



Anatomy of some Species in Family Cucurbitaceae from Nigeria

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Abstract

Nine genera comprising ten species of the family Cucurbitaceae were investigated using foliar anatomy to identify additional diagnostic characters of taxonomic importance. Both qualitative and quantitative data were collected, while quantitative data were analyzed using Duncan's Multiple Range Test to determine significant differences among taxa. The results revealed both similarities and differences in foliar anatomical characters. Shared features confirm the close relationship of the species within the family, whereas variations support their taxon-specific delimitation. All species exhibited actinodromous venation, polygonal to rectangular areoles, single, bifurcated or forked veinlet endings, anomocytic and brachyparacytic stomata, and glandular and non-glandular trichomes. However, the species were distinguished by epidermal cell shape, anticlinal wall pattern, stomatal type combinations, stomatal distribution, stomatal size, stomatal index, and trichome type. Irregular epidermal cells on both leaf surfaces were diagnostic for *Telfairia occidentalis* and *Trichosanthes cucumerina*. *Telfairia occidentalis* was uniquely hypostomatic, whereas all other species were amphistomatic. This hypostomatic condition may enhance water-use efficiency and resilience to climate-related stress through its influence on transpiration and gas exchange. Anomocytic and brachyparacytic stomata predominated, anisocytic stomata occurred occasionally, while tetracytic stomata were unique to *Cucumeropsis mannii*. Stomatal size also provided useful taxonomic evidence, being smallest in *Cucurbita maxima* and largest in *Trichosanthes cucumerina* on both leaf surfaces. Overall, species of Cucurbitaceae belonged to the lower (5–15%) and moderate (15–25%) stomatal index categories. The functional significance of stomatal index in relation to stomatal efficiency is also discussed. These findings demonstrate that foliar anatomical characters provide valuable evidence for species delimitation and taxonomic classification within the Cucurbitaceae.

Keywords: Taxonomic, Diagnostic, Epidermis, Stomata, Trichomes.

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Introduction

The Cucurbitaceae family include nearly 1000 species that are primarily native to tropical and subtropical regions of the world, but a small number of species are also found in temperate region (Schaefer and Renner, 2011; Guo *et al.*, 2020; Markin-Gomez *et al.*, 2024). They are largely tendril climbers and have characteristic pepo fruits (Guo *et al.*, 2020). They have large leaves, creeping or climbing stems usually with simple or branched tendrils, fleshy fruits called pepo, with

leathery exocarp, containing numerous seeds, and a woody root stock. *Cucurbit* species are among the economically most important vegetable crops worldwide (Pitrat *et al.*, 1999 and Paris, 2001).

According to Stace (1980), and Adedeji (2004), the anatomical structure of plants are useful in the taxonomic characterization of plants since they are less affected by environmental changes and therefore, highly conservative in taxa variations. Leaf anatomy has been widely used to solve taxonomic

problems in many plant families, such as Celasteraceae (Gomes *et al.*, 2005), Poaceae (Leandro *et al.*, 2016), Piperaceae (Gogosv *et al.*, 2012), Malpighiaceae (Araujo *et al.*, 2020), and Myrtaceae (Portella *et al.*, 2025), providing diagnostic characters that complement morphological data. Different anatomical aspects, such as the structure of the epidermis, presence of trichomes, types of stomata, venation patterns and arrangement of vascular bundles have contributed to the delimitation of taxa and the understanding of phylogenetic relationships (Ghimire *et al.*, 2014; Portella *et al.*, 2025). Inamdar and Gangadhara (1976, 2008) reported on the structure, ontogeny, classification and organographic distribution of trichomes and significance of stomata in some Cucurbitaceae. In year 2008, the two authors also reported on the structure, ontogeny, classification and organographic distribution of trichomes in some Cucurbitaceae.

According to Yiblet (2022), without correct identification, it may be unsafe to use some species of the family Cucurbitaceae as food or medication because they may resemble both poisonous and edible wild species. Because incidents of food poisoning in both people and domestic animals have been documented, care must be taken when gathering members of the Cucurbitaceae family for food or medicine (Yiblet, 2022). The morphological similarity of members of this family (most especially vegetatively), makes anatomical delimitation of the species of the family of great importance in the identification of taxa, hence this study. To complement the existing taxonomic evaluation of species in this family, foliar anatomical characters and venation studies of some species of plants from nine genera of the family namely; *Luffa*, *Citrullus*, *Cucurbita*, *Cucumis*, *Telfairia*, *Trichosanthes*, *Cucumeropsis*, *Lagenaria* and *Momordica* have been studied and hereby reported.

Materials and Methods

Foliar epidermal and venation studies were carried out on ten species representing nine genera in the family Cucurbitaceae. They are: *Citrullus lanatus* (Thunb.) Matsum. and Nakai (Black seeds), *Citrullus lanatus* (Thunb.)

Matsum. and Nakai (Brown seeds), *Luffa aegyptiaca* Mill. (Synonym: *Luffa cylindrica* M.Roem.), *Lagenaria siceraria* (Molina) Standl. (Spatulate fruit shape), *Lagenaria siceraria* (Molina) Standl. (Oval fruit shape), *Cucumis melo* Linn. (Black Edge Seeds), *Cucumis melo* Linn. (Brown Edge Seeds), *Cucumeropsis mannii* Naudin (Synonym: *Cucumeropsis edulis* (Hook.f.) Cogn.), *Cucumis sativus* L., *Momordica charantia* L., *Telfairia occidentalis* Hook.f., *Cucurbita maxima* Duchesne, *Trichosanthes cucumerina* L. (Synonym: *Trichosanthes anguina* L.).

Seeds of the cultivated plants were collected from a research institute, National Center for Genetic Resources and Biotechnology (NACGRAB) Moor Plantation Ibadan, Oyo State, Nigeria and Teaching and Research Farm Obafemi Awolowo University, Ile – Ife, Osun State, Nigeria while seeds of the non-cultivated ones were collected from the wild. The seeds were identified and confirmed in the IFE herbarium before planting them in the Botanical Garden of Obafemi Awolowo University Ile-Ife, Nigeria, in order to have free access to the plant species for the research work. Matured plants were further authenticated at the IFE and FRIN Herbaria.

For the venation study, sizeable portions of the matured leaves of the species and the varieties were obtained from the median part of the well expanded leaves. The portions so obtained were decolorized by boiling in 90% ethyl alcohol to remove the chlorophyll and further cleared in 2% sodium hydroxide solution. The portions were then cleared in 5% solution of domestic bleaching agent. The portions of the leaves were finally washed properly in water and stored in 50% ethanol for further studies. These were further stained in 1% aqueous solution of Safranin O and mounted on clean slides in 25% glycerol for venation studies. Venation pattern, shape of areoles and nature of veinlet endings were observed and documented. Number of veinlet endings, length and breadth of the areoles were also taken as described by Olatunji (1993).

For the foliar epidermal study, epidermal peels of both adaxial and abaxial surfaces were made by placing the desired epidermal surfaces face down and scrapping off with a

sharp blade all the tissues above the desired epidermis and intermittently irrigating with water until the required epidermis was reached as described by Cutler (1978) and modified by Adedeji (2004). The epidermal peels were then stained in 1% aqueous Safranin O for 5 - 10 mins, rinsed carefully in water to remove excess stain and mounted in dilute glycerol. Stomata size was calculated by multiplying the length and breadth of the stomata. Stomatal index was calculated as the percentage proportion of the number of stomata to the epidermal and subsidiary cells present on each leaf. The stomata index is expressed by the formula:

$$\text{S.I.} = \frac{S}{E + S} \times 100\%$$

Where, S.I. = Stomatal Index; S = number of stomata per unit area; E = number of ordinary epidermal cells plus the subsidiary cells in the same unit area.

Quantitatively, measurements were made for length and breadth of trichomes, length and breadth of stomata, length and breadth of epidermal cells and their area was calculated by multiplying the length and breadth of each character. Qualitatively, observations and descriptions of characters of the cell (cell shape, anticlinal cell wall pattern), stomata distribution, stomata shape, and trichome types were made. Photomicrographs of the characters studied were taken using ACCU-SCOPE microscope (ACCU-SCOPE Inc., Commack, NY). All microscopic measurements were made using an ocular (inserted into the eye piece of the microscope) and were multiplied by the ocular constant with respect to the microscope power under which the measurements were taken to obtain

the final micrometer values used. Quantitative data generated were subjected to one - way Analysis of Variance using Duncan Multiple Range Test to show significant differences.

Results

***Citrullus lanatus* (Brown seeds) (Thunb.) Matsum & Nakai (Figure 1A – M, Tables 1 – 6)**

Adaxial epidermal surface

Epidermal cells are polygonal in shape with straight anticlinal wall while epidermal cell size ranges between 250.00 μm^2 – 812.00 μm^2 . Leaf is amphistomatic, stomata largely circular in shape, stomata type: largely anomocytic, occasionally anisocytic and brachyparacytic, stomata size ranges between 125.00 μm^2 – 250.000 μm^2 and stomatal index on the surface ranges between 15.90% – 21.23%.

Abaxial epidermal surface

Epidermal cells largely polygonal to slightly irregular in shape with straight to wavy anticlinal wall, epidermal cell size ranges between 150.00 μm^2 - 600.00 μm^2 . Stomata amphistomatic, circular in shape, stomata type: brachyparacytic, anomocytic and rarely anisocytic. Stomata size ranges between 93.75 μm^2 - 337.50 μm^2 and stomatal index ranges between 16.92% - 27.12%.

Venation pattern

Areoles are polygonal to rectangular in shape, veinlet endings vary from 0 to 5 diverging singly, bifurcated or forked.

Trichomes

Stalked glandular and non-glandular present. Glandular trichomes are often with multicellular head, and unicellular or bicellular stalk. Non-glandular trichomes are often bicellular or multicellular uniseriate, occasionally prickle-like to unicellular.

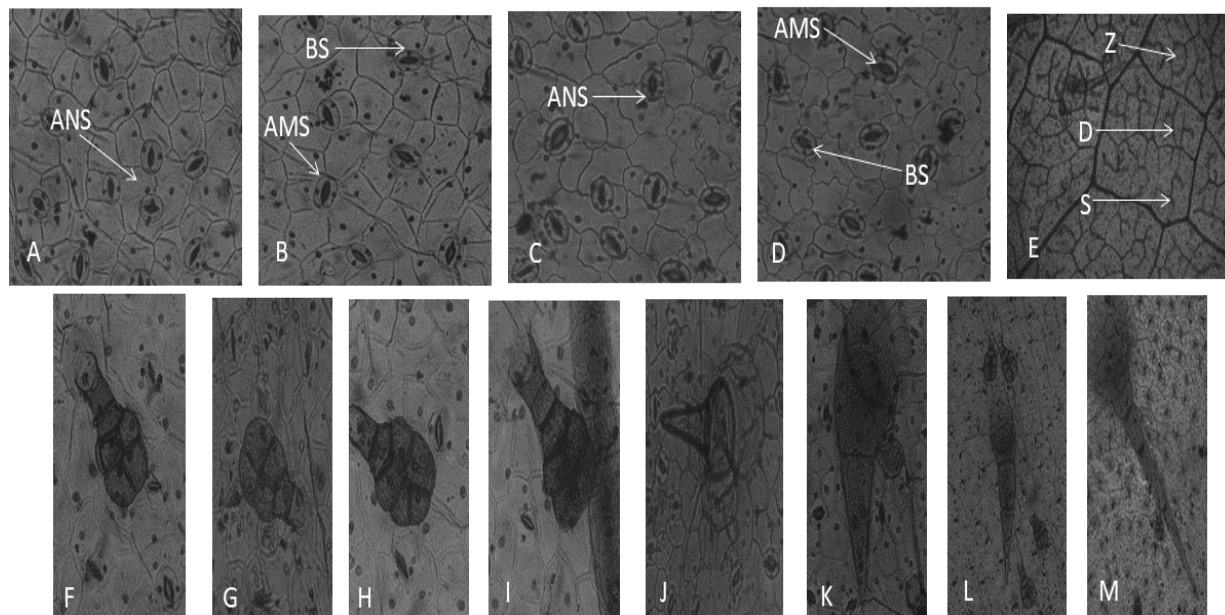


Figure 1: *Citrullus lanatus* (Brown seeds). Magnification: A – D, H -K = X400; E, L – M = X100

A – Adaxial surface showing Anisocytic stomata type, **B** – Adaxial surface showing Anomocytic and Brachyparacytic stomata type, **C** – Abaxial surface showing Anisocytic stomata type, **D** – Abaxial surface showing the Anomocytic and Brachyparacytic stomata type, **E** - Venation pattern showing veinlet endings, **F** - Glandular trichome with multicellular head and unicellular stalk on Adaxial surface, **G** – Glandular trichome with multicellular head and unicellular stalk on Abaxial surface, **H-I** – Glandular trichome with multicellular head and bicellular stalk on Abaxial surface, **J** – Non-glandular prickle-like to unicellular trichome on Adaxial surface, **K**– Non-glandular bicellular trichome on Adaxial surface, **L-M** - Non-glandular multicellular trichome on Adaxial surface. **LEGEND:** EP – Epidermal cell, BS – Brachyparacytic Stomata, AMS – Anomocytic Stomata, ANS – Anisocytic Stomata, S – Single veinlet ending, Z – Zero veinlet ending, D – Branched or forked veinlet ending.

***Citrullus lanatus* (Thunb.) Matsum and Nakai (Black seeds) (Figure2 A-H, Tables 1–6)**

Adaxial epidermal surface

Epidermal cells largely polygonal to irregular in shape with wavy to slightly undulating anticlinal wall, epidermal cell size ranges between $250.00 \mu\text{m}^2$ - $956.25 \mu\text{m}^2$. Leaf is amphistomatic, stomata elliptical to circular in shape, stomata type: brachyparacytic, anomocytic and anisocytic type, stomata size ranges between $150.00 \mu\text{m}^2$ - $300.00 \mu\text{m}^2$ and the stomatal index ranges between 8.88% - 13.65%.

Abaxial epidermal surface

Epidermal cells largely polygonal to irregular in shape with wavy to slightly undulating

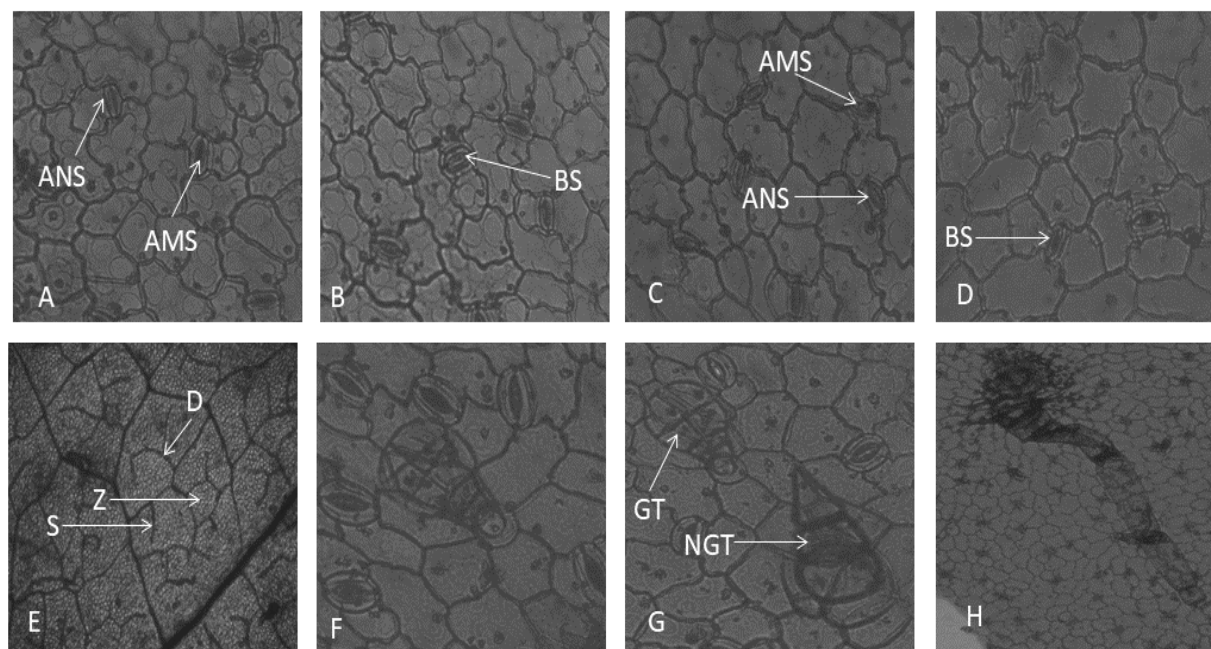
anticlinal wall, epidermal cell size ranges between $210.00 \mu\text{m}^2$ - $850.00 \mu\text{m}^2$. Stomata elliptical to circular in shape, stomata type: brachyparacytic, anomocytic and occasionally anisocytic types, stomata size ranges between $156.25 \mu\text{m}^2$ - $300.00 \mu\text{m}^2$ and stomatal index ranges between 11.59% - 19.06%.

Venation pattern

Areoles are polygonal to rectangular in shape, veinlet endings vary from 0 to 4 appearing singly, occasionally bifurcated or forked.

Trichomes

Stalked glandular and non-glandular trichomes present. Glandular trichomes are often with multicellular head, and unicellular or bicellular stalk. Non-glandular trichomes are often bicellular or multicellular uniseriate.



Magnification: A – D, F, G = X400, E and H = X100

Figure 2: *Citrullus lanatus* (Black seeds):

A – Abaxial surface showing Anisocytic and anomocytic stomata type, **B** – Abaxial surface showing Brachyparacytic stomata type, **C** – Adaxial surface showing Anomocytic and Anisocytic stomata type, **D** – Adaxial surface showing Brachyparacytic stomata type, **E**- Venation pattern showing veinlet endings, **F**- Glandular trichome with multicellular head and unicellular stalk on Adaxial surface, **G**- Glandular trichome with multicellular head and unicellular stalk and Non glandular bicellular trichome on Abaxial surface, **H**- Non glandular multicellular trichome on Adaxial surface. **LEGEND:** BS – Brachyparacytic Stomata, AMS – Anomocytic Stomata, ANS – Anisocytic Stomata, S – Single veinlet ending, Z – Zero veinlet ending, D – Branched or forked veinlet ending.

***Cucumis sativus* Linn. (Figure 3 A – I, Tables 1 – 6)**

Adaxial epidermal surface

Epidermal cells largely polygonal in shape with straight to slightly wavy anticlinal wall, epidermal cell size range between $168.75 \mu\text{m}^2$ - $937.50 \mu\text{m}^2$. Leaf is amphistomatic, Stomata elliptical to circular in shape, stomata type: brachyparacytic, anomocytic and anisocytic type, stomata size ranges between $93.75 \mu\text{m}^2$ – $262.50 \mu\text{m}^2$ and stomatal index ranges between 5.38% - 16.09%.

Abaxial epidermal surface

Epidermal cells largely polygonal to slightly irregular in shape with wavy to undulating to slightly sinuous anticlinal walls, epidermal cell

size ranges between $62.50 \mu\text{m}^2$ - $375.00 \mu\text{m}^2$. Stomata elliptical to circular in shape, stomata type: brachyparacytic, anomocytic and occasionally anisocytic. Stomata size ranges between $75.00 \mu\text{m}^2$ - $281.25 \mu\text{m}^2$ and the stomatal index ranges between 20.00% - 25.69%.

Venation pattern

Major veins actinodromous. Areoles polygonal to rectangular in shape, veinlet endings vary from 0 to 2 appearing singly.

Trichomes

Stalked glandular and non-glandular trichomes present. Glandular trichomes are often with multicellular head and unicellular stalk while non-glandular trichomes are often multicellular uniseriate, occasionally bicellular.

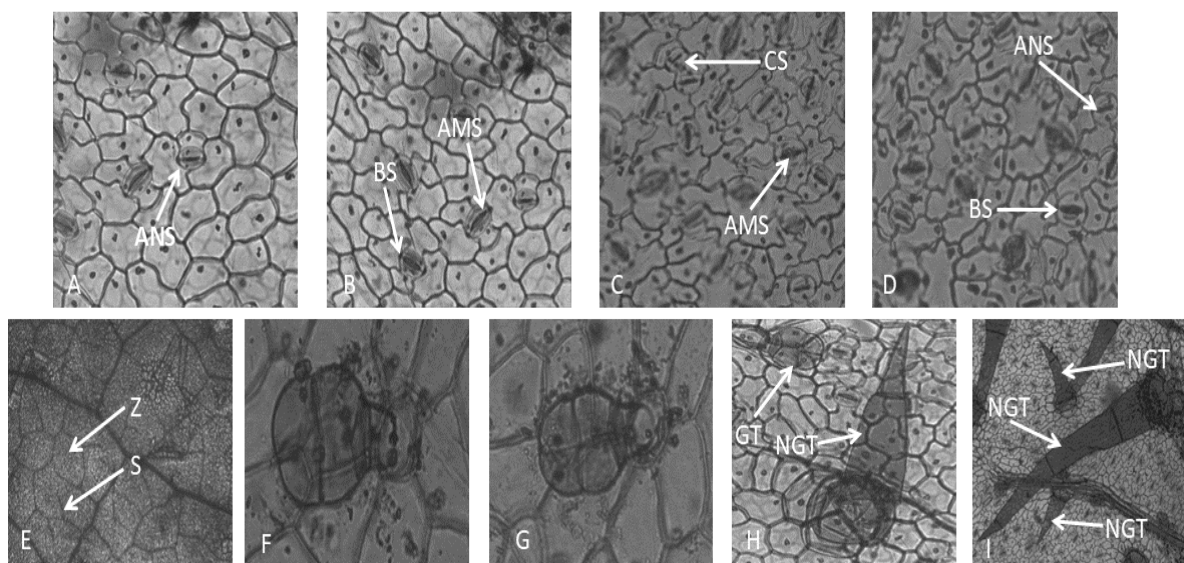


Figure 3: *Cucumis sativus*: Magnification: A –D, F-H, = X400; E and I = X100

A – Adaxial surface showing Anisocytic stomata type, **B** – Adaxial surface showing Anomocytic and Brachyparacytic stomata types, **C** – Abaxial surface showing Anomocytic and Contiguous stomata, **D** – Abaxial surface showing Anisocytic stomata, **E** – Venation pattern showing veinlet endings, **F** – **G** - Glandular trichomes with multicellular head and unicellular stalk on the Adaxial surface, **H** – Non-glandular bicellular trichome on adaxial surface, **I** – Non-glandular multicellular trichomes on Abaxial surface. **LEGEND:** EP – Epidermal cell, BS – Brachyparacytic Stomata, AMS – Anomocytic Stomata, ANS – Anisocytic Stomata, CS – Contiguous stomata, Z – Zero veinlet ending and S – Single veinlet ending.

***Cucumeropsis mannii* Naudin. (Synonym: *Cucumeropsis edulis* (Hooker.f) Cogn.) (Figure 4 A – K, Tables 1 – 6)**

Adaxial epidermal surface

Epidermal cells polygonal to irregular in shape with wavy to undulating anticlinal wall, epidermal cell size ranges between $312.50 \mu\text{m}^2$ - $975.00 \mu\text{m}^2$. Leaf is amphistomatic. Stomata elliptical to circular in shape, stomata shape; brachyparacytic, anisocytic, anomocytic and tetracytic, stomata size ranges between $175.00 \mu\text{m}^2$ - $337.50 \mu\text{m}^2$ and stomatal index ranges between 9.06% - 21.00%. Contiguous stomata are present.

Abaxial epidermal surface

Epidermal cells irregular in shape with sinuous anticlinal walls, epidermal cell size ranges between $150.00 \mu\text{m}^2$ - $812.50 \mu\text{m}^2$. Stomata

elliptical in shape, stomata type; mostly anomocytic, occasionally brachyparacytic and tetracytic, stomata size ranges between $87.50 \mu\text{m}^2$ - $281.25 \mu\text{m}^2$ and stomatal index ranges between 12.45% - 25.19%.

Venation pattern

Major veins actinodromous. Areoles polygonal to rectangular in shape, veinlet endings vary from 0 to 3 diverging singly, bifurcated or forked.

Trichomes

Stalked glandular and non-glandular trichomes present. Glandular trichomes are often with multicellular head and unicellular and bicellular stalk. Non-glandular trichomes are often bicellular, tricellular and multicellular uniseriate.

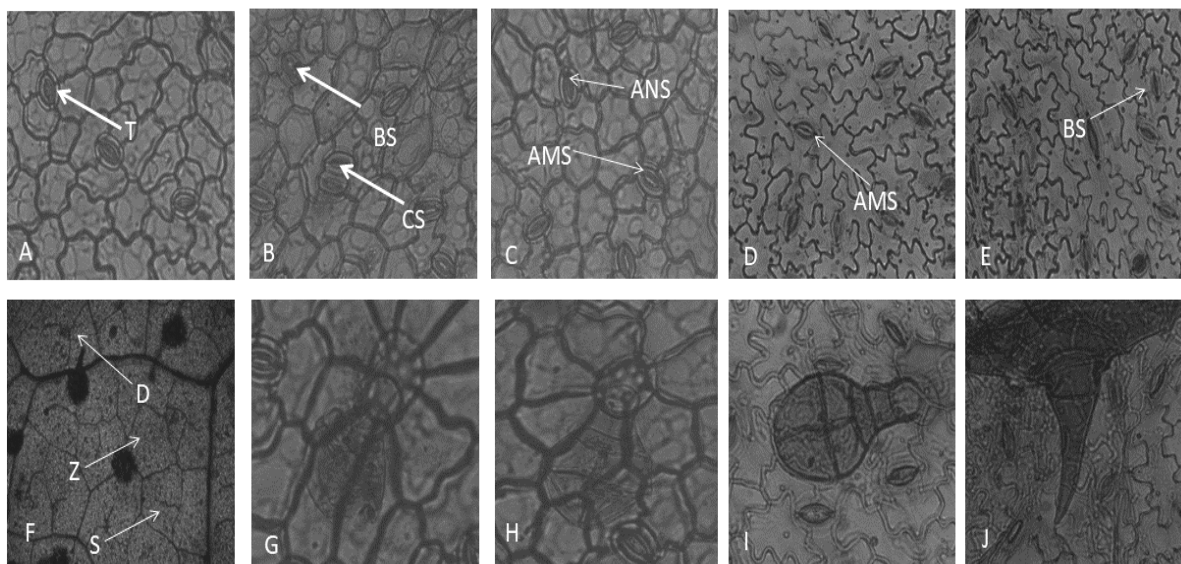


Figure 4: *Cucumeropsis mannii*. Magnification: A – E, G- K = X400, F = X100

A – Adaxial surface showing Tetracytic stomata type, **B** – Adaxial surface showing Contiguous stomata and Brachyparacytic stomata, **C** – Adaxial surface showing Anisocytic and Anomocytic stomata type, **D** – Abaxial surface showing Anomocytic stomata type, **E** – Abaxial surface showing brachyparacytic stomata type, **F** -Venation pattern showing veinlet endings, **G-I** glandular trichomes, **J**- Non-glandular trichomes. **LEGEND:** T – Tetracytic stomata, S – Single veinlet ending, Z – Zero veinlet ending, D – Branched or divided veinlet ending.

***Cucumis melo* Linn. (Black Edges Seeds)**
(Figure 5 A – J, Tables 1 – 6)

Adaxial epidermal surface

Epidermal cells polygonal in shape with straight anticlinal wall, epidermal cell size ranges between $250.00 \mu\text{m}^2$ - $1250.00 \mu\text{m}^2$. Leaf is amphistomatic. Stomata elliptical to circular in shape, stomata shape: brachyparacytic, anomocytic and anisocytic present, stomata size ranges between $156.25 \mu\text{m}^2$ - $300.00 \mu\text{m}^2$ and stomatal index ranges between 12.00% – 14.29%.

Abaxial epidermal surface

Epidermal cells largely polygonal to irregular in shape with wavy to slightly undulating anticlinal wall, epidermal cell size ranges between $175 \mu\text{m}^2$ - $700.00 \mu\text{m}^2$. Stomata largely

circular in shape occasionally elliptical, stomata type: brachyparacytic, anomocytic, anisocytic, stomata size ranges between $125.00 \mu\text{m}^2$ - $262.50 \mu\text{m}^2$ and stomatal index ranges between 17.09% - 23.29%.

Venation pattern

Major veins actinodromous. Areoles polygonal to rectangular in shape, veinlet endings vary from 0 to 4 appearing singly, bifurcated or forked.

Trichomes

Stalked glandular and non-glandular trichomes present. Glandular trichomes are often with multicellular head, unicellular to bicellular stalk while non-glandular trichomes are often multicellular uniseriate, occasionally prickly-like and unicellular.

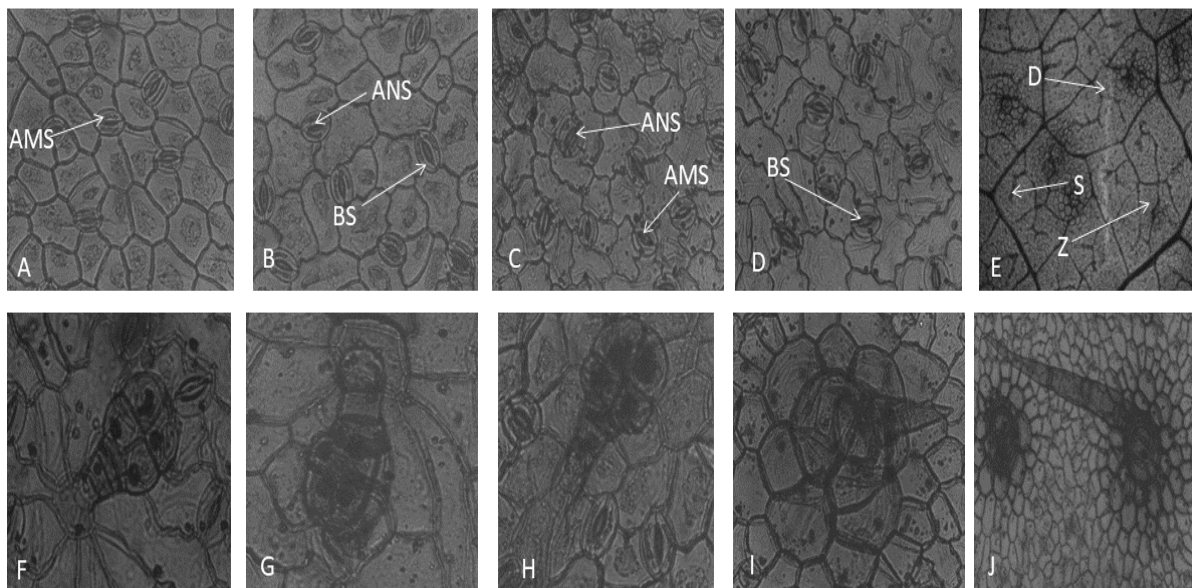


Figure 5: *Cucumis melo* Linn. (Seeds with Black edges): Magnification: A – D, F – I = X400; E and J = X100

A – Adaxial surface showing Anomocytic stomata type, **B** – Adaxial surface showing Anisocytic and Brachyparacytic stomata type, **C** – Abaxial surface showing Anomocytic and Anisocytic stomata type, **D** – Abaxial surface showing Brachyparacytic stomata type, **E** -Venation pattern showing veinlet endings, **F-H** glandular trichomes, **I-J** non-glandular trichomes. **LEGEND:** BS – Brachyparacytic Stomata, AMS – Anomocytic Stomata, ANS – Anisocytic stomata, S – Single veinlet ending, Z – Zero veinlet ending, D – Branched or divided veinlet ending.

***Cucumis melo* Linn. (Brown Edges Seeds) (Figure 6 A– J, Tables 1 – 6)**

Adaxial epidermal surface

Epidermal cells polygonal in shape with straight anticlinal wall, epidermal cell size ranges between $393.75\mu\text{m}^2$ - $1662.50\mu\text{m}^2$. Leaf is amphistomatic. Stomata circular to elliptical in shape, stomata type: brachyparacytic, anomocytic and anisocytic present, stomata size ranges between $125.00\mu\text{m}^2$ – $300.00\mu\text{m}^2$ and stomatal index ranges between 10.01% – 19.19%.

Abaxial epidermal surface

Epidermal cells largely polygonal to irregular in shape with wavy to slightly undulating anticlinal wall, epidermal cell size ranges between $230\mu\text{m}^2$ - $750.00\mu\text{m}^2$. Stomata largely

circular to elliptical in shape occasionally elliptical, stomata type: brachyparacytic, anomocytic, anisocytic, stomata size ranges between $125.00\mu\text{m}^2$ - $350.00\mu\text{m}^2$ and stomatal index ranges between 12.98% - 27.53%.

Venation pattern

Major veins actinodromous. Areoles polygonal to rectangular in shape, veinlet endings vary from 0 to 3 appearing singly, bifurcated or forked.

Trichomes

Stalked glandular and non-glandular trichomes present. Glandular trichomes are often with multi cellular head, and unicellular or bicellular stalk. Non-glandular trichomes are prickly-like, to unicellular, to bicellular and multicellular uniseriate.

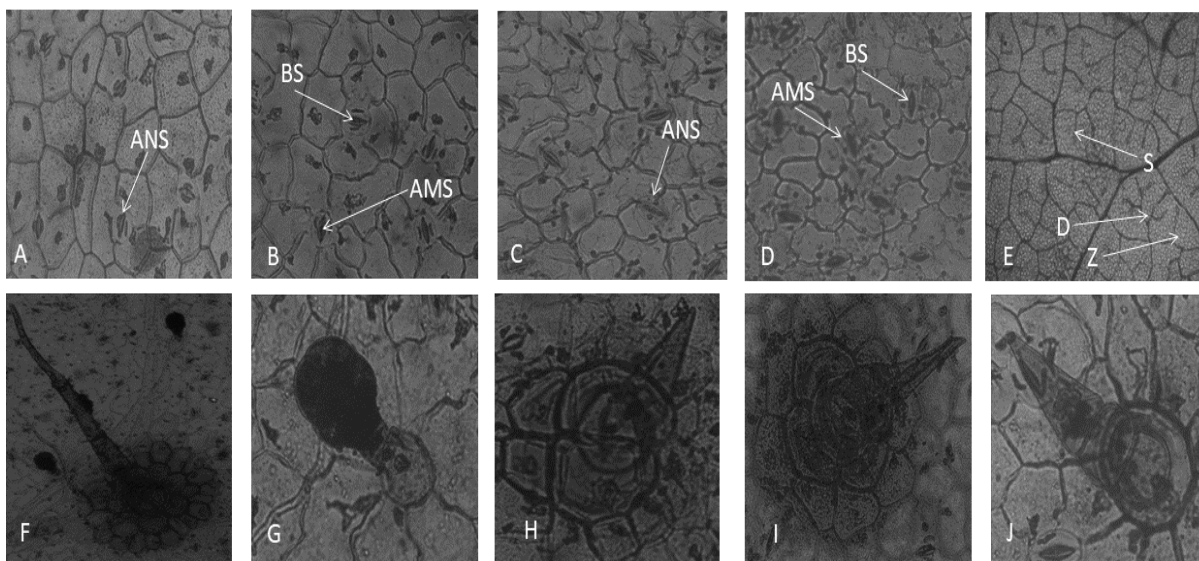


Figure 6: *Cucumis melo* Linn. (Seeds with Brown edges). Magnification: A – D, G – J = X400; E and F = X100

A – Adaxial surface showing Anisocytic stomata type, **B** – Adaxial surface showing Anomocytic and Brachyparacytic stomata types, **C** – Abaxial surface showing Anisocytic stomata type, **D** – Abaxial surface showing Anomocytic and brachyparacytic stomata types, **E** - Venation pattern, **G** – Glandular trichome, **F, H–J** non-glandular trichomes. **LEGEND:** BS – Brachyparacytic Stomata, AMS – Anomocytic Stomata, ANS – Anisocytic stomata, S – Single veinlet ending, Z – Zero veinlet ending, D – Branched or divided veinlet endings.

***Cucurbita maxima* Duch.ex Lam. (Figure 7 A - G, Tables 1 – 6)**

Adaxial epidermal surface

Epidermal cells polygonal to slightly irregular in shape with straight to wavy to slightly undulating anticlinal wall, epidermal cell size ranges between $131.25 \mu\text{m}^2$ – $487.50 \mu\text{m}^2$. Leaf amphistomatic. Stomata shape elliptical to circular, stomata type: brachyparacytic, anomocytic and anisocytic, stomata size ranges between $93.75 \mu\text{m}^2$ - $187.50 \mu\text{m}^2$ and stomatal index ranges between 11.58% - 20.32%.

Abaxial epidermal surface

Epidermal cells polygonal to irregular in shape with wavy to undulating anticlinal wall, epidermal cell size ranges between $100.00 \mu\text{m}^2$ - $412.50 \mu\text{m}^2$. Stomata elliptical to circular in

shape, stomata type: occasionally brachyparacytic, largely anomocytic, stomata size ranges between $93.75 \mu\text{m}^2$ - $218.75 \mu\text{m}^2$ and stomatal index ranges between 12.29% - 23.27%.

Venation pattern

Major veins actinodromous. Areoles polygonal to rectangular in shape veinlet endings vary from 0 to 6 diverging singly, bifurcated or forked.

Trichomes

Stalked glandular and non-glandular trichomes present. Glandular trichomes are often with multicellular head, and unicellular to bicellular stalk while non-glandular trichomes are often multicellular uniseriate, occasionally unicellular.

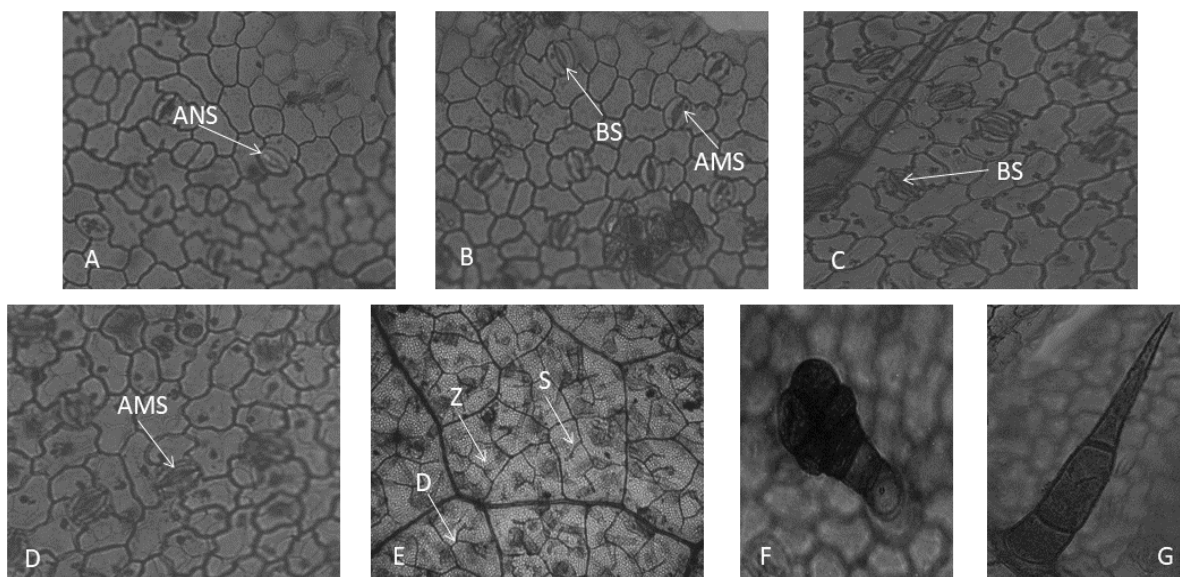


Figure 7: *Cucurbita maxima*. Magnification: A – D, F-G = X400, E = X100

A – Adaxial surface showing Anisocytic stomata type, **B** – Adaxial surface showing Brachyparacytic and Anomocytic stomata type, **C** – Abaxial surface showing Brachyparacytic stomata type, **D** – Abaxial surface showing Anomocytic stomata type, **E** - Venation pattern, **F**– Glandular trichome with multicellular head and unicellular stalk on Adaxial surface, **G** – Non-glandular multicellular trichome on Abaxial surface. **LEGEND:** AMS – Anomocytic Stomata, ANS – Anisocytic Stomata, BS – Brachyparacytic Stomata, S – Single veinlet ending, Z – Zero veinlet ending, D – Branched or divided veinlet ending.

***Lagenaria siceraria* (Molina) Standl. (Spatulate fruit shape) (Figure 8 – J, Tables 1 – 6)**

Adaxial epidermal surface

Epidermal cells polygonal in shape with straight anticlinal wall, epidermal cell size ranges between $312.50 \mu\text{m}^2$ - $1012.50 \mu\text{m}^2$. Leaf is amphistomatic. Stomata elliptical in shape, stomata type: brachyparacytic, anomocytic and anisocytic, stomata size ranges between $150.00 \mu\text{m}^2$ - $375.00 \mu\text{m}^2$ and stomatal index ranges between 5.83% - 13.37%.

Abaxial epidermal surface

Epidermal cells irregular in shape with sinuous anticlinal wall, epidermal cell size ranges between $218.75 \mu\text{m}^2$ - $656.25 \mu\text{m}^2$. Stomata elliptical in shape, stomata type occasionally

brachyparacytic and largely anomocytic, stomata size ranges between $150.00 \mu\text{m}^2$ - $393.75 \mu\text{m}^2$ and stomatal index ranges between 13.40% - 19.20%.

Venation pattern

Major veins actinodromous. Areoles polygonal to rectangular in shape, veinlet endings vary from 0 to 5 appearing singly, bifurcated or forked.

Trichomes

Stalked glandular and non-glandular trichomes present. Glandular trichomes are often with unicellular, bicellular and multicellular head and unicellular or bicellular stalk. Non-glandular trichomes are often bicellular to multicellular uniseriate.

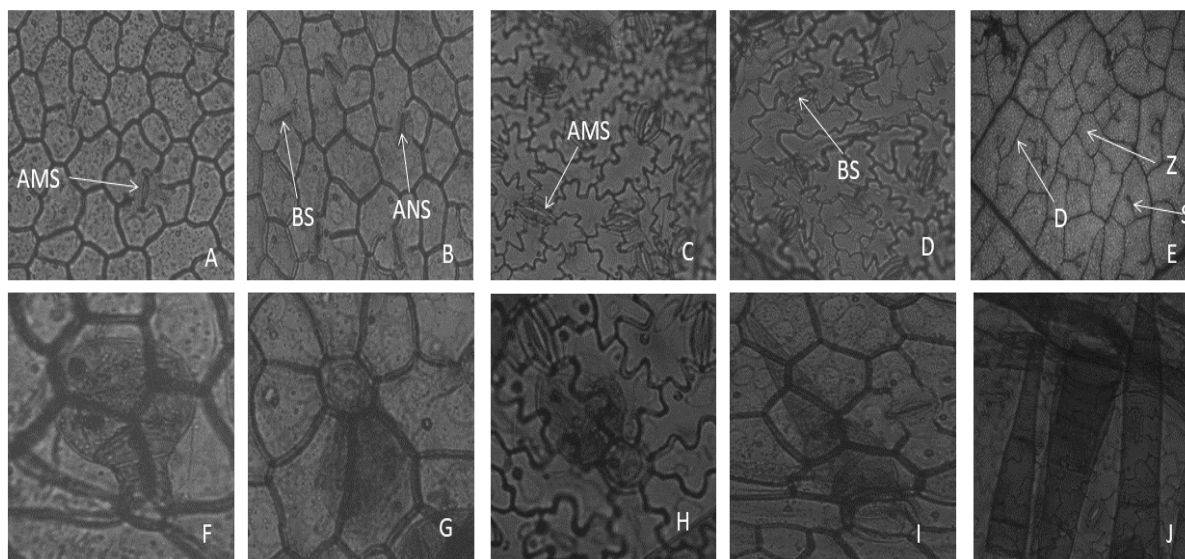


Figure 8: *Lagenaria siceraria* (Molina) Standl. (Spatulate fruit shape). Magnification: A – D, F-J = X400; E = X100

A – Adaxial surface showing Anomocytic stomata type, **B** – Adaxial surface showing Anisocytic and Brachyparacytic stomata type, **C** – Abaxial surface showing Anomocytic stomata type, **D** – Abaxial surface showing Brachyparacytic stomata, **E** – Venation pattern showing veinlet endings, **F** – Glandular trichome with bicellular head and bicellular stalk on Adaxial surface, **G** – Faint Glandular trichome with unicellular head and unicellular stalk on Adaxial surface (trichome base with surrounding cells boldly conspicuous), **H** – Glandular trichome with unicellular head and unicellular stalk on Abaxial surface (trichome base with surrounding cells boldly conspicuous), **I** – Non-glandular multicellular trichome on Adaxial surface, **J** – Non-glandular multicellular trichomes on Abaxial surface. **LEGEND:** BS – Brachyparacytic Stomata, AMS – Anomocytic Stomata, ANS – Anisocytic Stomata, S – Single veinlet ending, Z – Zero veinlet ending, D – Branched or divided veinlet ending.

***Lagenaria siceraria* (Molina) Standl. (Oval fruit shape) (Figure 9 A – J, Tables 1 – 6)**

Adaxial epidermal surface

Epidermal cells polygonal in shape with straight anticlinal wall, epidermal cell size ranges between $200.00 \mu\text{m}^2$ – $1187.50 \mu\text{m}^2$. Leaf is amphistomatic. Stomata elliptical to circular in shape, stomata type: brachyparacytic, anomocytic and anisocytic, stomata size ranges between $218.75 \mu\text{m}^2$ – $393.75 \mu\text{m}^2$ and stomatal index ranges between 8.69% – 18.00%.

Abaxial epidermal surface

Epidermal cells polygonal to irregular in shape with wavy to undulating anticlinal wall, epidermal cell size ranges between $168.75 \mu\text{m}^2$ – $750.00 \mu\text{m}^2$. Stomata elliptical to occasionally

circular in shape, stomata type: occasionally brachyparacytic, largely anomocytic, stomata size ranges between $150.00 \mu\text{m}^2$ – $350.00 \mu\text{m}^2$ and stomatal index ranges between 13.94% – 20.72%.

Venation pattern

Major veins actinodromous perfect marginal basal. Areoles polygonal to rectangular in shape, veinlet endings vary from 0 to 5 appearing singly, bifurcated or forked.

Trichomes

Stalked glandular and non-glandular trichomes present. Glandular trichomes are often with largely multicellular head and largely unicellular stalk. Non-glandular trichomes are often bicellular to multicellular uniseriate.

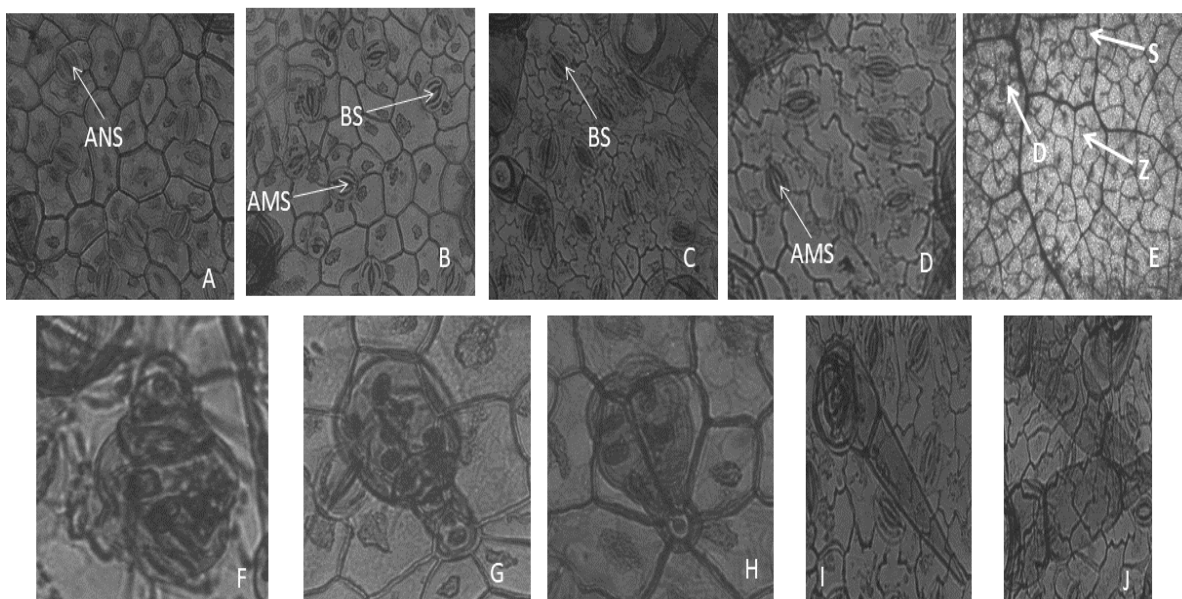


Figure 9: *Lagenaria siceraria* (Molina) Standl. (Oval fruit shape). Magnification: A – D, F – J = X400; E = X100

A – Adaxial surface showing anisocytic stomata type, **B** – Adaxial surface showing Brachyparacytic and Anomocytic stomata type, **C** – Abaxial surface showing Brachyparacytic stomata type, **D** – Abaxial surface showing Anomocytic stomata type, **E** -Venation pattern showing veinlet endings **F** – Glandular trichome with unicellular head and unicellular stalk on Abaxial surface, **G** – **H** – Glandular trichome with multicellular head and unicellular stalk on Adaxial surface, **I** – Non-glandular bicellular trichome on Abaxial surface, **J** – Non-glandular multicellular trichome on Abaxial surface. **LEGEND:** BS – Brachyparacytic stomata, AMS – Anomocytic Stomata, ANS – Anisocytic Stomata, S – Single veinlet ending, Z – Zero veinlet ending, D – Branched or divided veinlet endings.

***Luffa aegyptiaca* Mill. (Synonym: *Luffa cylindrica* M. (Roem). (Figure 10 A - I, Tables 1 – 6)**

Adaxial epidermal surface

Epidermal cells polygonal in shape with straight anticlinal wall, epidermal cell size ranges between $200.00 \mu\text{m}^2$ – $900.00 \mu\text{m}^2$. Leaf is amphistomatic. Stomata elliptical to circular in shape, stomata type: brachyparacytic, anomocytic and anisocytic, stomata size ranges between $112.50 \mu\text{m}^2$ - $218.75 \mu\text{m}^2$ and stomatal index ranges between 4.40% - 9.35%.

Abaxial epidermal surface

Epidermal cells polygonal to irregular in shape with wavy to undulating anticlinal wall, epidermal cell size ranges between $156.25 \mu\text{m}^2$

- $812.50 \mu\text{m}^2$. Stomata elliptical in shape, stomata type: brachyparacytic and anomocytic. Stomata size ranges between $125.00 \mu\text{m}^2$ - $337.00 \mu\text{m}^2$ and stomatal index ranges between 15.61% - 20.59%.

Venation pattern

Major veins actinodromous. Areoles polygonal to rectangular in shape, veinlet endings vary from 0 to 4 appearing singly, bifurcated or forked.

Trichomes

Stalked glandular and non-glandular trichomes present. Glandular trichomes are often with unicellular or multicellular head and unicellular stalk. Non-glandular trichomes are prickly-like, unicellular, and multicellular uniseriate.

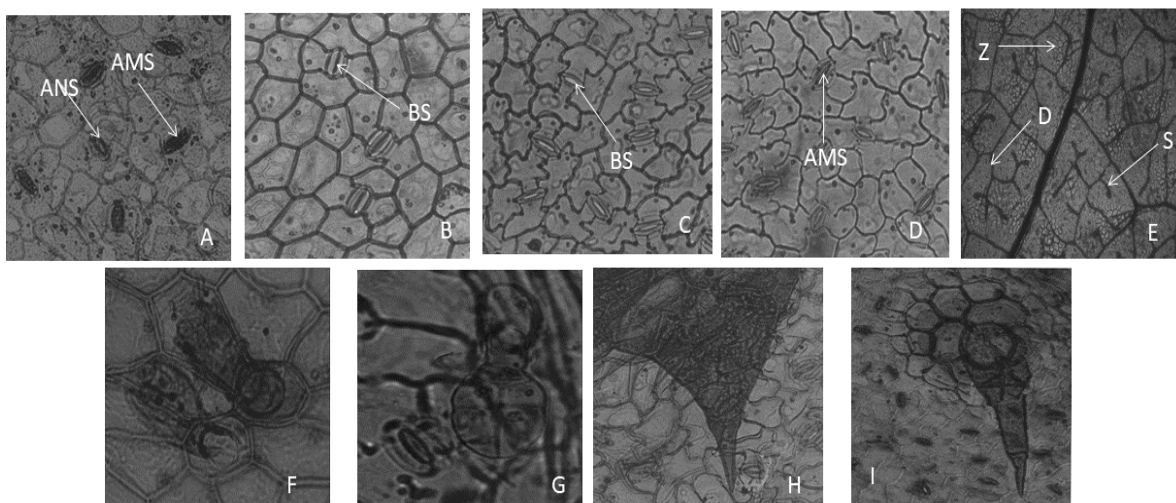


Figure 10: *Luffa aegyptiaca*. Magnification: A – D, F- I = X400; E = X100

A – Adaxial surface showing Anisocytic and Anomocytic stomata types, **B** – Adaxial surface showing Brachyparacytic stomata type, **C** – Abaxial surface showing brachyparacytic stomata type, **D** – Abaxial surface showing Anomocytic stomata type, **E** – Venation pattern showing veinlet endings, **F** – Glandular trichome with unicellular head and unicellular stalk on Adaxial surface, **G** – Glandular trichome with multicellular head and unicellular stalk on Abaxial surface, **H** – Non-glandular prickly-like unicellular trichome on Abaxial surface, **I** – Non-glandular unicellular trichome on Abaxial surface, **J** – Non-glandular multicellular trichome on Abaxial surface. **LEGEND:** BS – Brachyparacytic Stomata, AMS – Anomocytic Stomata, ANS – Anisocytic Stomata, S – Single veinlet ending, Z – Zero veinlet ending, D – Branched or divided veinlet ending.

***Momordica charantia* Linn. (Figure 11 A - H, Tables 1 – 6)**

Adaxial epidermal surface

Epidermal cells polygonal in shape with straight anticlinal wall, epidermal cell size ranges between $262.50 \mu\text{m}^2$ - $1068.75 \mu\text{m}^2$. Leaf is amphistomatic. Stomata elliptical to circular in shape, stomata type: brachyparacytic and anomocytic, stomata size ranges between $93.75 \mu\text{m}^2$ - $262.50 \mu\text{m}^2$ and stomata index ranges between 0.31% - 3.63%.

Abaxial epidermal surface

Epidermal cells largely irregular in shape with undulating to sinuous anticlinal wall, epidermal cell size ranges between $175.00 \mu\text{m}^2$ - $412.50 \mu\text{m}^2$. Stomata elliptical in shape, stomata type:

Occasionally brachyparacytic and largely anomocytic, stomata size ranges between $93.75 \mu\text{m}^2$ - $300.00 \mu\text{m}^2$ and stomata index ranges between 14.50% - 21.07%.

Venation pattern

Major veins actinodromous. Areoles polygonal to rectangular in shape, veinlet endings vary from 0 to 3, appearing singly, occasionally bifurcated or forked.

Trichomes

Stalked glandular and non-glandular trichomes present. Glandular trichomes are often with unicellular to multicellular head and bicellular stalk. Non-glandular trichomes are often multicellular uniseriate.

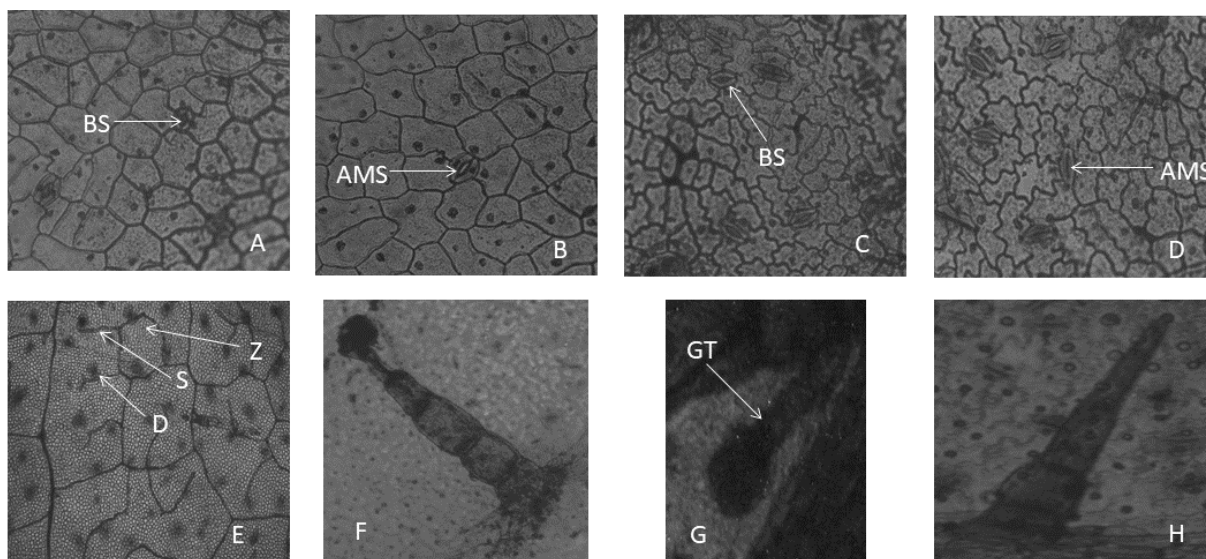


Figure 11: *Momordica charantia*. Magnification: A – D, H = X400; E – F = X100

A – Adaxial surface showing Brachyparacytic stomata type, **B** – Adaxial surface showing Anomocytic stomata type, **C** – Abaxial surface showing Brachyparacytic stomata type, **D** – Abaxial surface showing Anomocytic stomata type, **E** - Venation pattern showing veinlet endings, **F** – Non-glandular multicellular trichome on Adaxial surface, **G** – Glandular trichome with unicellular head and bicellular stalk on Abaxial surface, **H** – Non-glandular multicellular trichome on abaxial surface. **LEGEND:** BS – Brachyparacytic Stomata, AMS – Anomocytic Stomata, GT – Glandular trichome, S – Single veinlet ending, Z – Zero veinlet ending, D – Branched or divided veinlet ending.

***Telfairia occidentalis* (Hook.f) (Figure 12 A - I, Tables 1 – 6)**

Adaxial epidermal surface

Epidermal cells irregular in shape with sinuous anticlinal wall, epidermal cell size ranges between 300.00 μm^2 - 900.00 μm^2 . Leaf is hypostomatic. Stomata absent on the adaxial surface.

Abaxial epidermal surface

Epidermal cells irregular in shape with sinuous anticlinal wall, epidermal cell size ranges between 168.75 μm^2 - 862.50 μm^2 . Stomata largely elliptical in shape, stomata type: occasionally anisocytic, brachyparacytic and largely anomocytic, presence of contiguous stomata. Stomata present on abaxial surface

only, stomata size ranges between 75.00 μm^2 - 350.00 μm^2 and stomatal index ranges between 19.36% - 25.00%.

Venation pattern

Major veins actinodromous. Areoles polygonal to rectangular in shape, veinlet endings vary from 0 to 5 diverging singly, bifurcated or forked.

Trichomes

Stalked glandular and non-glandular trichomes present. Glandular trichomes are often with unicellular to multicellular head, and unicellular to bicellular stalk. Non-glandular trichomes are often bicellular to multicellular uniseriate.

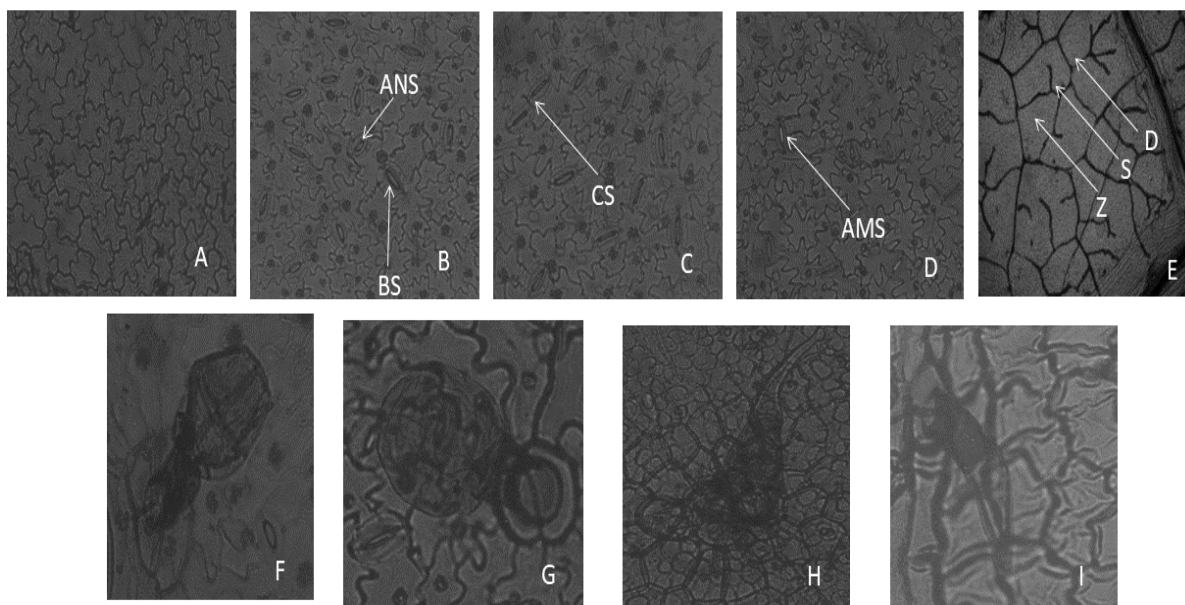


Figure 12: *Telfairia occidentalis*: Magnification: A- E= X100; F-I = X400

A – Adaxial surface showing Anisocytic stomata, **B** – Abaxial surface showing Anisocytic and Brachyparacytic stomata type, **C** – Abaxial surface showing contiguous stomata, **D** – Abaxial surface showing Anomocytic stomata type, **E** – Venation pattern showing veinlet endings, **F** – Glandular trichome with multicellular head and unicellular stalk on Abaxial surface, **G** – Glandular trichome with unicellular head and unicellular stalk on Abaxial surface, **H** – Non-glandular multicellular trichome on Abaxial surface, **I** – Non-glandular bicellular trichome on Abaxial surface. **LEGEND:** AMS – Anomocytic stomata, ANS – Anisocytic stomata, S – Single veinlet ending, Z – Zero veinlet ending, D – Branched veinlet ending.

***Trichosanthes cucumerina* Naudin,**
(Synonym: *Trichosanthes anguina* Linn.
(Figure 13 A - F, Tables 1 – 6)

Adaxial epidermal surface

Epidermal cells irregular in shape with wavy to undulating anticlinal wall, epidermal cell size ranges between $300.00 \mu\text{m}^2$ - $1375.00 \mu\text{m}^2$. Leaf is amphistomatic. Stomata elliptical to circular in shape, stomata type: brachyparacytic and anomocytic, stomata size ranges between $112.50 \mu\text{m}^2$ - $500.00 \mu\text{m}^2$ and stomatal index ranges between 0.51% - 4.74%.

Abaxial epidermal surface

Epidermal cells irregular in shape with undulating to sinuous anticlinal wall epidermal

cell size ranges between $225.00 \mu\text{m}^2$ - $625.00 \mu\text{m}^2$. Stomata elliptical to circular in shape, stomata type: brachyparacytic and anomocytic, stomata size ranges between $187.50 \mu\text{m}^2$ - $625.00 \mu\text{m}^2$ and stomatal index ranges from 13.50% - 20.14%.

Venation pattern

Veins actinodromous perfect marginal basal. Areoles polygonal to rectangular in shape, veinlet endings vary from 0 to 2 appearing singly, bifurcated or forked.

Trichomes

Non-glandular trichomes observed largely. They are often unicellular, bicellular and multicellular uniseriate.

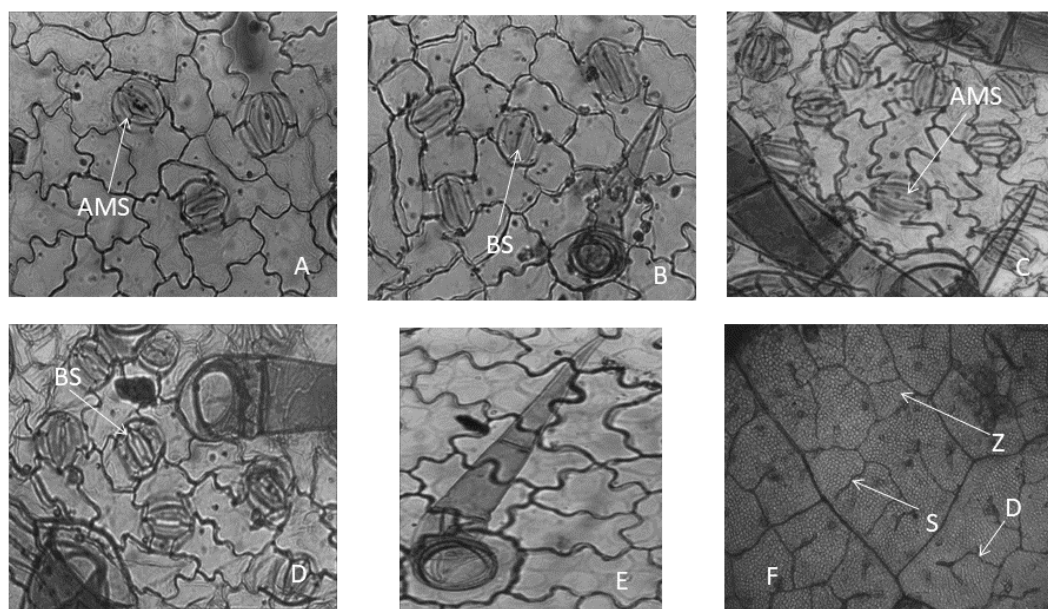


Figure 13: *Trichosanthes cucumerina*: Magnification: A – E = X400, F= X100

A – Adaxial surface showing Anomocytic stomata type, **B** – Adaxial surface showing Brachyparacytic stomata type, **C** – Abaxial surface showing Anomocytic stomata type, **D** – Abaxial surface showing Brachyparacytic stomata type, **E** – Non-glandular multicellular trichome on Adaxial and Abaxial surfaces, **F** – Venation pattern showing veinlet endings. **LEGEND:** AMS – Anomocytic Stomata, BS – Brachyparacytic stomata, NGT – Non-Glandular Trichomes, S – Single veinlet ending, Z – Zero veinlet ending, D – Branched or divided veinlet endings.

Table 1: Summary of Qualitative Foliar Epidermal Characters on the Adaxial Surface of the Species of Family Cucurbitaceae Studied

Species	Epidermal Cell Shape	Anticlinal Wall Pattern	Stomata Distribution	Stomata Shape	Stomata Type
<i>Citrullus lanatus</i> (Brown Seeds)	Polygonal	Straight	Amphistomatic	Circular	Anomocytic, Brachyparacytic, Anisocytic
<i>Citrullus lanatus</i> (Black Seeds)	Polygonal Irregular	Wavy, slightly Undulating	Amphistomatic	Elliptical, Circular	Anomocytic, Brachyparacytic, Anisocytic
<i>Cucumis sativus</i>	Polygonal	Straight, slightly Wavy	Amphistomatic	Elliptical, Circular	Anomocytic, Brachyparacytic, Anisocytic
<i>Cucumeropsis mannii</i>	Polygonal Irregular	Wavy, Undulating	Amphistomatic	Elliptical, Circular	Anomocytic, Brachyparacytic, Anisocytic, Tetracytic
<i>Cucumis melo</i> (Black Edges)	Polygonal	Straight	Amphistomatic	Elliptical, Circular	Anomocytic, Brachyparacytic, Anisocytic
<i>Cucumis melo</i> (Brown Edges)	Polygonal	Straight	Amphistomatic	Circular	Anomocytic, Brachyparacytic, Anisocytic
<i>Cucurbita maxima</i>	Polygonal, slightly Irregular	Straight, Wavy	Amphistomatic	Elliptical, Circular	Anomocytic, Brachyparacytic, Anisocytic

<i>Lagenaria siceraria</i> (Spatulate Fruit Shape)	Polygonal	Straight	Amphistomatic	Elliptical	Anomocytic, Brachyparacytic, Anisocytic
<i>Lagenaria siceraria</i> (Oval Fruit Shape)	Polygonal	Straight	Amphistomatic	Elliptical, Circular	Anomocytic, Brachyparacytic, Anisocytic
<i>Luffa aegyptiaca</i>	Polygonal	Straight	Amphistomatic	Elliptical, Circular	Anomocytic, Brachyparacytic, Anisocytic
<i>Momordica charantia</i>	Polygonal	Straight	Amphistomatic	Elliptical, Circular	Anomocytic, Brachyparacytic
<i>Telfairia occidentalis</i>	Irregular	Sinuuous	Hypostomatic	-	-
<i>Trichosanthes cucumerina</i>	Irregular	Wavy, Undulating	Amphistomatic	Elliptical, Circular	Anomocytic, Brachyparacytic.

Table 2: Summary of Qualitative Foliar Epidermal Characters on the Abaxial Surface of the Species of Family Cucurbitaceae Studied

Species	Epidermal Cell Shape	Anticlinal Wall Pattern	Leaf Surface Stomata	Stomata Shape	Stomata Type
<i>Citrullus lanatus</i> (Brown Seeds)	Polygonal, Irregular	Straight, Wavy	Amphistomatic	Circular	Anomocytic, Brachyparacytic, Anisocytic
<i>Citrullus lanatus</i> (Black Seeds)	Polygonal, Irregular	Wavy, slightly Undulating	Amphistomatic	Elliptical, Circular	Anomocytic, Brachyparacytic, Anisocytic
<i>Cucumis sativus</i>	Polygonal, slightly Irregular	Wavy, Undulating, slightly Sinuous	Amphistomatic	Elliptical, Circular	Anomocytic, Brachyparacytic, Anisocytic
<i>Cucumeropsis mannii</i>	Irregular	Sinuuous	Amphistomatic	Elliptical	Anomocytic, Brachyparacytic Tetracytic
<i>Cucumis melo</i> (Black Edges Seeds)	Polygonal, Irregular	Slightly Undulating	Amphistomatic	Circular, Elliptic	Anomocytic, Brachyparacytic, Anisocytic
<i>Cucumis melo</i> (Brown Edges Seeds)	Polygonal, Irregular	Wavy, slightly Undulating	Amphistomatic	Circular, Elliptical	Anomocytic, Brachyparacytic, Anisocytic
<i>Cucurbita maxima</i>	Polygonal, Irregular	Wavy, Undulating	Amphistomatic	Elliptical, Circular	Anomocytic, Brachyparacytic
<i>Lagenaria siceraria</i> (Spatulate Fruit Shape)	Irregular	Sinuuous	Amphistomatic	Elliptical	Anomocytic, Brachyparacytic
<i>Lagenaria siceraria</i> (Oval Fruit Shape)	Polygonal, Irregular	Wavy, Undulating	Amphistomatic	Elliptical, Circular	Anomocytic, Brachyparacytic
<i>Luffa aegyptiaca</i>	Polygonal, Irregular	Wavy, Undulating	Amphistomatic	Elliptical	Anomocytic, Brachyparacytic
<i>Momordica charantia</i>	Irregular	Undulating, Sinuous	Amphistomatic	Elliptical	Anomocytic, Brachyparacytic
<i>Telfairia occidentalis</i>	Irregular	Sinuuous	Hypostomatic	Elliptical	Anomocytic, Brachyparacytic, Anisocytic
<i>Trichosanthes cucumerina</i>	Irregular	Undulating, Sinuous	Amphistomatic	Elliptical, Circular	Anomocytic, Brachyparacytic

Anatomy of some Species in Family Cucurbitaceae from Nigeria

Table 3: Summary of Areole Shape, Veinlet Ending Type and Types of Trichomes in the Species of Family Cucurbitaceae Studied

Species	Areole Shape	Veinlet Ending	Trichome Types
<i>Citrullus lanatus</i> (Brown Seeds)	Polygonal Rectangular	Single, Bifurcated, Forked	Glandular: Multicellular head, and unicellular or bicellular stalk Non-Glandular: Prickle-like, unicellular, bicellular or multicellular
<i>Citrullus lanatus</i> (Black Seeds)	Polygonal Rectangular	Single, Bifurcated, Forked	Glandular: Multicellular head, and unicellular or bicellular stalk Non-Glandular: Prickle-like, unicellular, bicellular or multicellular
<i>Cucumis sativus</i>	Polygonal Rectangular	Single, Bifurcated, Forked	Glandular: Multicellular head, and unicellular stalk Non-Glandular: Multicellular uniseriate, occasionally bicellular
<i>Cucumeropsis mannii</i>	Polygonal Rectangular	Single, Bifurcated, Forked	Glandular: Multicellular head, and unicellular stalk Non-Glandular: Bicellular, tricellular or multicellular uniseriate
<i>Cucumis melo</i> (Black Edges Seeds)	Polygonal Rectangular	Single, Bifurcated, Forked	Glandular: Multicellular head, and unicellular or bicellular stalk Non-Glandular: Prickle-like, unicellular or multicellular uniseriate
<i>Cucumis melo</i> (Brown Edges Seeds)	Polygonal Rectangular	Single, Bifurcated, Forked	Glandular: Multicellular head, and unicellular or bicellular stalk Non-Glandular: Prickle-like, unicellular or bicellular, or multicellular uniseriate
<i>Cucurbita maxima</i>	Polygonal Rectangular	Single, Bifurcated, Forked	Glandular: Multicellular head, and unicellular or bicellular stalk Non-Glandular: Multicellular uniseriate largely
<i>Lagenaria siceraria</i> (Spatulate Fruit Shape)	Polygonal Rectangular	Single, Bifurcated, Forked	Glandular: Unicellular, bicellular or multicellular head, and unicellular or bicellular stalk Non-Glandular: Bicellular or multicellular uniseriate
<i>Lagenaria siceraria</i> (Oval Fruit Shape)	Polygonal Rectangular	Single, Bifurcated, Forked	Glandular: Multicellular head, and unicellular stalk Non-Glandular: Bicellular to multicellular uniseriate
<i>Luffa aegyptiaca</i>	Polygonal Rectangular	Single, Bifurcated, Forked	Glandular: Unicellular or multicellular head and unicellular stalk Non-Glandular: Prickle-like, unicellular or multicellular uniseriate
<i>Momordica charantia</i>	Polygonal Rectangular	Single, Bifurcated, Forked	Glandular: Unicellular or multicellular head, and bicellular stalk Non-Glandular: Often multicellular uniseriate
<i>Telfairia occidentalis</i>	Polygonal Rectangular	Single, Bifurcated, Forked	Glandular: Unicellular to multicellular head and unicellular or bicellular stalk Non-Glandular: Bicellular to multicellular uniseriate
<i>Trichosanthes cucumerina</i>	Polygonal Rectangular	Single, Bifurcated Forked	Glandular: Not observed Non-Glandular: Unicellular, bicellular and multicellular uniseriate.

Table 4: Summary of Quantitative Foliar Epidermal Characters of the Species of Family Cucurbitaceae Studied

Species	ADAXIAL ECS (μm^2)	ADAXIAL Stomata Size (μm^2)	ADAXIAL Stomata Index (%)	ABAXIAL ECS (μm^2)	ABAXIAL Stomata Size (μm^2)	ABAXIAL Stomata Index (%)	No VE
<i>Citrullus lanatus</i> (BrS)	250.00 – 812.00	125.00 – 250.00	15.90 – 21.23	150.00 – 600.00	93.75 – 337.50	16.92 – 27.12	0 – 5
<i>Citrullus lanatus</i> (BS)	250.00 – 756.25	150.00 – 300.00	8.88 – 13.65	210.00 – 850.00	156.25 – 300.00	11.59 – 19.06	0 – 4
<i>Cucumis sativus</i>	168.75 – 937.50	93.75 – 262.50	5.38 – 16.09	62.50 – 375.00	75.00 – 281.25	20.00 – 25.69	0 – 2
<i>Cucumeropsis mannii</i>	312.50 – 975.00	175.00 – 337.50	9.06 – 21.00	150.00 – 812.50	87.50 – 281.25	12.45 – 25.19	0 – 3
<i>Cucumis melo</i> (BES)	250.00 – 1250.00	156.25 – 300.00	12.00 – 14.29	175.00 – 700.00	125.00 – 262.50	17.09 – 23.29	0 – 4
<i>Cucumis melo</i> (BrES)	393.75 – 1662.50	125.00 – 300.00	10.01 – 19.19	230.00 – 750.00	125.00 – 350.00	12.98 – 27.53	0 – 3
<i>Cucurbita maxima</i>	131.25 – 487.50	93.75 – 187.50	11.58 – 20.32	100.00 – 412.50	93.75 – 218.75	12.29 – 23.27	0 – 6
<i>Lagenaria siceraria</i> (SFS)	312.50 – 1012.50	150.00 – 375.00	5.83 – 13.37	218.75 – 656.25	150.00 – 393.75	13.40 – 19.20	0 – 5
<i>Lagenaria siceraria</i> (OFS)	200.00 – 1187.50	218.75 – 393.75	8.69 – 18.00	168.75 – 750.00	150.00 – 350.00	13.94 – 20.72	0 – 5
<i>Luffa aegyptiaca</i>	200.00 – 900.00	112.50 – 218.75	4.40 – 9.35	156.25 – 812.50	125.00 – 337.00	15.61 – 20.59	0 – 4
<i>Momordica charantia</i>	262.50 – 1068.75	93.75 – 262.50	0.31 – 3.63	175.00 – 412.50	93.75 – 300.00	14.50 – 21.07	0 – 3
<i>Telfairia occidentalis</i>	300.00 – 900.00	-	-	168.75 – 862.50	75.00 – 350.00	19.36 – 25.00	0 – 5
<i>Trichosanthes cucumerina</i>	300.00 – 1375.00	112.50 – 500.00	0.51 – 4.74	225.00 – 625.00	187.50 – 625.00	13.50 – 20.14	0 – 2

LEGEND: BrS – Brown Seeds; BS – Black Seeds; BES – Black Edge Seeds; BrES – Brown Edge Seeds; SFS – Spatulate Fruit Shape; OFS – Oval Fruit Shape; ECS – Epidermal Cell Size; No – Number; VE – Veinlet Ending

Anatomy of some Species in Family Cucurbitaceae from Nigeria

Table 5: Species grouping from Duncan's Multiple Range Test based on Leaf Epidermal Characters on the Adaxial Surface (Means with the same letter along the column are not significantly different).

Species	LA (μm)	BA (μm)	NV	SI %	SS (μm^2)	SE (μm^2)	LSGT (μm)	BSGT (μm)	LHGT (μm)	BHGT (μm)	LNGT (μm)	BNGT (μm)
<i>Citrullus lanatus</i> (BrS)	298.4 ^c	176.0 ^{cd}	1.8 ^{de}	19.37 ⁱ	170 ^c	470 ^{bc}	10.5 ^{gh}	14.3 ^f	32.3 ^g	26.5 ^{ef}	130 ^d	35.9 ^{fg}
<i>Citrullus lanatus</i> (BS)	174.0 ^a	112.0 ^a	1.3 ^{bcd}	10.79 ^e	240 ^{de}	590 ^{cde}	8.2 ^{cdef}	13.4 ^f	24.1 ^c	22.8 ^d	120 ^{cd}	29.2 ^{cde}
<i>Trichosanthes cucurbitina</i>	320.4 ^c	208.4 ^{cde}	1.0 ^{ab}	2.47 ^b	300 ^f	660 ^{ef}	0 ^a	0 ^a	0 ^a	0 ^a	120 ^{cd}	15.4 ^a
<i>Lagenaria siceraria</i> (SFS)	346.8 ^c	216.0 ^{de}	1.0 ^{abc}	9.58 ^d	250 ^e	660 ^{ef}	6.8 ^{bcd}	11.0 ^{bcd}	24.0 ^c	21.8 ^d	150 ^{de}	29.3 ^{cde}
<i>Lagenaria siceraria</i> (OFS)	210.8 ^{ab}	120.4 ^{ab}	1.8 ^{de}	13.78 ^f	290 ^f	640 ^{ef}	9.7 ^{fg}	12.3 ^e	28.0 ^{ef}	27.1 ^{fg}	180 ^{ef}	38.1 ^{gh}
<i>Cucumeropsis mannii</i>	237.6 ^c	196.8 ^{cde}	1.5 ^{bcd}	17.98 ^h	250 ^e	620 ^{def}	7.3 ^{bcde}	13.9 ^f	33.2 ^g	30.3 ^h	60.3 ^a	27.9 ^{cd}
<i>Luffa aegyptiaca</i>	311.6 ^c	184.4 ^{cde}	1.6 ^{bcd}	6.62 ^c	235 ^{de}	470 ^{bc}	8.6 ^{defg}	11.2 ^{cde}	18.9 ^b	19.7 ^{bc}	57.1 ^a	20.6 ^b
<i>C. melo</i> (BrES)	273.6 ^{bc}	160.4 ^{bc}	1.7 ^{cde}	17.39 ^h	220 ^d	740 ^f	9.3 ^{efg}	11.9 ^{de}	33.1 ^g	25.3 ^e	97.8 ^{bc}	26.7 ^c
<i>C. melo</i> (BES)	440.4 ^d	288.4 ^f	1.4 ^{bcd}	13.36 ^f	230 ^{de}	610 ^{cd}	9.8 ^{fgh}	11.2 ^{cde}	29.5 ^f	25.8 ^{ef}	98.3 ^{bc}	32.4 ^{de}
<i>Cucurbita maxima</i>	340.8 ^c	199.6 ^{cde}	1.9 ^{cde}	15.47 ^g	150 ^b	260 ^a	5.8 ^b	10.3 ^{bc}	26.2 ^{de}	21.3 ^{cd}	220 ^g	34.0 ^{efg}
<i>Momordica charantia</i>	631.6 ^f	410.4 ^g	1.4 ^{bcd}	0.81 ^a	170 ^c	580 ^{cde}	27.9 ⁱ	13.8 ^f	26.0 ^d	19.1 ^b	190 ^{fg}	25.2 ^{bc}
<i>Telfairia occidentalis</i>	349.0 ^c	231.2 ^e	1.8 ^{de}	0.00 ^a	0 ^a	550 ^{bcde}	16.0 ^h	14.3 ^f	29.6 ^f	28.6 ^g	82.1 ^{ab}	33.0 ^{defg}
<i>Cucumis sativus</i>	439.6 ^d	274.0 ^f	0.5 ^a	13.17 ^f	170 ^c	450 ^b	6.4 ^{bc}	10.0 ^b	22.3 ^c	21.2 ^{cd}	160 ^{de}	33.9 ^{efg}

LEGEND: LA – Length of Areoles, BA – Breadth of Areoles, NV – Number of veinlet endings, SI – Stomata Index, SS – Size of Stomata, SE – Size of Epidermal cell, LSGT – Length of Stalk Glandular Trichome, BSGT – Breadth of Stalk Glandular Trichome, LHGT – Length of Head of Glandular Trichome, BHGT – Breadth of Head of Glandular Trichome, LNGT – Length of Non-Glandular Trichome, BNGT – Breadth of Non-Glandular Trichome, BrS – Brown Seeds, BS – Black Seeds, SFS – Spatulate Fruit Shape, OFS – Oval Fruit Shape, BrES – Brown Edge Seeds, BES – Black Edge Seeds.

Table 6: Species grouping from Duncan's Multiple Range Test based on Leaf Epidermal Characters on the Abaxial Surface (Means with the same letter along the column are not significantly different).

Species	SI %	SS (μm^2)	SE (μm^2)	LSGT (μm)	BSGT (μm)	LHGT (μm)	BHGT (μm)	LNGT (μm)	BNGT (μm)
<i>Citrullus lanatus</i> (BrS)	23.80 ^f	160 ^{ab}	350 ^{cd}	8.5 ^{def}	10.7 ^{efg}	30.1 ^{fg}	23.7 ^{fg}	140 ^{cd}	26.6 ^b
<i>Citrullus lanatus</i> (BS)	15.69 ^b	220 ^{cd}	502 ^f	8.6 ^{def}	11.7 ^{gh}	28.8 ^{ef}	26.7 ^{hi}	110 ^{bc}	31.2 ^{bc}
<i>Trichosanthes cucumerina</i>	18.80 ^{cd}	280 ^f	420 ^{de}	0 ^a	0 ^a	0 ^a	0 ^a	170 ^e	27.8 ^b
<i>Lagenaria.siceraria</i> (SFS)	14.63 ^b	240 ^{de}	440 ^{de}	6.8 ^{bc}	11.0 ^{efgh}	24.0 ^c	21.8 ^{de}	180 ^e	27.4 ^b
<i>Lagenaria siceraria</i> (OFS)	17.62 ^{cd}	240 ^{de}	410 ^{de}	7.7 ^{cde}	11.4 ^{fgh}	25.2 ^c	22.4 ^{def}	190 ^{ef}	34.3 ^{cd}
<i>Cucumeropsis mannii</i>	19.54 ^e	170 ^{ab}	440 ^{de}	8.6 ^{def}	12.7 ⁱ	30.8 ^g	28.2 ⁱ	57.5 ^a	13.3 ^a
<i>Luffa aegyptiaca</i>	17.91 ^{cd}	195 ^{bc}	430 ^{de}	9.2 ^{ef}	8.1 ^b	19.2 ^b	18.7 ^c	78.8 ^{ab}	26.0 ^b
<i>Cucumis melo</i> (BrES)	19.63 ^e	185 ^{ab}	450 ^e	7.6 ^{cde}	11.9 ^{hi}	28.5 ^{ef}	23.2 ^{efg}	140 ^{cd}	27.0 ^b
<i>Cucumis melo</i> (BES)	19.87 ^e	180 ^{ab}	370 ^{cde}	9.1 ^{ef}	11.2 ^{efgh}	27.5 ^{de}	24.2 ^g	120 ^c	26.5 ^b
<i>Cucurbita maxima</i>	18.40 ^{cd}	150 ^{ab}	230 ^{ab}	5.5 ^b	9.6 ^{cd}	25.8 ^{cd}	20.9 ^d	170 ^{de}	28.0 ^b
<i>Momordica charantia</i>	19.06 ^e	162 ^{ab}	300 ^{bc}	33.5 ^g	10.4 ^{def}	24.9 ^c	16.2 ^b	300 ^g	31.7 ^{bc}
<i>Telfairia occidentalis</i>	19.96 ^e	160 ^{ab}	430 ^{de}	9.9 ^f	10.7 ^{efg}	29.0 ^{efg}	25.7 ^h	71.5 ^a	25.8 ^b
<i>Cucumis sativus</i>	24.12 ^f	165 ^{ab}	190 ^a	7.3 ^{cd}	9.3 ^c	19.5 ^b	19.4 ^c	220 ^f	38.7 ^d

LEGEND: SI – Stomata Index, SS – Size of Stomata, SE – Size of Epidermal cell, LSGT – Length of Stalk Glandular Trichome, BSGT – Breadth of Stalk Glandular Trichome, LHGT – Length of Head of Glandular Trichome, BHGT – Breadth of Head of Glandular Trichome, LNGT – Length of Non-Glandular Trichome, BNGT – Breadth of Non-Glandular Trichome, BrS – Brown Seeds, BS – Black Seeds, SFS – Spatulate Fruit Shape, OFS – Oval Fruit Shape, BrES – Brown Edge Seeds, BES – Black Edge Seeds.

Discussion

The study of plant anatomy and morphology in the era of climate change provides valuable insights into plant adaptation, resilience, resource use efficiency, carbon dynamics, and ecosystem dynamics, all of which are essential for sustainable management and conservation efforts in a changing environment (Adamakis, 2025). According to Stace (1980), Adedeji (2004) and Arogundade *et al.*, (2024), the anatomical structure of plants are useful in the taxonomic characterization of plants since they are less affected by environmental changes, and therefore highly conservative in taxa variations. Suffice to say that it (anatomical structure) is highly useful in the taxonomic characterization of the family Cucurbitaceae as has been observed and documented in this study.

There are similarities as well as differences in the foliar anatomical characters of the species studied. The similarities establish the species as members of the same family while the differences confirm their taxon-specificity. All the species studied have actinodromous venation pattern, polygonal to rectangular areole shape, veinlet endings are generally single, bifurcated or forked. All have anomocytic and brachyparacytic stomatal types and the presence of trichomes. However, the species can be delimited on the basis of epidermal cell shape, anticlinal cell wall pattern, stomatal type combinations, leaf surface stomata distribution, stomata shape, stomatal index, stomata size and trichome type.

Epidermal cell shape though preponderantly polygonal on the adaxial foliar epidermal surface of most of the cells of the species studied, can be used in the delimitation of some species: it is polygonal to irregular in *Citrullus lanatus* (Black Seeds), *Cucumeropsis mannii*, and *Cucurbita maxima* and irregular in *Telfairia occidentalis* and *Trichosanthes cucumerina*. On the abaxial surface, it is polygonal to irregular in most of the species studied, while it is irregular in *Cucumeropsis mannii*, *Lagenaria siceraria* (Spatulate Fruit Shape), *Momordica charantia*, *Telfairia occidentalis* and *Trichosanthes cucumerina*. Irregular

epidermal cell shape on both surfaces is quite diagnostic for *Telfairia occidentalis* and *Trichosanthes cucumerina*, and this character can be used to delimit the two species from the other species of the family studied. On the adaxial surface, epidermal cells are biggest in *Cucumis melo* (Brown Edge Seeds) and smallest in *Cucurbita maxima*, while on the abaxial surface they are biggest in *Citrullus lanatus* (Black Seeds) and smallest in *Cucumis sativus*.

Anticlinal wall pattern of epidermal cells on both surfaces is also useful in the delimitation of species. On the adaxial surface, it is largely straight in most of the species studied with few exceptions. It is wavy to undulating in *Citrullus lanatus* (Black Seeds), *Cucumeropsis mannii*, *Trichosanthes cucumerina*; straight to wavy in *Cucurbita maxima*, and *Cucumis sativus*, sinuous in *Telfairia occidentalis*. On the abaxial surface, it is straight to wavy, wavy to slightly undulating, wavy to undulating to sinuous, sinuous, slightly undulating, and undulating to sinuous, in the species studied. It is noteworthy however, that sinuous anticlinal cell wall pattern on both adaxial and abaxial epidermal surfaces delimits *Telfairia occidentalis* from the other species studied.

Telfairia occidentalis is also delimited from all the other species studied in being hypostomatic in leaf surface stomata distribution while all the other species are amphistomatic. According to Adamakis (2025), changes in climate can pose challenges to plant survival. By studying plant anatomy, scientists can identify traits associated with resilience to climate stressors. The hypostomatic nature of *Telfairia occidentalis* could be significant in transpiration and gas exchange processes of the plant in providing fewer number of stomata for these processes. This could actually be relevant as a trait associated with resilience to climate stressors.

Stomata shape is quite diagnostic in the family. It is preponderantly circular or elliptical in the species of the family. On the adaxial surface, it is largely circular in *Citrullus lanatus* (Brown Seeds) and *Cucumis melo* (Brown Edge Seeds). It is largely

elliptical in *Lagenaria siceraria* (Spatulate Fruit Shape), while it is elliptical to circular in the other species. On the abaxial surface, it is largely circular in *Citrullus lanatus* (Brown Seeds), largely elliptical in *Cucumeropsis mannii*, *Lagenaria siceraria* (Spatulate Fruit Shape), *Luffa aegyptiaca*, *Momordica charantia* and *Telfairia occidentalis*, while it is elliptical to circular in the other species.

It is quite noteworthy that epidermal cell shape and anticlinal wall pattern on the adaxial surface and stomata shape on the abaxial surface can be used to delimit *Citrullus lanatus* (Spatulate Fruit Shape) and *Citrullus lanatus* (Oval Fruit Shape) from each other, most especially when only fragments of leaves of both or any are available.

Stomata type had been used by other workers for classification of genera and families of plants (Adedeji 2004; Saheed and Ogundare, 2012, Zaman *et al.*, 2024). Stomatal type is largely anomocytic or brachyparacytic and often to occasionally anisocytic in different combinations in the species of the family Cucurbitaceae studied. Tetracytic type was observed in *Cucumeropsis mannii* only and can be used to delimit this species from the other species of the family studied. On the adaxial surface, the anomocytic, brachyparacytic and anisocytic stomatal types are found in all the species studied, except in *Momordica charantia* and *Trichosanthes cucumerina* where only anomocytic and brachyparacytic types were observed. On the abaxial surface, anomocytic and brachyparacytic types only occur in *Cucurbita maxima*, *Lagenaria siceraria*, *Luffa aegyptiaca*, *Momordica charantia* and *Trichosanthes cucumerina*.

Stomata index is the proportion of stomata to the total number of epidermal cells (including stomata) per unit area. High stomata index means more stomata per area which leads to increased transpiration which translates to more water loss. This is beneficial in humid environments where water loss is not critical and helps with carbon dioxide uptake for photosynthesis (Phunthong *et al.*, 2024). According to Olatunji (1993) stomata index is highly constant for a certain species and can be used for species delimitation. Stomata

index is quite diagnostic in the species of family Cucurbitaceae studied. On the adaxial surface, mean stomatal index ranges from 0.81% to 19.37%. It is highest in *Citrullus lanatus* (Brown Seeds) and smallest in *Momordica charantia*, which indicates higher transpiration rate (which may not be an advantage) and better carbon dioxide uptake in *Citrullus lanatus* (Brown Seeds) than in *Momordica charantia*.

On the abaxial surface, mean stomatal index ranges from 14.63% - 24.12% with the lowest value in *Lagenaria siceraria* (Spatulate Fruit Shape) and highest in *Cucumis sativus*. It is noteworthy that stomatal index is generally higher and stomata size smaller on the abaxial surface than on the adaxial surface. According to Bertolino *et al* (2019), smaller stomata often respond faster to environmental changes, enabling more efficient regulation of water loss. Lower stomatal index (5-15%) leads to improved water retention which is ideal for drought resistance; moderate stomatal index (around 15-25%) leads to a balance between water conservation and photosynthesis which is typical of agriculturally optimized species; and higher stomatal index (25-40%), leads to high water and gas exchange capacity which is ideal in wet environment plants (Durand *et al.*, 2019; Bertolino *et al.*, 2019; Li, *et al.*, 2020; Wang *et al.*, 2023). It can thus be deduced that plants in the family Cucurbitaceae belong to the lower and moderate stomatal index groups with the implication of improved water retention which is ideal for drought resistance and a balance between water conservation and photosynthesis.

In plants, species with smaller stomata generally open and close faster, granting adaptive advantages under fluctuating environments because of faster response time and higher water use efficiency (Dittberner, *et al.*, 2018). On the adaxial surface, mean stomata size ranges from 150 – 300 μm^2 , while it ranges from 150 – 280 μm^2 on the abaxial surface. It is smallest on both surfaces of *Cucurbita maxima* and biggest on both surfaces of *Trichosanthes cucumerina*.

Plant trichomes are specialized unicellular or multicellular structures that cover surfaces of plants. The morphology of these epidermal

protuberances varies greatly depending on the tissue and the germplasms. Therefore, they have often been used in plant classification (Wagner, 1991; Wang, *et al.*, 2019). Besides their role in mechanical defense against biotic and abiotic stresses, trichomes also play a role in the chemical defense of plants by producing a variety of metabolites (Werker, 2000, Wagner *et al.*, 2004). These trichomes show unicellular or multicellular, glandular or non-glandular, and branched or unbranched patterns (Werker, 2000; Yang and Ye, 2013).

According to Metcalfe and Chalk, (1979), the presence of a particular trichome can frequently delimit species, genera or even families. This study observed and documented glandular and non-glandular types of trichomes on both foliar epidermal surfaces of the species of family Cucurbitaceae studied. Glandular trichomes are often with multicellular head and unicellular or bicellular stalk in the species studied. However, unicellular and bicellular heads were observed in *Lagenaria siceraria* (Spatulate Fruit Shape) which were largely missing in *Lagenaria siceraria* (Oval Fruit Shape), and this can be used to delimit the two varieties. Unicellular head was also occasionally observed in *Luffa aegyptiaca*, *Momordica charantia* and *Telfairia occidentalis*. On the adaxial surface, they are longest in *Telfairia occidentalis* and shortest in *Cucurbita maxima* while on the abaxial surface, they are longest in *Momordica charantia* and shortest in *Cucurbita maxima*. *Trichosanthes cucumerina* can be delimited from all the other species studied in being the only species with non-glandular trichomes only.

Non-glandular trichome types observed in the family are prickle-like, unicellular, bicellular, tricellular and multicellular uniseriate. The multicellular uniseriate type was observed and documented for all the species studied, while the prickle-like trichome type delimits *Citrullus lanatus*, *Cucumis melo* and *Luffa aegyptiaca* from all the other species studied. They are preponderantly multicellular uniseriate in *Cucumis sativus*, *Cucurbita maxima* and *Momordica charantia*. On the adaxial surface, they are longest in *Cucurbita*

maxima and shortest in *Luffa aegyptiaca* while they are longest in *Momordica charantia* and shortest in *Cucumeropsis mannii* on the abaxial surface. It is noteworthy that both the glandular and non-glandular trichomes of *Momordica charantia* are the longest on the abaxial epidermal surface when compared with the trichomes of other species studied.

Venation pattern is largely actinodromous in all the species studied. Areole shape is polygonal to rectangular while the veinlet endings are generally single, bifurcated or forked and range from 0 – 2, 0 – 3, 0 – 4, 0 – 5, and 0 – 6, in the species of the family studied, with the least, 0 – 2 range occurring in *Cucumis sativus* and *Trichosanthes cucumerina* and the highest range, 0 – 6, occurring in *Cucurbita maxima*. Areoles are longest and widest in *Momordica charantia*, shortest and narrowest in *Citrullus lanatus* (Black Seeds). Adedeji (2004) also used areole size to delimit the species of *Emilia* Cass

Duncan Multiple Range Test reveals that values of trichomes (both glandular and non-glandular) on the adaxial epidermal surface are more taxon-specific than values of other characters which show significant overlaps.

It is noteworthy from this anatomical study that just as the different species can be delimited from one another based on some characters, the two varieties of taxa *Citrullus lanatus* (Spatulate Fruit Shape and Oval Fruit Shape) and *Cucumis melo* (Brown Seeds Edge and Black Seeds Edge) can also be delimited from each other based on some anatomical characters.

References

- Adamakis, I. O. 2025. Plant Development and Morphogenesis. *Plants*. Special issue.
- Adedeji, O. (2004). Leaf epidermal studies of the species of *Emilia* Cass. (Senecioneae, Asteraceae) in Nigeria. *Botanica lithunica*. 10: 121 – 133.
- Araujo, J.S., Almeida, R.F. and Alves-Meira, R.M.S. (2020). Taxonomic relevance of leaf anatomy in *Banisteriopsis* C.B. Rob. (Malpighiaceae). *Acta Botanica Brasilica*. 34(1): <https://doi.org/10.1590/0102-33062019abb0276>

- Arogundade, O.O., Adedeji, O. and Ogunlowo, I.I. (2024). Diversity of foliar trichomes, trichomes basal insertion cells and cells surrounding the basal insertion cells in family Asteraceae. *Ife Journal of Science*. 26(3): 781-802.
- Bertolino, L.T., Caine, R.S. and Gray, J.E. (2019). Impact of stomatal density and morphology on water-use efficiency in a changing world. *Sec. Plant Physiology*. 10:225. doi: 10.3389/fpls.2019.00225
- Cutler, D. F. (1978). *Applied plant anatomy*. Longman, London.
- Dittberner, H., Korte, A., Mettler-Altmann, T., Weber, A.P.M., Monroe, G. and Meaux, J. (2018). Natural variation in stomata size contributes to the local adaptation of water-use efficiency in *Arabidopsis thaliana*. *Molecular Ecology*. 27(20): 4052-4065.
- Durand, M., Brendel, O., Bure, C., and Le-Thiec, D. (2019). Altered stomatal dynamics induced by changes in irradiance and vapour-pressure deficit under drought: impacts on the whole-plant transpiration efficiency of poplar genotypes. *New Phytologist*. 222(4): 1789 – 1802
- Ghimire, B., Lee, C., and Hep, K. (2014). Leaf anatomy and its implications for phylogenetic relationships in Taxaceae s. l. *Journal of Plant Research*. 127: 373 – 388.
- Gogosz, A.M., Boeger, M., Negrelle, R. and Bergo, C. (2012). Comparative leaf anatomy of nine species of the genus *Piper* (Piperaceae). *Rodriguesia*. 63(2): 405 – 417.
- Gomes, S.M.A., Silva, E.A.M., Lombardi, J.A., Azevedo, A.A. and Vale, F.H.A. (2005). Anatomia foliar como subsídio a taxonomia de Hippocrateoideae (Celastraceae) no Sudeste do Brasil. *Acta Botanica Brasílica*. 19(4):945-961. <http://dx.doi.org/10.1590/S0102-33062005000400029>.
- Grubben, G.J.H. (2004). *Plant Resources of Tropical Africa: Vegetables (PROTA 2)*, Vol. 2. Prota, Wageningen, Netherlands. Netherlands/Backhuys Publishers, Leiden, Netherlands/CTA, Wageningen Netherlands. Pp 253 – 237.
- Guo, J., Xu, W., Hu, Y., Huang, J., Zhao, Y., Zhang, L., Huang, C. and Ma, H. (2020). Phylotranscriptomics in Cucurbitaceae reveal multiple whole-genome duplications and key morphological and molecular innovations. *Molecular Plant*. 13(8): 1117-1133.
- Hopkins, A. J. (2001). *Importance of leafy vegetables*. Atlanta, USA. Pp.125-137.
- Inamdar, J.A. and Gangadhara, M. (1976). Structure, ontogeny and taxonomic significance of stomata in some Cucurbitaceae. *Feddes Repertorium*. 87: 295 – 312.
- Inamdar, J.A. and Gangadhara, M. (2008). Structure, ontogeny, classification and organographic distribution of trichomes in some Cucurbitaceae. *Feddes Repertorium*. 86: 307-320. <http://dx.doi.org/10.1002/fedr.19750860503>.
- Leandro, T.D., Rodrigues, T.M., Clark, L.G., and Scatena, V.L. (2018). Fusoid cells in the grass family Poaceae (Poales): a developmental study reveals homologies and suggests new insights into their functional role in young leaves. *Annals of Botany*. 122: 833 – 848.
- Li, Q., Jihua, H., He, N., Xu, L. and Zhang, Z. (2020). Changes in leaf stomatal traits of different aged temperate forest stands. *Journal of Forestry Research*. 32(3). <http://dx.doi.org/10.1007/s11676-020-01135-5>.
- Markin-Gomez, J.J., Pozo, D.G., Rodriguez-Lorenzo, J.L., Tocino, A., and Cervantes, E. (2024). Geometric analysis of seed shape diversity in the Cucurbitaceae. *Seeds*. 3(1): 40-55.
- Metcalf, C.R. and Chalk, L. (1979). *Anatomy of the dicotyledons*, 2nd ed. Vol. 1, Clarendon Press, Oxford. Pp. 63-75.

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- Olatunji, O.A. (1993). *Practical manual for plant anatomy* – Obafemi Awolowo University, Ile – Ife (manuscript).
- Paris, H.S. (2001). Characterization of the *Cucurbita pepo* collection at the New Year research center, Israel. *Plant Genetic Resources Newsletter*. 162: 41-46.
- Phunthong, C., Pitaloka, M.K., Chutteang, C., Ruengphayak, S., Arikrit, S., and Vanavichit, A. (2024). Rice mutants, selected under severe drought stress, show reduced stomatal density and improved water use efficiency under restricted water conditions. *Frontiers in Plant Science*. <https://doi.org/10.3389/fpls.2024.1307653>.
- Pitrat, M., Chauvet, M., and Foury, C. (1999). Diversity, history and production of cultivated Cucurbits. *Acta Horticulturae*. 492: 21-28.
- Portella, D.A.C., Oliveira, M.I.U., Mourao, K.S.M., Thadeo, M. (2025). Revealing leaf structure characters of taxa of *Campomanesia* Ruiz and Pav. (Myrtaceae) to use in the taxonomy of the genus. *Flora*. 330: 152759. <https://doi.org/10.1016/j.flora.2025.152759>.
- Saheed, S.A and Ogundare, C.S (2012). Foliar epidermal characters and petiole anatomy of four species of *Citrus* L. (Rutaceae) from South – Western Nigeria. *Bangladesh Journal of Plant Taxonomy*. 19 (1): 25 – 31.
- Schaefer, H. and Renner, S.S. (2011). Cucurbitaceae In: Kubitzki, K. (ed.), *The families and genera of vascular plants, Sapindales, Cucurbitales, Myrtaceae*. Berlin: Springer. 10: 112–174.
- Stace, C.A., (1980). *Plant Taxonomy and Biosystematics*. Edward Arnold, London, Pp: 113-129.
- Wagner, G.J., Wang, E. and Shepherd, R.W. (2004). New approaches for studying and exploiting an old protuberance, the plant trichome. *Annals of Botany*. 93: 3-11.
- Wagner, G.J. (1991). Secreting glandular trichomes: More than just hairs. *Plant Physiology*. 96: 675 – 679.
- Wang, W., Huo, Z., Rong, Y., Wang, C., Zhang, C., Wang, X. (2023). A novel water use efficiency model based on stomata coupling crop growth and farmland water cycle processes in arid area. *Journal of Hydrology*. 617 Part A, <https://doi.org/10.1016/j.jhydrol.2022.128974>
- Wang, D.J., Zeng, J.W., Ma, W.T., Lu, M., An, H.M. (2019). Morphological and structural characters of trichomes on various organs of *Rosa roxburghii*. *HortScience*. 54 (1): 45 – 51.
- Werker, E. (2000). Trichome diversity and development. *Advances in Botanical Research*. 31:1-35.
- Yang, C., and Ye, Z. (2012). Trichomes as models for studying plant cell differentiation. *Cellular and Molecular Life Sciences*. 70(11). <http://dx.doi.org/10.1007/s00018-012-1147-6>.
- Yiblet, Y. (2022). Overview of Cucurbitaceae Families. In: Wang, H. (ed.), *Biological and Abiotic Stress in Cucurbitaceae Crops*. IntechOpen. <http://dx.doi.org/10.5772/intechopen.104275>: 112.
- Zaman, W., Lee, E.M. and Park, S. (2024). Endemic species analysis: Foliar epidermal anatomical characters of *Aster glehnii* F. Schmidt (Asteraceae). *Microscopy Research and Technique*. 87(7): 1640 – 1646.