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ORIGINAL ARTICLE

Foliar Epidermal Study on Selected Medicinal Plants Used in Homeopathy

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ABSTRACT

Background: Homeopathy is a complementary alternative medicine system which was introduced by Samuel Hahnemann in Europe in the last part of the eighteenth century. In homeopathy, drugs are obtained from various source materials such as plants, chemicals, minerals, and animals. However, plants are the major source and about 65% of medicines homeopathic medicines obtained from plants (HPI Vol. I to XI). Authentication and identification of genuine drugs is major concern for manufacturing units/industries. The present study will help to add key parameters in the identification of drugs. **Objective:** The objective of this study is to characterize the foliar epidermal characteristics of selected plants used in homeopathy. **Materials and Methods:** The foliar epidermal studies of *Aegle marmelos* (L.) Corrêa, *Bryophyllum calycinum* Salisb., *Cannabis indica* Lam., *Cephalandra indica* (Wight and Arn.) Naudin, *Eucalyptus globulus* Labill., *Gaultheria procumbens* L., *Gymnema sylvestre* (Retz.) R. Br. ex Sm., *Justicia adhatoda* L., *Nyctanthes arbor-tristis* L., and *Ricinus communis* L. **Results:** The study showed various characteristic features such as presence or absence of hairs or trichomes, trichomes if present were uni to multicellular, types and size of stomata, stomatal index on dorsal and ventral sides, vein-islet per mm^2, vein termination per mm^2, and presence or absence of idioblasts, etc. All these features will help in the identification and characterization of medicinal plants. **Conclusion:** The study revealed that the diversity of foliar characters of the leaf was varying from plant to plant and this variation may be a valuable tool for the authentication and identification of drug.

Key words: Foliar, homeopathy, stomata, vein termination, vein-islet

SUMMARY

- Based on result, it may be summarized that each plant has their unique epidermal features through which plant species will identified and standardized. Foliar epidermal features such as size of the epidermal cell, stomatal index, stomatal types, length and breadth of guard cell, length and breadth of stoma or pore cell, trichome index, trichome types, length and breadth of trichomes, crystal types, size of crystal are diagnostic parameters. Present study reveals that micromorphological characteristics of leaf in selected medicinal plant species shows high degree of variations from each other. Foliar epidermal features are also very important and useful parameters for the taxonomic identification, authentication and standardization point of view.

Abbreviations Used: Cm: centimeter, µm: micrometer, mm: millimeter, Ad: Adaxial, Ab: Abaxial, L: Length, W: Width

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INTRODUCTION

Medicine, as a field of science, has evolved over the years. It is practicality, use and methods of treatment have seen a constant progression with human evolution. Though improving and moving towards higher usage of chemically synthesized drugs in healthcare, medicine and its practitioners still find a better alternative in plants for the treatment of various conditions. Homeopathy, Ayurveda, Unani, Siddha rely majorly on plant products (drugs) for the treatment of most of the diseases, for example, plants play a pivotal role in disease treatment and about 65%

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of all the drugs used in homeopathy are derived from plants.[1,2] Such heavy reliance on plants for treatment has led to adulteration in the drugs, which decreases or diminishes the quality of the product leading to side effects or harm and defamation of the system. Adulteration in herbal drugs has become a major cause of concern in recent years. As the demand for the plant-based medicines are high, so for the industries, the manufacturers it becomes challenging to maintain the quality without compromise. This trend has been going on for the last many years as some of the drugs in demand are not produced in high quantities while some are not readily available and some others get lost simply in profit-making for the pharmaceutical industries. Adulteration of herbal drugs is an illegal practice and there are stringent laws that prohibit it but, despite the efforts of the government and the practitioners, these adulterated products still somehow find a way into our lives and render the efforts put in by the practitioner ineffective.

The epidermal characteristics of the leaf surfaces have very peculiar and unique features. Through botanically aspect, foliar epidermal parameters are also a significant feature; it distinguishes species to species and also very important for the identification of the plant. Taxonomists not too much used these characters for identification purpose. Bandulska[3] Florin,[4] Harris,[5] Metcalfe, and Chalk[6] were chief contributor who dragged the consideration toward foliar epidermal characters in the taxonomic investigation. There are so many taxonomic parameters which are were characterized for the identification of the plant, out of which cuticular or epidermal characters are also used now. These characters or parameters help in the identification, authentication, and preliminary screening of closely related plant species and raw drugs more conveniently and cost effectively rather than going for other advanced costlier, time-consuming molecular methods.

The epidermal system varies from species to species thus, it becomes a distinguishable parameter for the characterization of plants. These foliar epidermal characters are the major parameters for taxonomic identification of plant species and to distinguish between authentic raw drug and their adulterants.[7] The epidermal layer of the leaf has specialized structures such as epidermal cell shape, epidermal cell wall, their arrangements, stomata, trichomes, crystals, etc. The foliar epidermal characterization is an economical and convenient and less time-consuming method for the identification and authentication plant species. This study takes just hours to a few days in epidermal studies, thus helps in authentication and identification of medicinal plants in more convenient and cost-effective way. Here, in this study, we have focused on very basic techniques for drug authentication, i.e., foliar epidermal studies. Their advantages are being cost-effectiveness and lesser time consumption.

The importance of foliar epidermal morphology was used and contributed by so many researches from time to time Rao,[8] Harris,[5] Rao and Ramayya,[9] Sen,[10] Metcalfe,[11] Esau,[12] Wallis,[13] Trease and Evans,[14] Johansen,[15] Tomlinson,[16] etc. The main objective of this study was to survey the leaf epidermal characters assist for the identification and to solve the authentication of leafy medicinal raw drugs used in homeopathy. Description of qualitative and quantitative traits of foliar epidermal in ten medicinal plant species *Aegle marmelos* (L.) Corrêa, *Bryophyllum calycinum* Salisb., *Cannabis indica* Lam., *Cephalandra indica* (Wight and Arn.) Naudin, *Eucalyptus globulus* Labill., *Gaultheria procumbens* L., *Gymnema sylvestre* (Retz.) R. Br. ex Sm., *Justicia adhatoda* L., *Nyctanthes arbor-tristis* L., and *Ricinus communis* L. has been made.

MATERIALS AND METHODS

In this investigation, ten medicinal plant taxa from 9 families were taken. The leaves were taken from both woody and herbaceous plants, with different shape, size, and morphology. The plant materials were collected and supplied by the Centre for Medicinal Plants and Research in Homoeopathy, Emerald, Tamil Nadu. The leaf epidermal studies were carried out in the Pharmacognosy Laboratory, Drug Standardization Department, DDPR Central Research Institute for Homeopathy, Noida. Good collection practices were followed during the collection of the plant as per guidelines of the National Medicinal Plants Board and Botanical Survey of India.

The raw drugs which were supplied from the CMPRH were in dried form, these raw drugs were diagnosed through macroscopical studies such as leaf size, color, texture, odor, and taste. For foliar epidermal studies, dried leaves were softened by immersing into Luke water for 24–48 h. After softening, the leaves were cut into pieces and soaked into a saturated chloral hydrate solution for de-coloration and clearing.

For peeling, one end was held firmly with thumb and the other end scraped gently with a safety razor blade. Then, thin clear areas were cut off. The pieces were washed with water, then loosely adhering cells were brushed off with the help of pointed hairbrush. After washing, the samples were stained with safranin or other staining solution. Leaf samples were mounted in 50% glycerine solution with and without any reagent for surface study. Different diagnostic characters were observed, recorded, and photomicrography was done. With the help of trinocular Radical RTC S-7 microscope, different observations, namely type of stomata, stomatal index, epidermal cell walls types, presence and absence of the trichomes, crystals were recorded.

The qualitative and quantitative values of foliar epidermal cells such as the size of the epidermal cell, stomatal index, stomatal types, length and breadth of guard cell, length and breadth of stoma or pore cell, trichome index, trichome types, length and breadth of trichomes, crystal types, size of crystal on both the surfaces were recorded.

Stomatal number and stomatal index

The average number of stomata per square millimeter of epidermis is known as stomatal number. Whereas the percentage proportion of the number of stomata to the total number of epidermal cells in the same unit area is termed as stomatal index.[17,18]

Stomatal index can be calculated by using the following equation:

$$\text{Stomatal index} = \frac{\text{Stomatal cells}}{\text{Stomatal cells} + \text{Epidermal cells including hairs}} \times 100$$

The number of stomata and the number of epidermal cells in each field were counted. The mean of stomatal number and index were calculated from both the surface of the leaf.

Vein-islet and Vein termination number

Vein islet is the minute area of photosynthetic tissue encircled by the eventually division of the conducting strands. It is the average number of vein-islets per mm^2 of the lamina. It is determined by counting the number of vein-islets in an area of per mm^2 of the central part of the leaf between the midrib and the margin. Vein termination number is the average number of vein termination per mm^2 of the leaf surface. It is determined by counting the number of vein terminations in an area of per mm^2 of the central part of the leaf between the midrib and the margin.[14,15]

Palisade ratio

The average number of palisade cells beneath each upper epidermal cell of a leaf is known as the palisade ratio. It is determined from the leaf portion of the raw drug by counting the palisade cells beneath epidermal cells. The palisade cells under the four epidermal cells (including cells which are more than half and excluding cells which are less than half within the area of epidermal cells) were counted.[14,19]

Trichome number and trichome index

The average number of trichomes per square millimeter of epidermis is known as trichome number. Whereas the percentage proportion of the number of trichomes to the total number of epidermal cells in the same unit area is termed as trichome index.

Trichome index can be calculated by using the following equation:

$$\text{Trichome index} = \frac{\text{Trichomes}}{\text{Trichomes + Epidermal cells}} \times 100$$

The number of trichomes and the number of epidermal cells in each field were counted. The mean of trichome number and index were calculated from both the surface of the leaf.[14,15]

RESULTS AND DISCUSSION

The present study was based on the foliar epidermal features of 10 selected plant species. This experimental work provides the significant affirmation of foliar epidermal parameters for the authentic identification of medicinal plants used in homeopathy. This study is mainly on the complex structures of the epidermal cell and different cell inclusions complex such as stomata, trichome, and crystal present on both adaxial and abaxial surfaces. Whereas the quantitative measurements include: number of stomata, number of trichomes, number of vein islet, number of vein termination, length and width of the epidermal cells, trichomes, stomatal guard cell, stomatal pore, crystal, trichomes index, and stomatal index.

Aegle marmelos (L.) Corrêa

Epidermal cells polygonal, 4–7 sided, iso to anisodiametric, anticlinal wall straight and thick, surface smooth, size varied from 15-28 × 12–20 µm. crystals prismatic type, abundant in number, 4–5 sided, iso or anisodiametric, each cell contained a single rectangular or pentagonal crystal, size varied from 13-20 × 6–10 µm, scattered all over the surface. Leaves amphistomatous with anisocytic, paracytic and cyclocytic type stomata, oval shaped, subsidiary cells indistinct, stomatal number ranged from 200–264 to 570–612 on the adaxial and abaxial side and stomatal index 2.03–4.36 and 11.4–4.43 on adaxial and abaxial surface, size of stomatal guard cells and pores varied from 19-23 × 16–18 µm and 11–13 × 3–6 µm, respectively. Uniseriate, unicellular, pointed apex, curved trichomes present on both sides of the leaf. Trichome number ranged from 1–3 to 7-12 per mm^2 on the adaxial and abaxial side and trichome index 0.13–0.28 and 0.0–0.12 on the adaxial and abaxial surface, size of trichomes varied from 170-210 × 11–16 µm, respectively. Palisade ratio 3–6 per epidermal cell, vein islet 14–18 per mm^2 and vein termination numbers were 11–15 per mm^2, respectively [Figure 1a-c].

Bryophyllum calycinum Salisb

Epidermal cells irregular or polygonal, 5–7 sided, iso to anisodiametric, anticlinal wall straight and thin, surface smooth, size varied from 80-140 × 40–80 µm. Crystals were not found. Leaves amphistomatous with anisocytic type, elliptic in shaped, subsidiary cells slightly distinct, stomatal number ranged from 20–26 to 55-64 per mm^2 on the adaxial and abaxial side and stomatal index 8.3–16.32 and 10–21.65 on adaxial and abaxial surface, size of stomatal guard cells, and pores varied from 27–31 × 18–24 µm to 17–22 × 4–9 µm, respectively. Trichomes were absent. Palisade ratio 3–5 per epidermal cell, vein islet 4–9 per mm^2 , and vein termination numbers were 8–12 per mm^2, respectively [Figure 1d and e].

Cannabis indica Lam

Epidermal cells polygonal, 4–7 sided, iso to anisodiametric, anticlinal wall straight and thin, surface smooth, size varied from 24-50 × 19–24 µm. Crystal rosette type, medium in number, isodiametric, each cell contained a single crystal, scattered on and near veins; size varied from 13 to 20 × 6–10 µm. Leaves amphistomatous with anomocytic type, elliptic to oval in shaped, subsidiary cells indistinct, stomatal number ranged from 95–120 to 196–260 per mm^2 on the adaxial and abaxial side and stomatal index 5.6–8.75 and 27.60–39.32 on adaxial and abaxial surfaces, size of stomatal guard cells and pores varied from 20–26 × 16–20 µm to 10–15 × 1–2 µm, respectively. Two types of trichomes were found, i.e., papilose, unicellular, uniseriate, pointed apex, peltate base type of trichomes were abundant on the upper surface and uniseriate, unicellular pointed apex, peltate base trichomes were present on the lower side of leaf, trichome number ranged from 30–38 to 275-330 per mm^2 on adaxial and abaxial surface and trichome index were 1.5–3.5 and 20.27–25.67 on adaxial and abaxial surface, size of trichomes varied from 75-145 × 12–25 µm and papilose size varied from 15-20' × 12–16 µm, respectively. Palisade ratio 5–7 per epidermal cell, vein islet 21–24 per mm square, and vein termination numbers were 90–120 per mm square, respectively [Figures 1f-h and 2a].

Cephalandra indica (Wight and Arn.) Naudin

Epidermal cells polygonal, 6–8 sided, iso to anisodiametric, anticlinal wall wavy and thin, surface smooth, size varied from 25-60 × 22–32 µm.

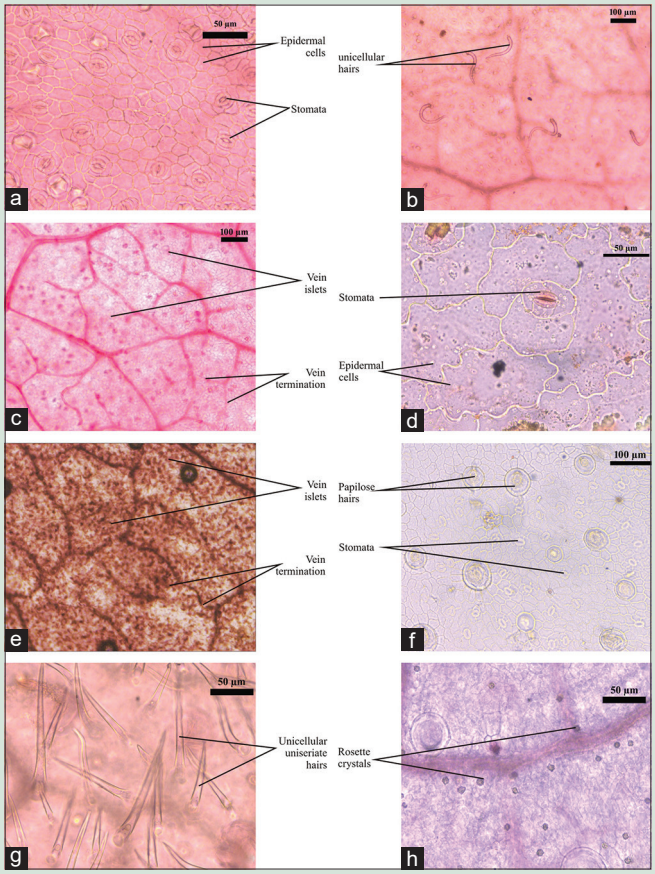

Figure 1: *Aegle marmelos* (L.) Corrêa: (a) Leaf peel showing distribution of stomata and epidermal cells on the leaf surface; (b) Leaf peel showing unicellular hairs; (c) Leaf peel showing vein islets and vein termination; *Bryophyllum calycinum* Salisb. (d) Leaf peel showing distribution of stomata and epidermal cells on the leaf surface; (e) Leaf peel showing vein islets and vein termination; *Cannabis indica* Lam.: (f) Leaf peel showing distribution of stomata and epidermal cells on the leaf surface; (g) Leaf peel showing unicellular hairs; (h) Leaf peel showing rosette crystals on surface

Crystals rosette type, sparse in number, isodiametric, scattered all over the surface, size varied from 28-50 × 25–45 µm; Leaves amphistomatous with anomocytic type, elliptic shaped, subsidiary cells indistinct, stomatal number ranged from 25–40 to 170-220 per mm^2 on the adaxial and abaxial side and stomatal index 7.69–10 and 19.29–24.13 on adaxial and abaxial surface, size of stomatal guard cells and pores varied from 22–26 × 15–19 µm to 12–15 × 2–4 µm, respectively. Pant and Banerji[20] were recorded uniseriate multicellular and capitate glandular trichomes in the leaves, but in the present study, we found both glandular and non-glandular types of trichomes were present mainly on the abaxial surface of the leaf along with the margins and the veins. Trichomes are sparse, uniseriate, multicellular, blunt apex, straight or curved, foot is embedded into the epidermal cells. Trichome number ranged from 3-8 per mm^2 on abaxial side and trichome index 2.2–4.3 on abaxial surface, size of trichomes varied from 65-180 × 20–30 µm, respectively. Palisade ratio 3–5 per epidermal cell, vein islet 8–12 per mm^2, and vein termination numbers were 10–18 per mm^2 , respectively [Figure 2b-f].

Eucalyptus globulus Labill

Epidermal cells polygonal, 4–7 sided; iso to anisodiametric, anticlinal wall straight and thick, surface smooth, size varied from 20-30 × 12–20 µm. Two types of crystals were found i.e., prismatic (cubic form) and rosette type, abundant in number, 4–8 sided in prismatic crystals, iso or anisodiametric, scattered near veins and also all over the surface, size varied from 20-23 × 10–18 µm in prismatic crystals and 18–23 × 15–21 µm in rosette. Leaves amphistomatous with anomo-cyclocytic type, oval shaped, subsidiary cells indistinct, stomatal number ranged from 20–35 to 59-80 per mm^2 on the adaxial and abaxial side and stomatal index 2.9–4 and 6.25–10 on adaxial and abaxial surface, size of stomatal guard cells and pores varied from 40–54 × 31–45 µm to 20–30 × 6–11 µm, respectively. Trichomes were absent. Palisade ratio 4–7 per epidermal cell; vein islet 14–21 per mm^2 and vein termination numbers were 16–25 per mm^2, respectively. Shah *et al.*[21] reported the cyclocytic stomata and rosette crystal, but in this study, two types of crystals are present [Figures 2g, h and 3a, b].

Gaultheria procumbens L.

Epidermal cells polygonal, 4–7 sided, iso to anisodiametric, anticlinal wall irregular and medium thickness, surface smooth, size varied from 30-61 × 26–40 µm. Crystals were not observed on the epidermal surface but present inside the leaf. Rosette form of crystals were found isodiametric in shape. Leaves hypostomatous with paracytic type,

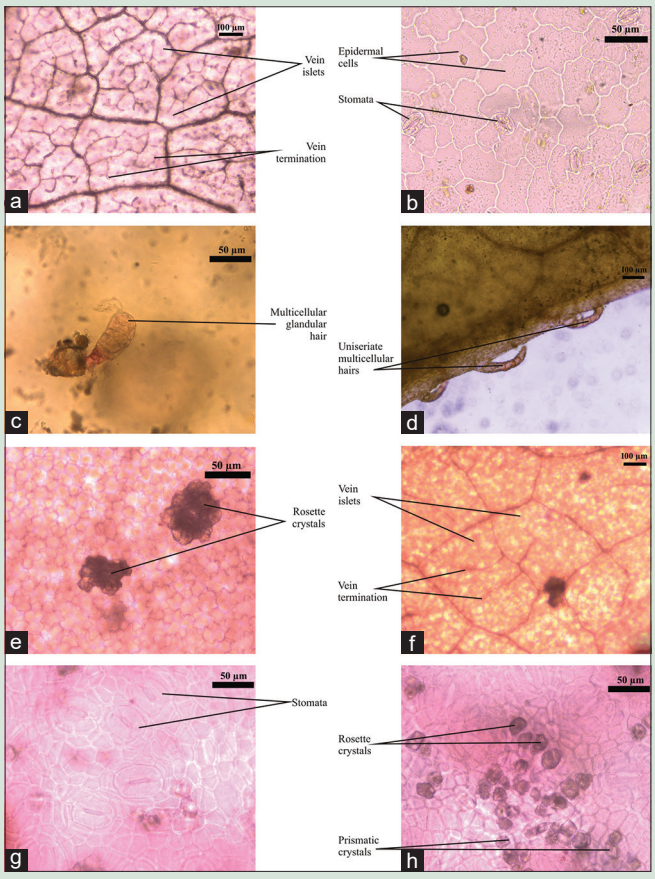

Figure 2: (a) Leaf peel of *Cannabis indica* Lam showing vein islets and vein termination; *Cephalandra indica* (Wight and Arn.) Naudin.: (b) Leaf peel showing distribution of stomata and epidermal cells on the leaf surface (c) Leaf peel showing multicellular glandular hair (d) Leaf margin showing unilocular, multicellular hairs (e) Leaf peel showing rosette crystal on leaf surface; (f) Leaf peel showing vein islets and vein termination; *Eucalyptus globulus* Labill. (g) Leaf peel showing distribution of stomata and epidermal cells on the leaf surface (h) Leaf peel showing both prismatic and rosette crystals on surface

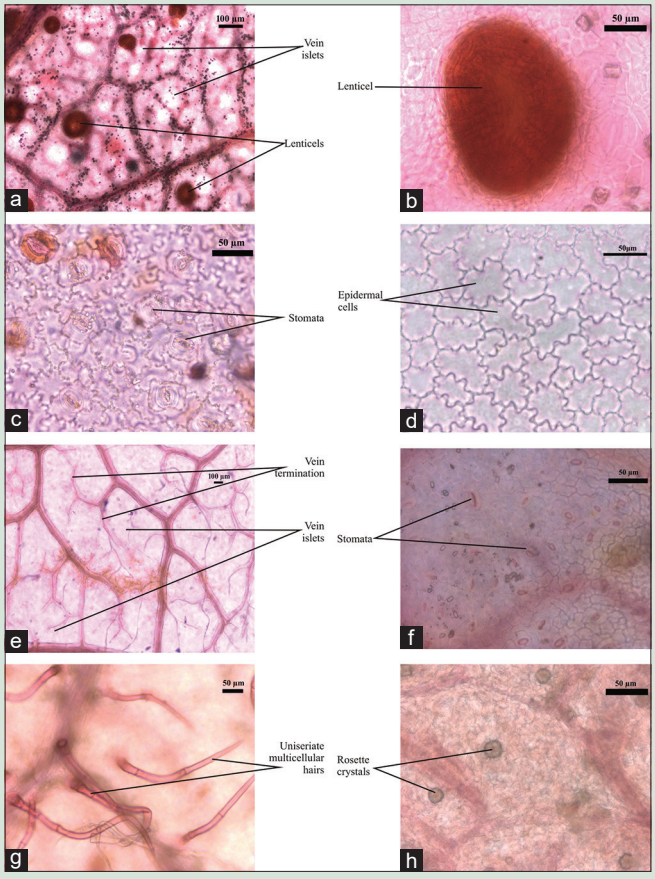

Figure 3: *Eucalyptus globulus* Labill. (a) Leaf peel showing vein islets and vein termination; (b) Leaf epidermal surface showing enlarged view of lenticels; *Gaultheria procumbens* L. (c) Leaf peel showing distribution of stomata and epidermal cells on the leaf surface; (d) Leaf peel showing epidermal cells on the leaf surface; (e) Leaf peel showing vein islets and vein termination; *Gymnema sylvestre* (Retz.) R.Br.ex Sm. (f) Leaf peel showing distribution of stomata and epidermal cells on the leaf surface; (g) Leaf peel showing unilocular, multicellular hairs; (h) Leaf peel showing rosette crystals on surface

rounded or oval shaped, subsidiary cells indistinct, stomatal number ranged from 5-106 per mm^2 on the abaxial side and stomatal index 17.35–23.80 on adaxial and abaxial surface, size of stomatal guard cells and pores varied from 24–28 × 15–20 µm to 10–13 × 6–9 µm, respectively. Trichomes were not present. Palisade ratio 4–5 per epidermal cell, vein islet 3–5 per mm^2 , and vein termination numbers were 4.5–8 per mm^2, respectively [Figure 3c-e].

Gymnema sylvestre (Retz.) R. Br. ex Sm.

Epidermal cells polygonal, 5–7 sided, iso to anisodiametric, anticlinal wall straight and thick, surface smooth, size varied from 28-40 × 17–23 µm. Rosette form of crystals were found isodiametric in shape, size varied from 20-25 × 18–22 µm. Leaves hypostomatous with anisocytic type, elliptic shaped, subsidiary cells indistinct, the stomatal number ranged from 150-186 per mm^2 on the abaxial side and stomatal index 9.31–10.53 on abaxial surface, size of stomatal guard cells and pores varied from 15–25 × 12–15 µm to 12–18 × 3–5 µm, respectively. Multicellular, uniserate, non-glandular, pointed apex, straight, peltate base trichomes present on the upper side of leaf. Trichome number ranged from 10-20 per mm^2 on adaxial side and trichome index 0.52–1.14 on adaxial surface, size of trichomes varied from 200-280 × 14–20 µm respectively. Palisade ratio 4–6 per epidermal cell, vein islet 4–8 per mm^2, and vein termination numbers were 20–28 per mm^2, respectively [Figures 3f-h and 4a].

Justicia adhatoda L.

Epidermal cells polygonal, 5–8 sided, iso to anisodiametric, anticlinal wall slightly wavy and thin, surface smooth, size varied from 30-70 × 20–40 µm. No crystals were found. Leaves amphistomatous with diacytic type, ellipic shaped, subsidiary cells slightly distinct, stomatal number ranged from 0–1 to 130-172 per mm^2 on the adaxial and abaxial side and stomatal index 0–1.05 and 11.34–17.02 on adaxial and abaxial surface, size of stomatal guard cells and pores varied from 22–30 × 20–28 µm to 12–20 × 3–4 µm, respectively. Multicellular, uniseriate, non-glandular, pointed apex, straight, and peltate base trichomes were present on both sides of leaf. Trichome number ranged from 19–24 to 45–63 on the adaxial and abaxial side and trichome index 1.88–3.01 and 4.41–7.26 per mm square on adaxial and abaxial surface, size of trichome varied from 80-230 × 15–25 µm, respectively. Palisade ratio 4.5–9 per epidermal cell, vein islet 3–6.5 per mm^2, and vein termination numbers were 10–18 per mm^2, respectively [Figure 4b-d].

Nyctanthes arbor-tristis L.

Epidermal cells polygonal, 5–8 sided, iso to anisodiametric, anticlinal wall straight and thick, surface smooth, size varied from 28-40 × 17–23 µm. No crystals were present. Leaves hypostomatous with anomocytic type, elliptic shaped, subsidiary cells indistinct, stomatal number ranged from 170-210 and stomatal index 9.9–11.76 on abaxial surface, size of stomatal guard cells, and pores varied from 22–26 × 18–21 µm to 12–21 × 2–5 µm, respectively. Mainly, four types of trichomes were present on both sides of leaf. These were unicellular uniseriate, blunt apex, straight; unicellular uniseriate, pointed apex, straight; unicellular

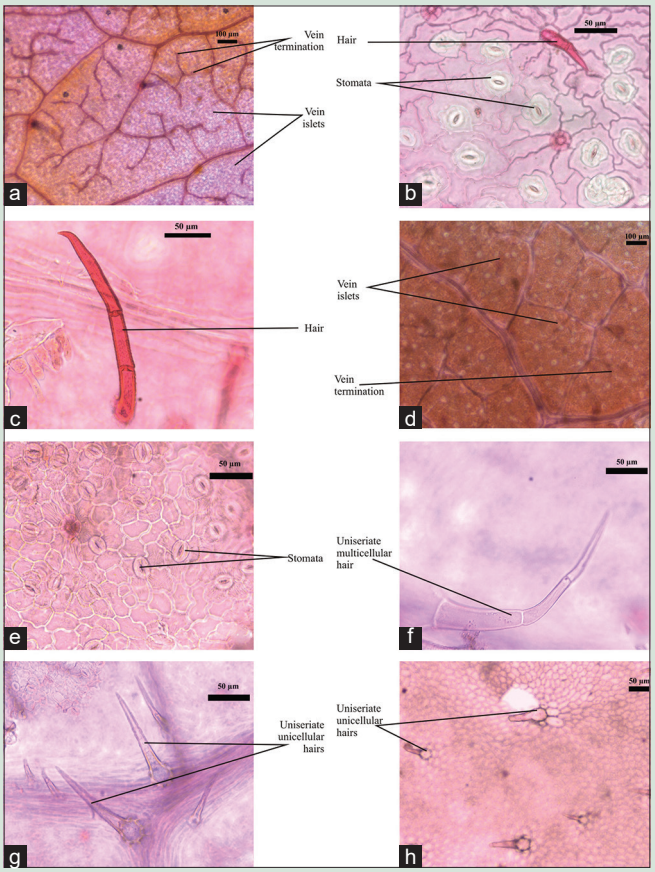

Figure 4: (a) Leaf peel of *Gymnema sylvestre* (Retz.) R.Br. ex Sm. showing vein islets and vein termination; *Justicia adhatoda* L. (b) Leaf peel showing distribution of stomata, epidermal cells and hairs (c) Leaf epidermal surface showing unilocular, multicellular hair (d) Leaf peel showing vein islets and vein termination; *Nyctanthes arbor-tristis* L. (e) Leaf peel showing stomata and epidermal cells (f) Leaf peel showing multicellular uniseriate pointed apex, curved hair (g) Leaf peel showing unicellular, uniseriate pointed apex hairs (h) Leaf peel showing unicellular, uniseriate blunt apex hairs

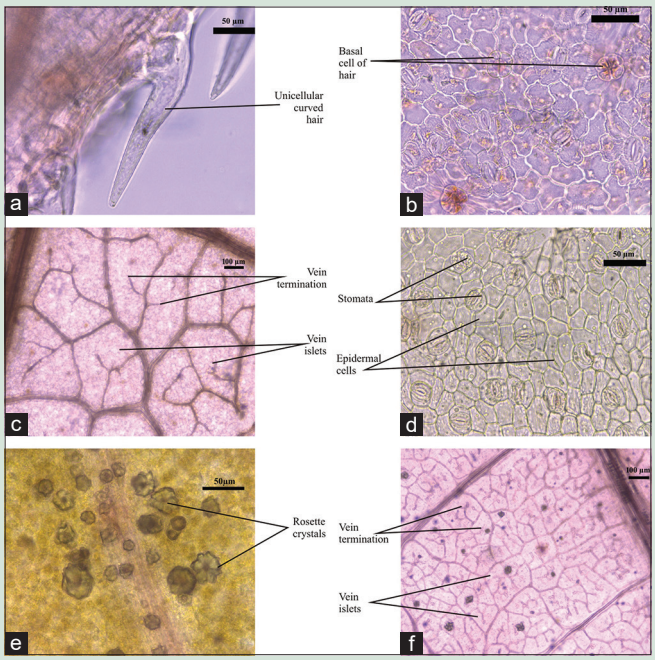

Figure 5: *Nyctanthes arbor-tristis* L. (a) Leaf peel showing unicellular, uniseriate with pointed apex, curved hairs; (b) Leaf peel showing basal cells of hairs and stomata; (c) Leaf peel showing vein islets and vein termination; *Ricinus communis* L. (d) Leaf peel showing distribution of stomata and epidermal cells on the leaf surface; (e) Leaf peel showing distribution of rosette crystals; (f) Leaf peel showing vein islets and vein termination

uniseriate, blunt apex, curved; multicellular uniseriate with pointed apex, curved; all types of trichomes have multicellular or peltate base. Trichome number ranged from 4–7 to 9-11 per mm^2 on the adaxial and abaxial side and trichome index 0.0–1.38 and 1.42–2.87 on the adaxial and abaxial surface, size of trichomes varied from 85-250 × 26–45 µm, respectively. Palisade ratio 4–7 per epidermal cell, vein islet 10–13/per mm^2, and vein termination numbers were 12.5–16 per mm^2, respectively [Figures 4e-h and 5a-c].

Ricinus communis L.

Epidermal cells polygonal, 5–7 sided, anisodiametric, anticlinal wall straight and thin, surface smooth, size varied from 24-36 × 15–21 µm. Crystal rosette type, sparse in number, isodiametric, scattered all over the surface, size varied from 12-42 × 12–33 µm. Leaves hypostomatous with anomocytic and tetracytic stomata type, oval or rounded shaped, subsidiary cells indistinct, stomatal number ranged from 138–170 to 185-200 per mm^2 on adaxial side and abaxial side and stomatal index 12.82–17.32 and 17.56–19.53 on abaxial and abaxial surface, size of guard cells and pores varied from 17–23 × 16–23 µm to 11–14 × 5–10 µm, respectively. Trichomes were not present. Palisade ratio 4–8 per epidermal cell, vein islet 17–30 per mm^2, and vein termination numbers were 97–110 per mm^2 respectively [Figure 5d- f].

The foliar epidermal studies above drugs reveal that each species have some unique characters through which we can identify the plant species. Epidermal cells shape varies from polygonal to irregular, cell wall straight to sinuous. The largest size of the epidermal cell was found in *B. calycinum* and the smallest in *A. marmelos*. The presence or absence of stomata on adaxial surface, major type of stomata found in the plant species were anomocytic, cyclocytic (*A. marmelos*), diacytic (*J. adhatoda*), tetracytic (*G. sylvestre, R. communis*). Among these plants,

Table 1: Qualitative characters of foliar epidermal of the ten medicinal plants

Medicinal plant	Surface	Epidermal cell shape	Epidermal cell wall	Stomata	Stomata type	Trichome	Type of trichome
Aegle marmelos	Adaxial	Polygonal	Straight	Present	Anisocytic, paracytic and cyclocytic	Present	Uniseriate, unicellular
	Abaxial	Polygonal	Straight	Present	Anisocytic, paracytic and cyclocytic	Present	Uniseriate, unicellular
Bryophyllum calycinum	Adaxial	Irregular	Slightly sinuous	Present	Anisocytic	Absent	-
	Abaxial	Polygonal and Irregular	Straight and Slightly sinuous	Present	Anisocytic	Absent	-
Cannabis indica	Adaxial	Polygonal	Straight	Present	Anomocytic	Present	Unicellular, pallilose like
	Abaxial	Polygonal	Straight	Present	Anomocytic	Present	Uniseriate, unicellular
Cephalandra indica	Adaxial	Irregular	Slightly sinuous	Present	Anomocytic	Absent	-
	Abaxial	Irregular	Slightly sinuous	Present	Anomocytic	Present	Uniseriate multicellular, glandular and non-glandular
Eucalyptus globules	Adaxial	Polygonal	Straight	Present	Anomocytic	Absent	-
	Abaxial	Polygonal	Straight	Present	Anomocytic	Absent	-
Gaultheria procumbens	Adaxial	Irregular	Sinuous	Absent	-	Absent	-
	Abaxial	Irregular	Sinuous	Present	Paracytic	Absent	-
Gymnema sylvestre	Adaxial	Polygonal	Straight	Absent	-	Present	Uniseriate multicellular
	Abaxial	Polygonal	Straight	Present	Anisocytic and tetracytic	Present	Uniseriate, multicellular
Justicia adhatoda	Adaxial	Irregular	Sinuous	Present	Diacytic	Present	Uniseriate, multicellular
	Abaxial	Irregular	Sinuous	Present	Diacytic	Present	Uniseriate, multicellular
Nyctanthes arbor-tristis	Adaxial	Polygonal	Straight	Absent	-	Present	Unicellular, multicellular, peltate, pointed and blunt apex
	Abaxial	Polygonal	Straight	Present	Anomocytic	Present	Uniseriate unicellular, multicellular, pointed and blunt apex
Ricinus communis	Adaxial	Polygonal	Straight	Present	Anomocytic, tetracytic	Absent	-
	Abaxial	Polygonal	Straight	Present	Anomocytic, tetracytic	Absent	-

Table 2: Quantitative characters of foliar epidermal of the ten medicinal plants

Medicinal plant	Number of stomata (1 mm^2)		Stomatal index (1 mm^2)		Palisade ratio	Vein islet (1 mm^2)	Vein termination (1 mm^2)	Number of Trichomes (1 mm^2)		Trichome index (1 mm^2)	
	Ad	Ab	Ad	Ab				Ad	Ab	Ad	Ab
Aegle marmelos	229	592.6	3.31	12.39	4	15.8	12.8	1.4	9.16	0.2	0.62
Bryophyllum calycinum	23	58.75	15.20	18.69	3.25	7.33	10.33	A	A	A	A
Cannabis indica	110.33	217.66	6.8	32.66	5.9	22	107	33.6	309.4	2.67	21.64
Cephalandra indica	33.8	198	8.96	22.20	5	8	11.6	A	4.8	A	2.7
Eucalyptus globules	29.4	71	3.27	8.02	6.2	17.67	21.04	A	A	A	A
Gaultheria procumbens	A	86.8	A	20.66	4.6	3.8	5.7	A	A	A	A
Gymnema sylvestre	A	159.6	A	9.86	5.16	6.2	22.8	14.6	A	0.64	A
Justicia adhatoda	0.8	152	0.49	13.82	7.1	4.9	13	22	53.33	2.49	5.93
Nyctanthes arbor-tristis	A	186.2	A	10.42	5.6	11.9	13.7	5.4	9.75	0.70	2.16
Ricinus communis	151.4	199	15.07	18.48	5.6	23.5	100.25	A	A	A	A

Table 3: Qualitative characters of foliar epidermal of the ten medicinal plants

Medicinal plant	Stomatal gaurd cell (µm)		Stomatal pore (µm)		Epidermal cell		Trichome (µm)		Crystal size (µm)	
	L	W	L	W	L	W	Ad	Ab	Ad	Ab
Aegle marmelos	20.6	17	11.8	4.4	20	14.2	198.2	132	11.8	8.6
Bryophyllum calycinum	24.2	19.2	19.6	5.2	170	70.5	A	A	A	A
Cannabis indica	22.5	17.8	12.6	1.4	35.83	20.83	124.4	17	15.23	12.56
Cephalandra indica	23.8	16.4	13.2	3.2	39.8	25.2	A	110.6	39.6	30
Eucalyptus globulus	46.8	40	27.2	8.6	26.2	14.4	A	A	20.5	17.7
Gaultheria procumbens	26.2	16.6	11.4	7.6	49.2	32.8	A	A	A	A
Gymnema sylvestre	20	13.6	14	3.6	28.75	20.5	220	16.75	22.5	20.8
Justicia adhatoda	25.25	24.25	17.33	3.33	47.5	30.75	162.5	19.5	A	A
Nyctanthes arbor-tristis	24.2	18.8	15	3.8	32	18.8	189.4	32.4	A	A
Ricinus communis	21.5	19.6	13.2	5	30.6	17.6	A	A	26.8	24.6

the largest stomatal guard cell found in *E. globulus* and the smallest in *G. sylvestre*. Abundance number of stomata on abaxial surface found in *A. marmelos* and scanty in *G. procumbens.* The highest stomatal index on the abaxial surface occurs in *C. indica* and the lowest number in *E. globulus*.

The presence or absence of trichomes, trichomes vary from unicellular (*A. marmelos, C. indica*) to multicellular, conical to elongated, glandular to non-glandular. Longest trichome was found in *G. sylvestre* (220 µm) and the smallest in *G. sylvestre* (16.75 µm). Abundance number of trichomes on abaxial surface found in *C. indica* and scanty in *C. indica.* The highest trichome index on the abaxial surface occurs in *C. indica* and lowest number in *A. marmelos* [Tables 1-3]. The results of the leaf epidermal features of the ten medicinal plants whose leaf part were used in homeopathy were investigated and summarized in this study. Ten species showed variation in the shape of epidermal cells, types of stomata, number of stomata, size of stomata, palisade ratio, vein-islet, and vein termination.

CONCLUSION

Medicinal plants are the key source of natural drug therapeutic; plants have been used all over the world since ancient times for the treatment and cure of disease. The world trade of herbal products is one of the major services in the global economy and the demand is rising in both developed and developing countries. However, one of the major setbacks in traditional medicine is the misidentification of species for the constituents of these herbal medicines. Therefore, authentication and identification of medicinal plants are of extremely importance for herbal medicines. Foliar epidermal evaluation may also solve the problem by differentiating the genuine material from the adulterants, substitutes and spurious drugs. Therefore, the characterization of plants with such study is an ideal approach for the identification of medicinal plant species and populations of the same species. The study of the epidermal leaf features of medicinal plant species are highly significant and taxonomically important tools in plant taxonomy; their applications in the identification and delimitation of plant species as well as in resolving taxonomic problems among critical species and genera have been recognized.

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Conflicts of interest

There are no conflicts of interest.

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