Roberty fruit. International Journal of Pharmacognosy and Phytochemical Research. 2017; 9(7):1045-1050.

47. Bashir A, Ibrar K, Shumaila B, Sadiq Azam. Chemical composition and antifungal, phytotoxic, brine shrimp cytotoxicity, insecticidal, and antibacterial activities of the essential oil of Acacia modesta. Journal of Medicinal plants Research. 2012; 6(31):4653-4659.

48. Bashir A, Ibrar K, Shumaila B, Sadiq Azam. Chemical composition and antifungal, phytotoxic, brine shrimp cytotoxicity, insecticidal, and antibacterial activities of the essential oil of Acacia modesta. Journal of Medicinal plants Research. 2012; 6(31):4653-4659.

49. Bashir A, Ibrar K, Shumaila B, Azam S. Chemical composition and antifungal, phytotoxic, brine shrimp cytotoxicity, insecticidal and antibacterial activity of essential oils of Acacia modesta. Journal of Medicinal Plants Research. 2012; 6(3):4653-4659.

50. Panda SK, Mohanta YK, Padhi L, Park YH, Mohanta TK, Bae H. Large scale screening of Ethnomedicinal plants for identification of potential antibacterial compounds. Molecules. 2016; 21(3):293.

51. Manjamalai A, Narala Y, Haridas A, Grace B. Antifungal, Anti-inflammatory and GC-MS analysis of methanolic extract of Plectranthus amboinicus leaf. International Journal of Current Pharmaceutical Research. 2011; 3:129-136.

52. Chiaradia LD, Santos R, Vieira AA. Synthesis and pharmacological activity of chalcones derived from 2,4,6-trimethoxyacetophenone in RAW 264.7 cells stimulated by LPS: Quantitative structure-activity relationships. Bioorganic and Medicinal Chemistry. 2008; 16(2):658-67.

53. Ibrastructure IA, Hussein HM, Hameed IH. Cyclamenpersicum: methanolic extract using Gas Chromatography-Mass Spectrometry (GC-MS) technique. International Journal of Pharmaceutical Quality Assurance. 2017; 8(4):200-213.

54. Fürst R, Zündorf I. Plant-derived Anti-inflammatory compounds: Hopes and disappointments regarding the translation of preclinical knowledge into clinical progress. Mediators of Inflammation. 2014, 1-9.

55. Ghasemian M, Owlia S, Bagher Owlia M. Review of Anti-inflammatory Herbal Medicines. Advances in Pharmacological Sciences, 2016, 1-11.

56. Mogana R, Adhikari A, Debnath S, Hazra S, Teng-Jin K, Wiart C. The anti-acetyl cholinesterase and antileishmanial activities of Canarium patentinervium Miq. Biomed Research International. 2014, 903529.

57. Mbaveng AT, Zhao Q, Kuete ZV. Harmful and protective effects of phenolic compounds from African medicinal plants. In Toxicological survey of African Medicinal Plants. Elsevier, 2014, 577-609. Retrieved from https://www.sciencedirect.com/topics/pharmacology-toxicology-and-pharmaceutical-science/scopoletin. 20th June, 2019.

58. Asif M. Pharmacological activities and phytochemistry of various plant containing coumarin derivatives pharmacological activities and phytochemistry of various plant containing coumarin derivatives. Current Science Perspectives. 2015; 21(3):77-90.

59. Matos MJ, Santana L, Uriarte E, Abreu OA, Molina E, Yordi EG. Coumarins- an important class of phytochemicals. Open access peer-reviewed chapter, 2015. Retrieved from https://www.intechopen.com/books/phytochemicals-isolation-characterisation-and-role-in-human-health/coumarins-an-important-class-of-phytochemicals. 28th June 2019.