Bangladesh J. Bot. **55**(1): 31-35, 2026 (March) DOI: https://doi.org/10.3329/bjb.v55i1.88595

ANATOMICAL ADAPTATIONS OF *MONSTERA DELICIOSA* LIEBM.: A TROPICAL LIANA

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Keywords: Hypodermis, Protoxylem, Metaxylem, Epidermis, Stomata, Brachyparahexacytic

Abstract

The anatomical study of leaf of *Monstera deliciosa* Liebm. was performed commonly grown in Pakistan. The epiphytic species was collected from the trunk of *Ficus bengalensis*. The anatomical characters of the leaf were studied under the light microscope Transverse section of petiole consists of epidermis, thick cuticle, hypodermis, cortex, metaxylem, protoxylem and druses. Largest metaxylem (0.98±0.07) and protoxylem (0.75±0.07) were observed in the petiole. In mid vein upper and lower epidermis, sclerenchymatous hypodermis, metaxylem, protoxylem, phloem and needle-like crystals were observed. However, mesophyll cells, a large number of needle-like crystals, druses and vascular bundle were seen. Smallest metaxylem (0.60±0.03) and protoxylem (0.45±0.06) were observed in lamina. Anatomical features of epidermis include the brachyparahexacytic type stomata, kidney-shaped guard cells and irregular epidermal cells. Larger epidermal cells (19.36±0.80) were seen in the abaxial epidermis. So, it is concluded that this plant is adapted very well in epiphytic form and its fleshy stem help to survive in tropical areas.

Introduction

Monstera deliciosa Liebm., a member of the Araceae family, is a well-known tropical hemiepiphytic liana native to the rainforests of Central America. It is indigenous to the wet tropical forests of Guatemala and Southern Mexico and also occurs in parts of Panama and Costa Rica. The species has also been recorded in Pakistan (Khatak *et al.* 2010).

Commonly known as the breadfruit vine, fruit salad plant, Swiss-cheese plant, or split-leaf philodendron, *M. deliciosa* is widely recognized for its large, perforated leaves and distinctive climbing habit. These leaf perforations are believed to be evolutionary adaptations that help the plant cope with the shaded and humid conditions of its native tropical rainforest environment. Anatomical modifications, particularly in the leaves, play a crucial role in the optimal functioning of the plant (Liaqat *et al.* 2021).

It is a fast-growing, woody or herbaceous climbing vine that can attain a height of 20 m, with a heavy and cylindrical stem. Young plants produce small, entire leaves without lobes or holes, but as the plant matures, the leaves develop lobes or deeply cut strips along the margins. Perforations appear on each side of the midrib, ranging from oblong to elliptic in shape and varying in size. The inflorescence is elongated and erect (Kotraswamy *et al.* 2015). The plant is widely cultivated for ornamental purposes, particularly on fences and tree stumps, as well as in tropical gardens and homes.

Beyond its ornamental value, *M. deliciosa* has traditional uses in different regions. In Martinique, a root preparation is used to treat snake bites, while in Peru, the aerial roots are used as ropes. In Mexico, strong and coarse baskets are made from its aerial roots (Khan *et al.* 2020).

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The main objective of present research is to study the anatomical characteristics of leaves of *M. deliciosa* and to understand how these anatomical features have helped the adaptation of *M. deliciosa* as a climbing plant of the tropical region.

Materials and Methods

Monstera deliciosa Liebm. was collected from main campus of Government College University, Lahore, Pakistan.

For anatomical study, fine transverse sections were obtained by using sharp blade. Fine selected sections were placed in 30% alcohol for 2 min and then placed in 50% alcohol for 2 min and finally transferred in toluidine blue stain for 2 min. These sections were placed in 70% alcohol for 1 min and then put on glass slide by using camel hair brush. These sections were covered with the cover slips and observed under microscope. Different colours were appeared in sections (El-Shabasy and Al-Gifri 2019).

Results and Discussion

Transverse section of petiole showed epidermal cells, hypodermal cells, parenchyma cells, druses, xylem and phloem. Epidermal cells were observed as thin-walled cells, surrounded by a thick cuticle. Parenchymatous cortex was observed. Vascular bundles were in scattered form throughout the transverse section. Vascular bundles were collateral, xylem vessels were larger in diameter and were fewer in number as compared to phloem cells which were lesser in diameter but larger in number (Plate 1B-D). Phloem cells were lignified and unprotected by bundle sheath cells. Length of petiole parameters is presented in Table 1.

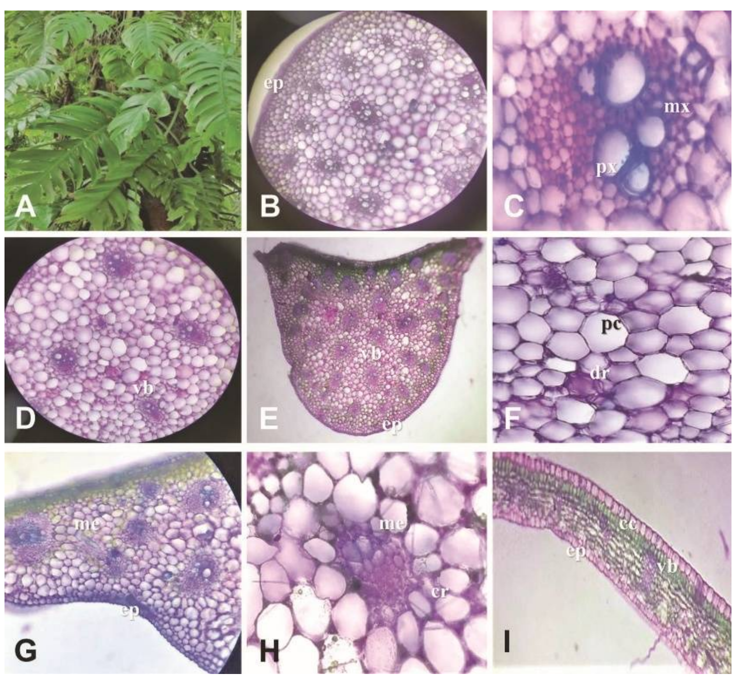

Plate 1. Anatomy of *Monstera deliciosa* Liebm. A: Leafs, B: Petiole (epidermis), C: Protoxylem, metaxylem, D: Central portion, E: Complete midrib, F: Parenchyma and druses, G: Section of leaf lamina (mesophyll cells, epidermis), H: Needle like crystals and vascular bundle and I: Epidermis, vascular bundle and collenchyma.

Transverse section of mid vein showed upper and lower epidermal cells, collenchyma cells, sclerenchyma cells, parenchymatous ground tissue, druses, xylem and phloem cells. The undulate-shaped circular mid vein was comprised of both upper and lower epidermis. Epidermis was one-celled and without cuticle. Sclerenchymatous hypodermis, collenchyma and parenchymatous ground tissue were seen below epidermis. Vascular bundles were collateral and scattered throughout the surface of section and embedded in the basic tissue 1E-F). Length, range of length, width and range of width is shown in Table 1.

Table 1. Length and width of the cells of petiole, midrib and lamina of *Monstera deliciosa* Liebm.

Parameter	Petiole (mm)		Midrib (mm)		Lamina	
	Length	Width	Length	Width	Length	Width
Cortex	1.74±0.15	1.96±0.20	0.68±1.36	1.71±0.32	0.87±0.03	1.51±0.07
Epidermis	0.52±0.07	0.60±0.07	0.60±0.07	0.90±0.07	0.94±0.1	0.79±0.06
Hypodermis	0.87±0.03	1.32±0.09	0.71±0.1	0.98±0.07	-	-
Metaxylem	0.98±0.07	1.05±0.07	0.85±0.04	1.06±0.06	0.60±0.03	0.49±0.06
Protoxylem	0.75±0.07	0.74±0.06	0.60±0.07	0.66±0.05	0.45±0.06	0.4±0.03
Phloem	0.41±0.03	0.49±0.03	0.31±0.01	0.39±0.03	0.18±0.03	0.88±0.04

Transverse section of leaf lamina showed one-celled upper and lower epidermal cells, mesophyll cells, cluster of druses, needle-like crystals of calcium oxalate, xylem and phloem cells. Epidermis is one-celled, below which is present sclerenchyma, followed by the presence of homogeneous mesophyll cells, druses in clusters. Needle-like raphide crystals were present in palisade tissue as shown in Plate 1 (G-I). Smaller number of xylem and phloem were present. Length and width is shown in Table 1.

Anatomical studies of abaxial epidermis showed stomata, subsidiary and epidermal cells as shown in Plate 2(A-C) Stomata were brachyparahexacytic. Kidney-shaped guard cells were observed which were having thickened inner and outer ledge. Thick-walled subsidiary cells were observed which were rectangular in shape. Epidermal cells were also thick walled and irregular in shape. Length and width of cells is shown in Table 2.

Anatomical studies of adaxial epidermis showed stomata, subsidiary and epidermal cells (2D-F). Characters of adaxial epidermis were almost similar to abaxial epidermis like the presence of brachyparahexacytic stomata, kidney-shaped guard cells with thickened inner and outer ledge. Thick- walled subsidiary cells were observed which were rectangular in shape. Epidermal cells were also thick-walled and irregular in shape. Length, range of length, width and range of width of cells shown in Table 2.

Anatomical studies of epiphytes have shown that these plants have specific adaptive features that help them to survive in environments with variable water and nutrient availability (Benzing 1990).

The large size of metaxylem (0.98 ± 0.07 mm) and protoxylem (0.75 ± 0.07 mm) indicates that water conduction is very important in these plants. The presence of druses and crystals indicates that these plants have a defensive mechanism against herbivores and mechanical injury. These structures also regulate calcium in plants (Lersten and Horner 2000).

Anatomical features such as the upper and lower epidermis, sclerenchymatous hypodermis, metaxylem, protoxylem, phloem, and needle-like crystals were present. The sclerenchymatous hypodermis provides mechanical rigidity to the leaves. This is important for large leaves growing in the canopy's microclimate, where wind and water flow may subject the leaves to mechanical stress. The large number of needle-like crystals and druses present in the midrib may provide mechanical support to the leaves, apart from protecting the leaves from herbivory (Bercu and Fagarus 2010, Arogundade and Adedeji 2017).

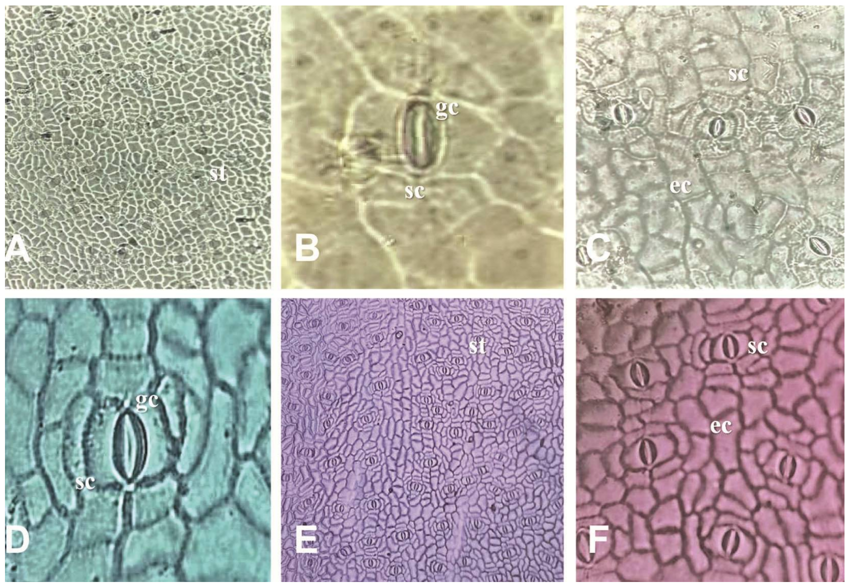

Plate 2. Anatomy of abaxial and adaxial epidermis of *Monstera deliciosa* Liebm. A: View of abaxial epidermis (10x), B: One celled view of stomata (40x), C. Epidermal cells and subsidiary cells, D: One celled view of adaxial epidermis (40x), E: 10x view, F: Epidermal cells, subsidiary cells.

Table 2. Length and width of the cells of abaxial and adaxial epidermis of *Monstera deliciosa* Liebm.

Parameter	Abaxial epidermis (mm)		Adaxial epidermis (mm)	
	Length	Width	Length	Width
Guard cell	10.89±0.52	6.35±0.52	10.28±0.30	5.7±0.30
Subsidiary cell	10.89±0.52	6.35±0.52	10.19±0.80	6.35±0.52
Epidermal cell	19.36±0.80	11.8±12.7	16.34±1.38	10.01±1.40

The anatomical features of the lamina include homogeneous mesophyll with a large number of vascular bundles, druses, and needle-like crystals. The smallest metaxylem and protoxylem, measuring 0.60 ± 0.03 and 0.45 ± 0.06 mm, respectively, were found in the lamina. The reduction in the size of the vascular bundles may be to optimize the use of resources also shown by Hanif *et al.* (2025) and Hazzazi *et al.* (2025)

Additional epidermal features such as brachyparahexacytic stomata, kidney-shaped guard cells, and irregularly shaped epidermal cells also emphasize the adaptations to epiphytic life. The larger epidermal cells on the abaxial side (19.36 ± 0.80 μm) are probably related to water storage and structural strength to withstand desiccating conditions and humidity fluctuations in epiphytic habitats (Benzing 1990, Zotz 2013).

The anatomical features of *M. deliciosa* appear to be adapted to an epiphytic life habit. The thick cuticle, sclerenchymatous hypodermis, vascular tissues, druses, and epidermal features altogether show clear adaptations to epiphytic life habits. The fleshy stem and vascular system enable the plant to survive in tropical habitats where water is available only intermittently and mechanical stress is high. The findings are in line with the general patterns seen in epiphytic Araceae, in which the anatomy of the leaves and petiole is related to ecological functions and survival in aerial habitats (Lüttge *et al.* 2011).

The presence of collateral vascular bundles in petiole and midrib, sclerenchymatous hypodermis, homogeneous mesophyll and collenchyma, brachyparahexacytic stomata, kidney-shaped guard cells, and wide abaxial epidermal cells were observed. The study revealed that cell diameter reduces gradually from petiole to lamina and abaxial epidermal cells were wider than adaxial epidermal cells. These anatomical features are important to understand the taxonomic identification of *M. deliciosa*. and its ecological adaptations as a tropical liana. The study of the anatomy of *M. deliciosa* is not only beneficial to understand its taxonomy and ecology but may also prove to be helpful in future pharmacological studies.

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(Manuscript received on 10 July, 2025; revised on 16 March, 2026)