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Research

Anisomeles malabarica Leaves: Revisiting Pharmacognostic Features and Taxonomic Paradigms

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Abstract

This study investigates the pharmacognostic and phytochemical properties of *Anisomeles malabarica*, a medicinal plant from the *Lamiaceae* family. A comprehensive analysis was performed, encompassing macroscopic, microscopic, and numerical taxonomic studies. The anatomical observations revealed distinctive traits such as unicellular trichomes, collenchymatous and parenchymatous ground tissue, and vascular bundles with concentric arrangements. Quantitative microscopy parameters, including stomatal index and vein islet number, were documented. Physiochemical analyses showed values within Ayurvedic pharmacopeia standards, ensuring the plant's purity and quality. The presence of essential inorganic elements like calcium, potassium, and iron was confirmed, with no detection of toxic heavy metals, underscoring its safety for medicinal use. DNA barcoding validated the species identity, enhancing its taxonomic classification. These findings highlight *A. malabarica*'s potential for therapeutic applications and its importance in pharmacognostic standardization.

Keywords: *Anisomeles malabarica*, pharmacognosy, phytochemical analysis, anatomical studies, taxonomic evaluation, therapeutic potential, numerical taxonomy, DNA barcoding, Lamiaceae, medicinal plants.

INTRODUCTION

Anisomeles R.Br. is a genus belonging to Lamiaceae subfamily Lamioideae [1]. Its species are short-lived perennial shrubs distributed in northern Australia, Malesia and southern Asia. The genus was described by Robert Brown [2], with three species, *A. salviifolia* R.Br., *A. moschata* R.Br. and *A. inodora* R.Br., based on specimens that he himself collected from northern Australia, and a specimen collected earlier by Banks and Solander. Soon afterwards, it was realised that two species named by Linnaeus from India (Nepeta indica L. and Nepeta malabarica L.) were referable to *Anisomeles* (Sims 1819) [3]. *Anisomeles* belong to *Lamiaceae* family is represented by 45 genera and 574 species with 256 endemic species. It is an Aromatic, densely pubescent, perennial herb, 1.2- 2m in height belonging to the family *Lamiaceae* [4].

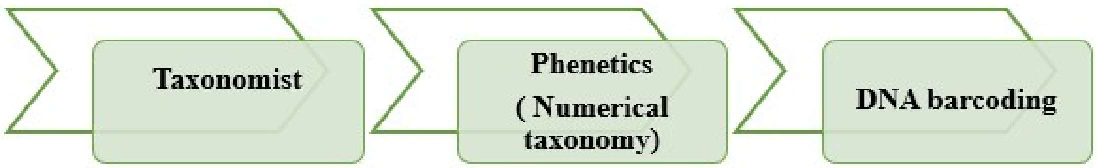
MATERIAL AND METHODS

Collection Of Plant

The leaves of *Anisomeles malabarica* (L.) R.Br. ex-Sims (Lamiaceae) were collected from, Tiruvannamalai district in Tamil Nadu, India during the month March 2024.

Authentication

The leaves of *Anisomeles malabarica* was authenticated by experts typically examine the plant's various parts, including flowers, stems, and leaves. A good specimen is collected, washed, and dried. This process ensures accurate identification by



The macroscopic study is the morphological description of the plant parts which are seen by naked eye or magnifying lens. Free hand transverse sections of petiole and leaf were taken and stained with 0.8% Safranin and 0.5% Astra blue and observed for their peculiar characters. The powder microscopy characters of the *Anisomeles malabarica* leaves were observed. Physiochemical character such as foreign matters, extractive values, loss on drying, Ash values, viz. total ash, acid soluble ash, sulphated ash and water-soluble ash were determined as per standard procedure [5].

RESULTS

Taxonomist

The plant sample was authenticated by Dr. D. Stephen, Department of Botany, The American College, Madurai.

Numerical Taxonomy

The *Anisomeles* genus, from the *Lamiaceae* (mint) family, comprises aromatic herbs and shrubs native to Asia, particularly in regions like India, Sri Lanka, Southeast Asia, and Australia. Through numerical taxonomy, which uses statistical methods to analyze plant characteristics quantitatively, researchers have been able to classify and distinguish key species within this genus, such as *Anisomeles malabarica*, *Anisomeles indica*, and *Anisomeles heyneana*. Numerical approaches allow for objective comparisons based on morphological traits, chemical profiles, and genetic markers. This systematic method enhances understanding of the genus, aiding in accurate classification and revealing relationships within *Anisomeles* that could guide further pharmacological exploration. The following are the four species of *Anisomeles* was selected for numerical taxonomy

- *Anisomeles malabarica*
- *Anisomeles indica*
- *Anisomeles heyneana*

Chart Of Similarity

The organoleptic and morphological type scripts of leaf parts of various species in genus *Anisomeles.*

Table 1: Chart of similarity

	SPECIES		
CHARACTERS	***Anisomeles malabarica***	***Anisomeles indica***	***Anisomeles heyneana***
Leaf arrangement	1	1	1
Apex	1	1	1
Margin	1	1	1
Base	1	2	2
Venation	1	1	1

Leaf length	1	2	2
Leaf colour	1	2	2
Taste	1	1	2

- **Leaf arrangement:** opposite -1, not opposite-2
- **Apex:** Acute-1, not Acute-2
- **Margin:** Crenate-1, not Crenate-2
- **Base:** Rounded and slightly cuneate-1, Asymmetrical-2
- **Venation:** Reticulate-1, not Reticulate-2
- **Leaf length:** 5-7 cm long-1, 3.8-10×5.5-6 cm-2, 5-12 cm-2
- **Leaf colour:** Pale green-1, not Pale green-2
- **Taste:** slightly astringent-1, mild astringent-2

Chart Smilarity

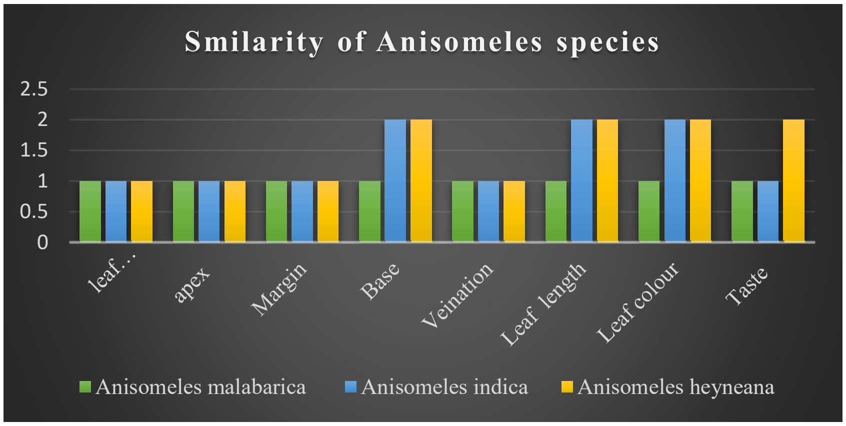


Fig 1: Chart of similarity for four species of *Anisomeles*

Chart Of Dissimilarity

Table 2: Chart of Dissimilarity for three species of *Anisomeles*

SPECIES	*Anisomeles malabarica*	*Anisomeles indica*	*Anisomeles heyneana*
Anisomeles malabarica	1	0.625	0.5
Anisomeles indica	0.625	1	0.625
Anisomeles heyneana	0.5	0.625	1

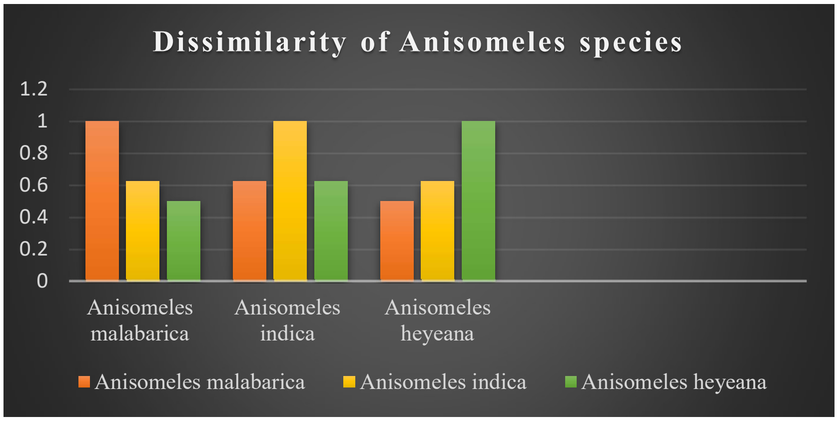


Fig 2: Chart of dissimilarity for three species of *Anisomeles*

$$\text{Sample Matching Coefficient SSM} = NS / NS + ND \times 100$$
$$= 17/17+7 \times 100$$
$$= 17/24 \times 100$$
$$= 0.70833 \times 100$$
$$SSM = 70.833\%$$

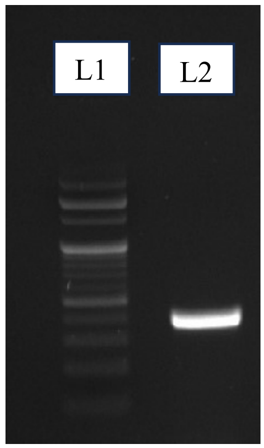
NS – Number of similar characters
ND- Number of dissimilar characters

The matching co-efficient of *Anisomeles malabarica* with respect to other species was found to be 70.83%.

DNA Barcoding

Table 3: Quality check and quantification of DNA

Sample	Concentration in ng/µl	$A_{260/280}$	$A_{230/260}$
Anisomeles malabarica	294.0	1.69	1.42



L1: Ladder, L2: AM
Fig 3: Gel image of PCR amplified product

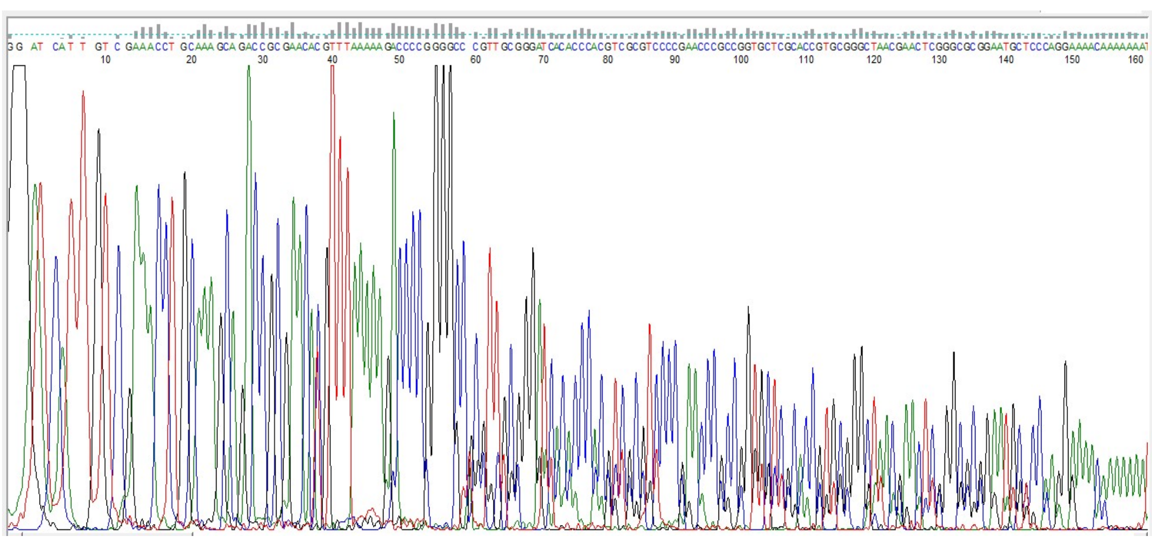
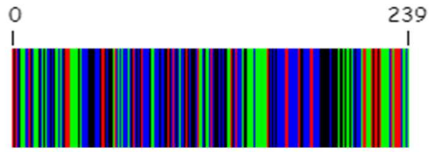


Fig 4: Chromatograms of *Anisomeles malabarica* DNA barcoding

Table 4: Sequence obtained

Sample code	Sequence with Barcode and BLAST Hit
> SCRIPCOGAM31	Tgtcgaaacctgcaaagcagaccgcgaacacgtttaaaaagaccccggggcccgttgcgggatcacacccacgtcg cgtccccgaacccgccggtgctcgcaccgtgcgggctaacgaactcgggcgcggaatgctcccaggaaaacaaaa aaatgcgcgcccccttccccccctggccccttccccggggggcggggaggagaagacgcccattaaatgttgtaaaaa ctattttcaaca



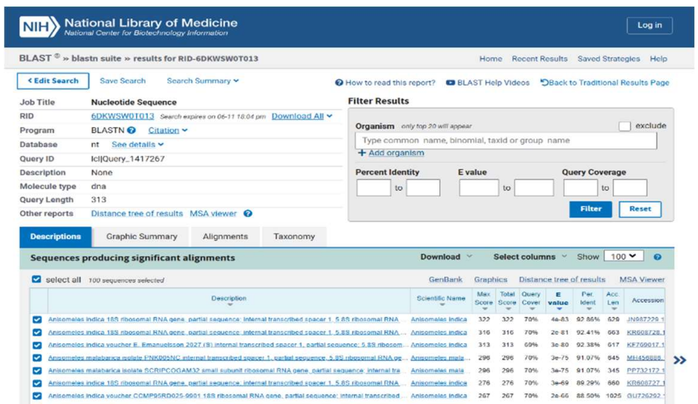


Fig 5: National Library of Medicine – *Anisomeles malabarica*

Table 5: Genbank Submission Details

Voucher no.	Specimen name	Submission Id	Accession no.	Gen Bank Link
SCRIPCOGAM31	*Anisomeles malabarica*	SUB14406394	PP732172	https://www.ncbi.nlm.nih.gov/nuccore/PP732172.1?report=GenBank

Morphology Of Anisomeles Malabarica

Fig 6: *Anisomeles malabarica* Plant

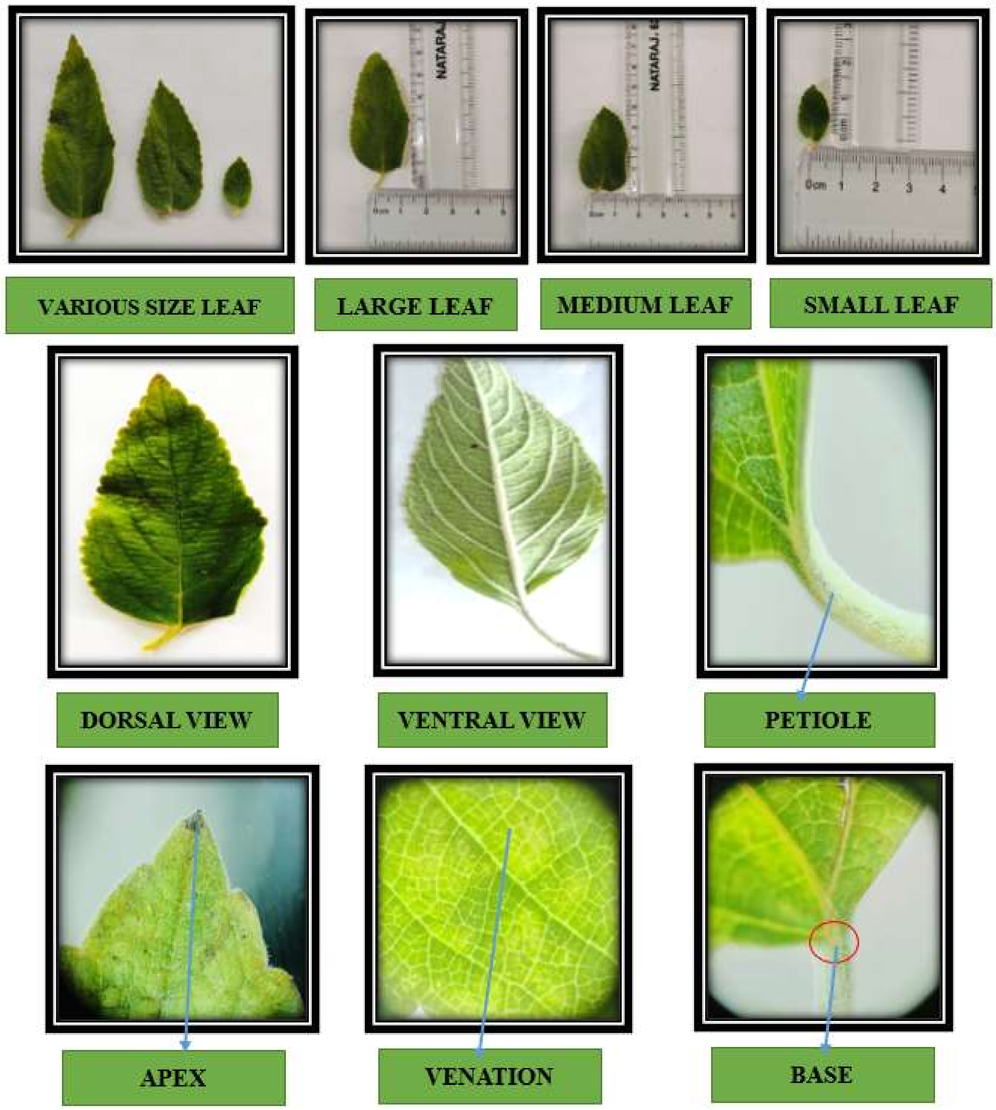


Plate 1. Morphology Of *Anisomeles malabarica*

Table 6: Organoleptic & Macroscopical features of leaves of *Anisomeles malabarica*

CHARACTER	OBSERVATION
Type	Simple leaves with cauline arrangement in the axis
Arrangement	Opposite
Colour	Upper surface – Pale green, Lower surface- greenish white
Odour	Aromatic, pleasant
Size	3.6 to 16 x 1.3 to 7 cm
Surface	Velvety lanate above
Shape	Ovate -Lanceolate Oblong-Lanceolate
Apex	Acute in larger leaves, acuminate in smaller leaves
Articulate	Rounded
Base	Narrow and attenuate
Margin	Crenate – serrate
Lobe Variation	Large 14-19 lobes Medium 14-15 lobes

	small 7-8 lobes
Venation	Reticulate
Petiole	Petiolate - Stout
Petiole length	0.7 to 3.5 cm long
Stipulation	Stipulate – cauline 47–90 mm long
Venation-primary vein Secondary vein	6-7 pair with 6-7 number of minute whitish glands are present, 13-15 pairs with 2-3 number of whitish minute glands are seen in lamina
Surface Texture	Lanate (woolly texture) due to dense trichomes

Microscopic Evaluation

Among the quality control methods for medicinal plants recommended by WHO organization, the macroscopic characters are mostly subjective to substitutes and adulterants exist which closely resembles the genuine material, it is often necessary to substantiate the findings of the macroscopy examination by microscopy. The anatomical comparison of a plant used as drug includes micro anatomical studies of dissociated and section tissues. An attempt in the present study discloses the transverse section of leaves and petiole of *Anisomeles malabarica.*

TS of Petiole

The transverse section (TS) of the petiole is nearly quadrangular with a wavy outline, featuring a flat adaxial side and a convex abaxial side. Both adaxial and abaxial epidermis are single-layered, parenchymatous, and covered with thin cuticle, bearing simple unicellular and glandular trichomes. The ground tissue, predominantly on the adaxial side, consists of 2–3 layers of collenchyma followed by parenchyma, with intracellular spaces and starch grains. The vascular bundles are radially arranged, with two smaller adaxial bundles and a larger central crescent-shaped bundle, enclosed by 3–4 parenchymatous pericyclic layers. Xylem faces adaxially and phloem abaxially, with prismatic crystals present below the xylem and starch grains in the phloem. The abaxial collenchyma is thicker (1–4 layers) than the adaxial (1–2 layers). Lateral ground tissue is small, with rounded, regularly arranged parenchyma cells.

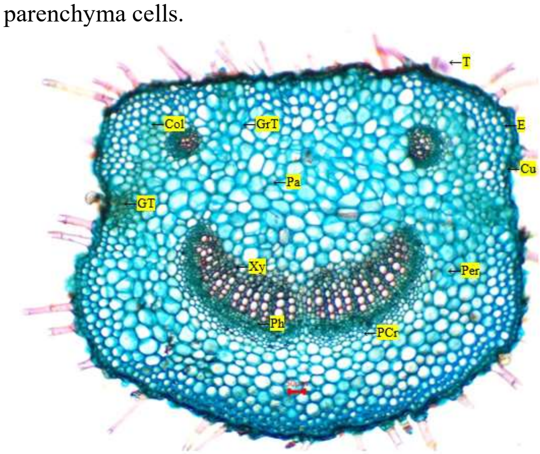
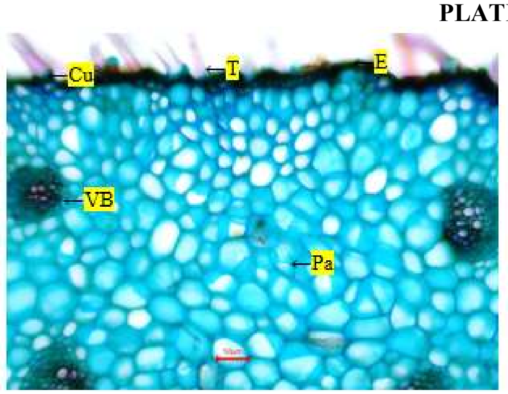


PLATE 2. TS of petiole



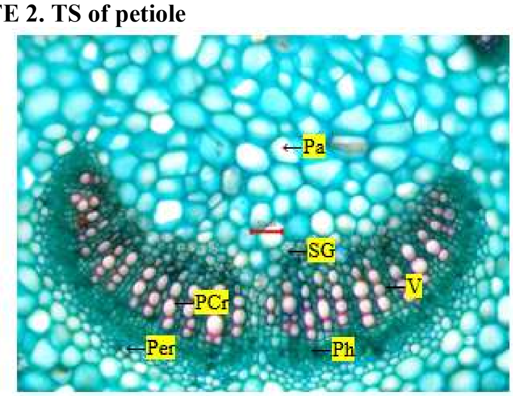


PLATE 3. Upper portion enlarged **PLATE 4. Middle portion enlarged**

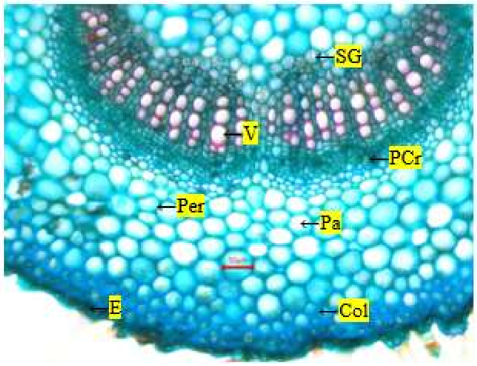


PLATE 5. Lower portion enlarged

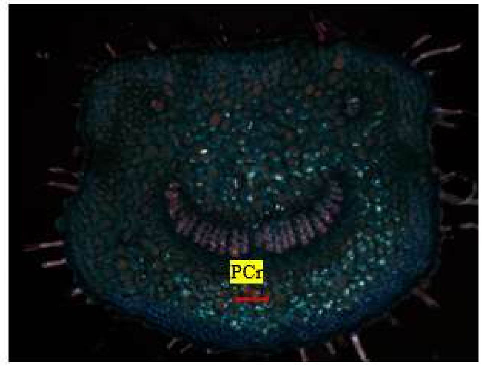


PLATE 6. TS of petiole under polarized field

Col - collenchyma; **Ct** - cortex; **Cu** - cuticle; **E** - epidermis; **GT** - glandular trichome; **GrT** - ground tissue; **Pa** - parenchyma; **PCr** - prismatic crystals; **Per** - pericycle; **Ph** - phloem; **SG** - starch grain; **T** - trichome; **V** - vessel; **Xy** – xylem

TS of Midrib

The transverse section (TS) of the midrib reveals single-layered upper and lower epidermis covered by a cuticle, with numerous unicellular trichomes and a few glandular trichomes. The upper crown epidermis is thick-walled and circular, with collenchymatous layers (1–4 cells wide) beneath, followed by thin-walled parenchyma with intercellular spaces. Ground tissue in the midrib contains two vascular bundles: a half-moon-shaped larger bundle on the abaxial side and a smaller closed collateral bundle on the adaxial side. Xylem, encircled by phloem, faces the abaxial side, with lignified fibres present in the xylem region. Phloem cells are compact and polygonal, with the adaxial phloem being smaller. Both vascular bundles are surrounded by parenchymatous pericyclic fibres, and starch grains are present in the xylem parenchyma. Ground tissue, embedding starch grains, also contains dark brown content.

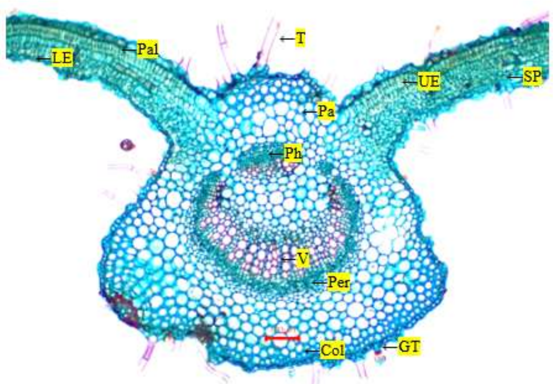


PLATE 7. TS of Midrib

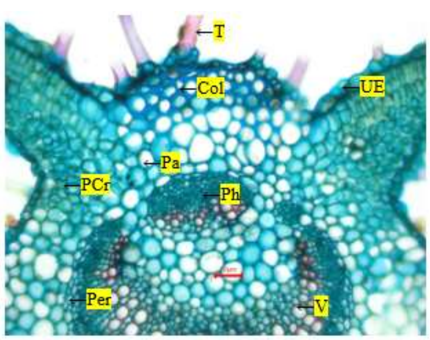


PLATE 8. Midrib upper enlarged view

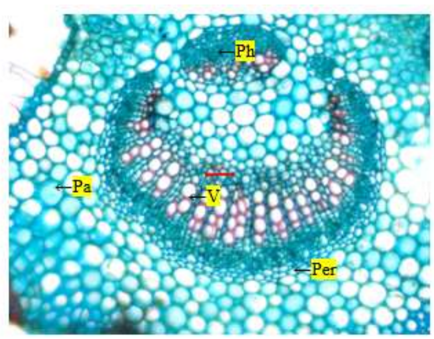


PLATE 9. Enlarged view of vascular bundle

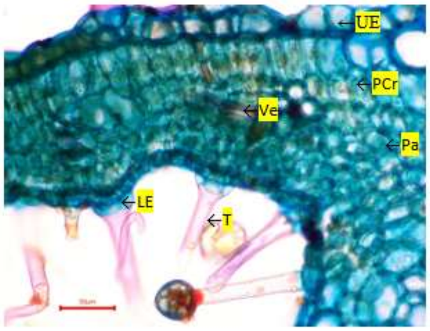


PLATE 10. Midrib lower portion enlarged

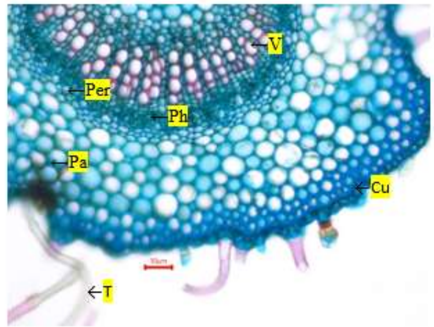


PLATE 11. Laminar extension from midrib

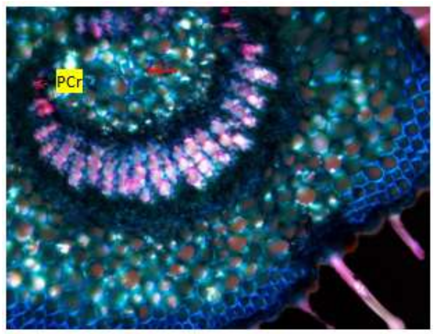


PLATE 12. TS of leaf under polarized field

Col - collenchyma; **Cu** - cuticle; **LE** - lower epidermis; **Pa** - parenchyma; **PCr** - prismatic crystals; **Pal** - palisade; **Per** - pericycle; **Ph** - phloem; **SP** - spongy parenchyma; **SG** - starchgrains; **T** - trichome; **UE** - upper epidermis; **V** - vessel; **Ve** – vein

TS of lamina

TS of lamina shows single layered upper and lower epidermis. In upper epidermis is irregular, thick-walled rectangular cells covered with thick cuticle and bears few several unicellular simple covering trichomes with bicellular bulbous base. Lower epidermis is regular and smaller than the upper epidermis and its shape is circular. Mesophyll tissue is differentiated into upper two layered palisade cells and it is discontinuous, biserrate, narrowly elongated cells filled with chlorophyll. Palisade cells have lower 2 to 3 layered, circular with various size spongy parenchyma cells with intercellular spaces; veins can be seen traversing through the mesophyll tissue.

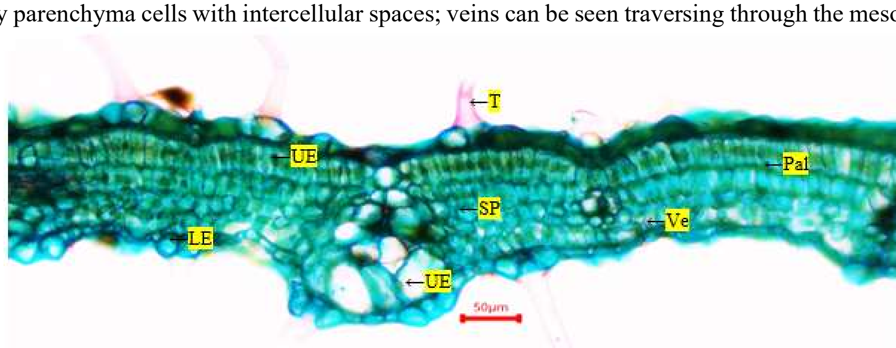


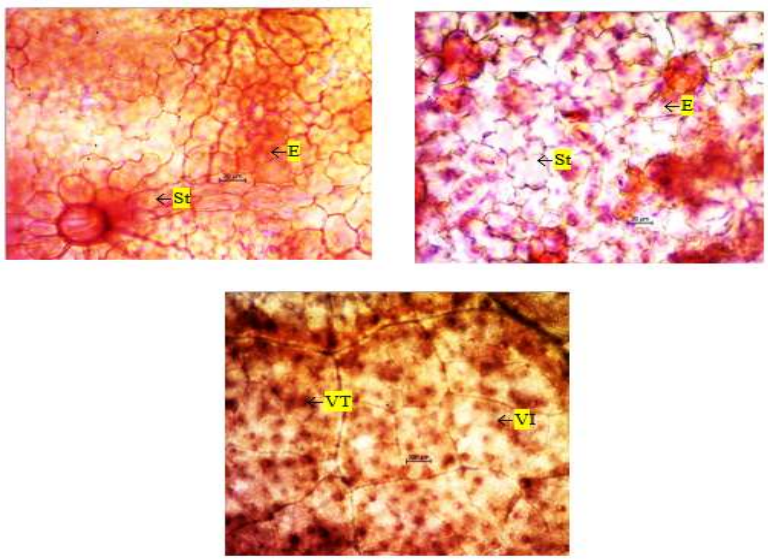
PLATE 13. TS OF LAMINA

LE - lower epidermis; **Pal** - palisade; **SP** - spongy parenchyma; **T** - trichome; **UE** - upper epidermis; **V** - vessel; **Ve** – vein

Quantitative Microscopy

Table 7: Quantitative microscopy of *Anisomeles malabarica* leaf

Parameters	Upper epidermis (/mm^2)	Lower epidermis (/mm^2)
Epidermal number	350 – 370	400 - 420
Stomatal number	40 – 50	65 - 70
Stomatal index	10 – 12	13 - 14
Palisade ratio	10 - 14	
Vein islets number	16 - 20	
Vein termination number	10 - 12	

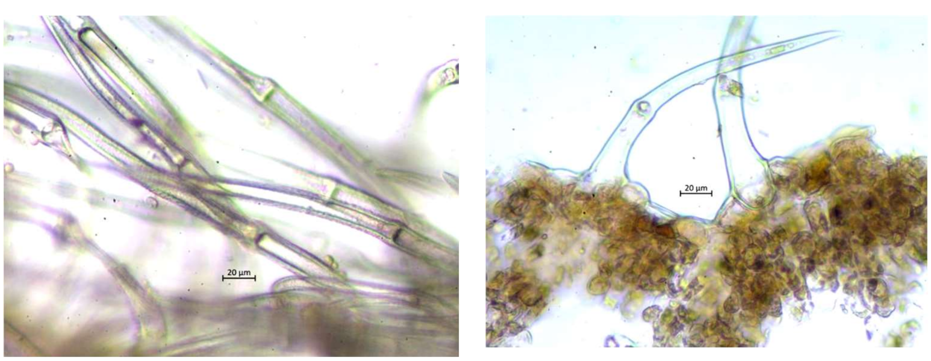


E - Epidermis; **St** - Stomata; **VI** - Vein Islet; **VT** - Vein Termination

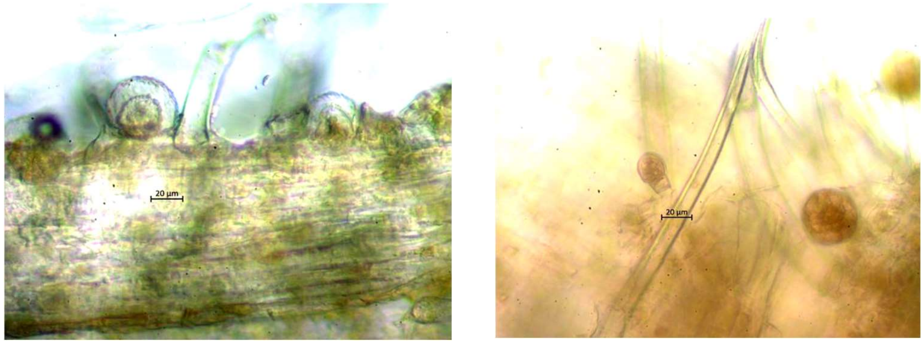
PLATE 14. Quantitative microscopy of *Anisomeles malabarica*

Powder Microscopy

Powder microscopy is a crucial method in pharmacognostic research, widely applied for the identification, standardization, and quality control of medicinal plants. This technique allows for the microscopic examination of plant powders to detect specific anatomical features, such as trichomes, stomata, vascular elements, and crystals that are diagnostic for particular species. By observing these features, researchers can authenticate plant materials, detect adulteration, and assess quality, which is especially important for medicinal herbs processed into powders.

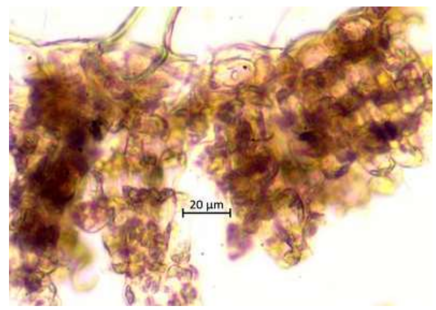


Covering trichomes

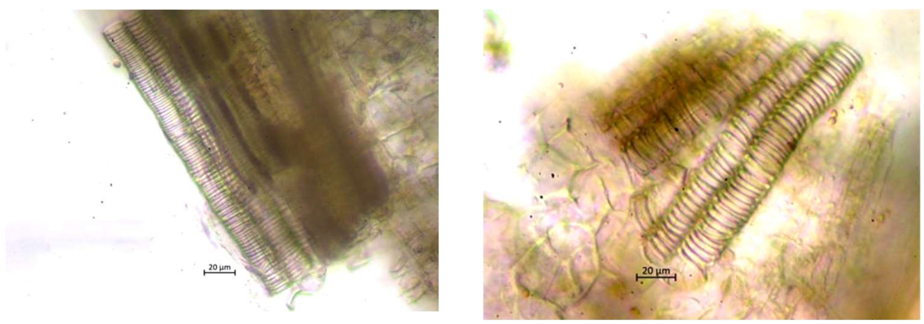


Epidermis with glandular trichomes

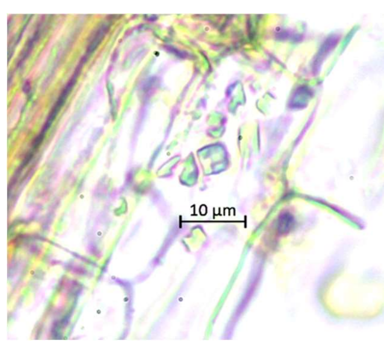
Epidermis in surface view with stomata



Palisade cells in sectional view



Spiral vessel



Prismatic crystals

Plate 15. Powder microscopy of *Anisomeles malabarica*

Table 18: Physiochemical analysis of *Anisomeles malabarica* leaves

S. No	Physiochemical Constants	Reports W/W%
1	Foreign Matter	Nill
2	Total Ash Value	5.08±0.08
3	Water Soluble Ash Value	1.076±0.038
4	Acid Insoluble Ash Value	1.653±0.003
5	Sulphated ash value	4.32±0.033
6	Loss on Drying.	5.08±0.086
7	Petroleum ether Extract	4.023±0.0145
8	Chloroform extract	5.66±0.66
9	Toluene extract	3.36±0.319
10	Ethyl acetate extract	1.043±0.02
11	Ethanol extract	8.03±0.03
12	50% Ethanol extract	4.66±0.33
13	60% Ethanol extract	9.36±0.31
14	70% Ethanol extract	3.71±0.35
15	Aqueous extract	14±0.57

Flow Properties Of The Powder	
Angle of repose	Θ = 27.175
Carr's index	0.2353
Hausner' s ratio	1.3077

Values are expressed in means of SEM ± Standard Error Mean

Qualitative Analysis Of Inorganic Elements And Heavy Metals In *Anisomeles Malabarica* Leaves.

PLATE 16: Qualitative analysis of inorganic elements and heavy metals analysis of *Anisomeles malabarica*.

Table 19: Qualitative analysis of inorganic and heavy metal

S.no	Inorganic elements	Observations
1	Aluminium	-
2	Arsenic	-
3	Borate	-
4	Calcium	+
5	Carbonate	-
6	Chloride	-
7	Copper	-
8	Iron	+
9	Lead	-
10	Mercury	-
11	Phosphate	-
12	Pottassium	+
13	Silver	-
14	Sulphate	+

The qualitative analysis of *Anisomeles malabarica* leaf ash powder revealed the presence of beneficial elements like calcium, iron, potassium, and sulphate, suggesting the plant's potential health benefits, including support for bone health, blood circulation, and detoxification. Importantly, no toxic heavy metals such as lead, arsenic, or mercury were detected, confirming the plant's safety for use in herbal formulations.

DISCUSSIONS

Numerical taxonomy is done to group species into higher taxa based on overall similarity. The resemblance among the individuals is then established on the basis of character (trait) analysis and the discrimination of taxonomic groups are chosen to study the overlapping characters. Numerical taxonomy proves to be a valuable tool in understanding the relationships between herbal plant species and their medicinal properties. The results provide insights into the classification of species based on multiple traits and highlight key species for further research and conservation efforts. The approach can significantly contribute to the discovery of new medicinal plants and the sustainable management of herbal resources[6].

The morphological characteristics of *Anisomeles malabarica*, such as its ovate-lanceolate leaves with a velvety upper surface and densely pubescent underside, align with traditional descriptions of species within the *Lamiaceae* family. The leaf shape, size, and the presence of crenate-serrate margins are distinctive features that are commonly observed in this genus. It emphasized that the shape and margin of leaves play a crucial role in the identification of medicinal plants, particularly within aromatic species like *Anisomeles malabarica*. The velvety texture observed in *A. malabarica* is attributed to the presence of trichomes on the leaf surface [7]. The morphology of the leaves in *Anisomeles indica, Anisomeles heyneana, and Anisomeles malabarica* reflects both shared characteristics and notable distinctions, indicative of their adaptations within the same genus. *Anisomeles indica* exhibits moderately sized leaves (3.8–10 x 5.5–6 cm) with an acute apex, crenate margins, and a softly pubescent surface, which gives it a delicate feel. *Anisomeles heyneana* shares some similarities, such as an acute apex and crenate margin, but has slightly larger, ovate-lanceolate leaves (5–12 cm) with an aromatic scent, enhancing its unique identity [8]. By contrast, *Anisomeles malabarica* is the largest of the three, growing up to 2 meters tall and featuring leaves that vary significantly in size (3.6–16 cm in length and 1.3–7 cm in width) apex and shape, depending on the leaf size. The leaves are velvety and lanate, with a woolly texture that may offer protection from environmental stress. This robust morphology and complex leaf structure, with features like a crenate-serrate margin and a stout petiole, distinguish *A. malabarica* and hint at its ecological versatility. These morphological differences not only highlight the diversity within the *Anisomeles* genus but also suggest potential variations in phytochemical profiles and environmental adaptations among the species [9].

The anatomical features of *Anisomeles malabarica* closely align with the descriptions of *Lamiaceae* family [7]. Microscopical studies revealed that the single-layered epidermis with cuticle, presence of unicellular covering trichomes and glandular trichomes, and ground tissue composed of collenchyma and parenchyma are consistent with typical *Lamiaceae* characteristics. The vascular bundles in *A. malabarica* are concentric and collateral, similar to those in *Lamiaceae* plants, with phloem surrounding the xylem and a pericyclic ring. The mesophyll structure, consisting of palisade and spongy parenchyma with intercellular spaces, also matches the *Lamiaceae* pattern. Additionally, the presence of starch grains and prismatic crystals in the ground tissue is typical for this family. *A. malabarica* has a nearly quadrangular petiole with a wavy outline, where the adaxial portion is flat and the abaxial portion is convex. The epidermal cells on both surfaces bear numerous simple unicellular covering trichomes, along with a few glandular trichomes. Notably, the adaxial side is broader, with extensive parenchymatous ground tissue containing collenchyma cells for structural support, a unique adaptation possibly enhancing mechanical stability. In contrast, *A. indica* and *A. heyneana* display more regular epidermal cells with polygonal shapes and a relatively thicker cuticle on the adaxial side, suggesting slight ecological or functional variations. In *A. malabarica*, the midrib has a single-layered epidermis with multiple layers of collenchyma cells below it, followed by parenchymatous ground tissue with a central, large, nearly circular vascular bundle that is conjoint, collateral, and closed. This arrangement includes a robust pericyclic layer, which is indicative of structural resilience. Conversely, *A. indica* and *A. heyneana* show a concavo-convex or plano-convex midrib shape with 4–6 layers of collenchyma cells beneath both epidermises, and in *A. heyneana*, air chambers are present beneath the stomata on the abaxial surface, potentially aiding gas exchange [8,9].

The lamina of *A. malabarica* has unicellular trichomes on both the upper and lower epidermis, with a differentiated mesophyll layer consisting of a two-layered palisade and a spongy parenchyma with intercellular spaces, which aid in photosynthesis and gas exchange. *A. heyneana* and *A. indica*, however, have dorsiventral leaf structures, with *A. heyneana* showing larger calcium oxalate and starch deposits in the spongy parenchyma, which may serve additional storage functions. Both species have a thicker cuticle on the adaxial surface, while *A. heyneana* also shows specialized non-glandular and glandular trichomes with mucilage presence in the epidermis, possibly to reduce water loss. *Anisomeles malabarica* displays a broad, crescent-shaped central vascular bundle surrounded by parenchymatous pericyclic layers, with smaller vascular bundles adaxially that are concentrically arranged. This arrangement differs from the collateral vascular bundle prominent in *A. indica* and *A. heyneana*, which are more centrally located within the midrib and surrounded by a bundle sheath. The ground tissue of *A. malabarica* has abundant prismatic crystals and starch grains, which suggest potential adaptations for storage or secondary metabolite accumulation. Similarly, *A. heyneana* contains broad calcium oxalate crystals and starch in the spongy parenchyma, indicating convergent features for storage, although the anatomical layout and size differ slight [8,9].

Microscopic leaf constants including stomatal number, epidermal cell number, stomatal index, vein islet number and palisade ratio were demonstrated in above table. The leaf constant measures for *Ansiomeles malabarica* of prior literary reports are vary from our current findings. In [10,11] S.I are 12 and 14 in upper epidermis and lower epidermis and V.I & V.T are 11-16 & 12-18 respectively. These values are highly differed from our findings this is because morphological changes due to the geographical and environmental factors. Determination of leaf constant number is also one of the useful tools in order to distinguish closely related species. The microscopic analysis of *Anisomeles malabarica* aligns well with standard anatomical descriptions, particularly for members of the *Lamiaceae* family. Key features such as multicellular trichomes and paracytic stomata indicate protective, secretory, and efficient gas exchange functions, which are common in medicinal plants [7]. The presence of palisade cells and spiral vessels supports efficient photosynthesis and vascular transport, both essential for the plant's metabolic activity and therapeutic properties. Additionally, prismatic calcium oxalate crystals contribute to defence and mineral storage, further highlighting its medicinal relevance. Finally powder microscopy was done to identify the microscopically structure for the purpose of authentication and to find the presence of adulterated substance.

Comparison of preceding research on physiochemical parameters with our current findings provides valuable insights into the shelf life and quality of medicinal plants. Factors such as moisturecontent, temperature, and environmental conditions significantly influence the shelf life of these plants. Studies have shown that moisture levels exceeding 8% can lead to insect infestation, while levels above 15% increase the risk of pathogenic contamination. According to Ayurvedic pharmacopeia standards, the total ash value should not exceed 13%, with water-soluble and acid- insoluble ash values not surpassing 1%. Alcohol extractive value is not less than 2.5%. Prior studies by (*Y.V Ushir et al., 2010, R. Sutharsingh et al., 2003, S. Disticraj et al., 2015, A.N Dharasurkar et al., 2019)* has investigated the physiochemical properties of *Anisomeles malabarica* leaves. Their findings indicate loss on drying percentages of 09.33%, 5.43%, and 5.43%, respectively, for *Anisomeles malabarica* leaves. Total ash values were found to be 11.65%w/w, 2.13w/w, 2.3%w/w, and 2.13%w/w, respectively, with acid-insoluble ash values of 2.56%w/w, 1.06%w/w, 1.06%w/w, and 1.06%w/w, and water-insoluble ash content of 04.46%w/w, 00.72%w/w, 0.72%w/w, and 0.72%w/w, respectively. The ethanolic extractive value of *Anisomeles malabarica* was determined to be 16.28%, 16.28%, and 11.71%, respectively. Comparing our results with the aforementioned literature, our proximate analysis values align closely with those reported by [12,13] and similar to the Ayurvedic pharmacopeia. Importantly, none of our values exceeded the standard thresholds, indicating a low risk of insect and microorganism invasion, thus enhancing shelf life. Moreover, our findings suggest no contamination in the powdered drug, which is essential for further studies. The characterization of powder flow properties plays a vital role in various stages of product development, manufacturing, and quality assurance. The Excellent flow property of powder having angle of repose between 25-30. Carr's index must be less than 10 and Hausner's ratio is between 1.0 -1.11, our findings are between these standard values, Thus A.M having good flow property. This documentation serves as a benchmark for authenticating herbal drugs, facilitating the detection of adulteration and standardization. It underscores the need for nationally recognized guidelines for assessing the quality of medicinal plants and the development of monographs to ensure their standardization.

The qualitative analysis of *Anisomeles malabarica* leaf ash powder revealed the presence of beneficial elements like calcium, iron, potassium, and sulphate, suggesting the plant's potential health benefits, including support for bone health, blood circulation, and detoxification. Importantly, no toxic heavy metals such as lead, arsenic, or mercury were detected, confirming the plant's safety for use in herbal formulations. While certain elements like boron and copper were absent, this does not affect the plant's medicinal value.

CONCLUSION

The pharmacognostic evaluation of *Anisomeles malabarica* confirms its suitability as a medicinal plant with significant therapeutic potential. Anatomical and physiochemical studies revealed unique structural adaptations and chemical properties that align with its traditional uses. The absence of toxic heavy metals and compliance with pharmacopeial standards ensure its safety for herbal formulations. Numerical taxonomy and DNA barcoding further elucidated its classification and phylogenetic relationships. This comprehensive characterization provides a robust foundation for its standardization and paves the way for future research into its pharmacological applications.

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