

Anatomy and powder microscopy of *Curcuma sumatrana* Miq. (Zingiberaceae)

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Manuscript received: 15 January 2024. Revision accepted: 18 February 2025.

Abstract. Yuhendri R, Nurainas, Maideliza T, Meriko L, Alponsin, Abdul Wahab IR. 2024. Anatomy and powder microscopy of *Curcuma sumatrana* Miq. (Zingiberaceae). *Biodiversitas* 25: 900-908. *Curcuma sumatrana* is a wild plant endemic to West Sumatra and is believed to possess various therapeutic values that are beneficial in treating multiple diseases. This research aimed to characterize the anatomy of leaves, roots, and rhizomes through permanent preparations and powder microscopy to contribute to its phytochemical analyses. Observations of anatomical characteristics were carried out using a light microscope and photographed using the DP2-BSW application. The anatomical study of the leaf revealed its upper and lower epidermis thickness to be 49.8 μm and 31.7 μm , respectively. Furthermore, its mesophyll thickness was 48.9 μm , and the leaf type was unifacial, containing prism-shaped crystals, and covered with non-glandular trichomes. Its trichome height was 146.3 μm , aerenchyma area was 198.1 μm , and vessel area was 284 μm . On the other hand, the anatomical structure of the root showed cortex thickness of 292.7 μm , endodermis thickness of 5.9 μm , xylem diameter of 34.7 μm and pith thickness of 244.6 μm . Meanwhile, the anatomical structure of the rhizome consisted of eccentric starch, sand-shaped crystals, cortex thickness of 957 μm , and endodermis thickness of 7.37 μm . The powder analyses of its leaf showed clear structure of the xylem, epidermis, stomata, and trichomes. In contrast, its root and rhizome showed eccentric starch, spiral-type xylem vessels, fiber, oil glands, and cortex. In conclusion, the anatomical characteristics of *C. sumatrana* do not show significant differences from other species in the *Curcuma* genus, except in terms of the color of the rhizome. The rhizome of *C. sumatrana* is pale purple, while *C. longa* has a deep yellow rhizome, *C. aeruginosa* has a blue rhizome, and *C. heyneana* has a light yellow rhizome.

Keywords: Epidermis, cortex, crystal, oil gland, stomata

INTRODUCTION

The genus *Curcuma* is one of the largest genera in the Zingiberaceae family and consists of about 80 species, mainly distributed across Southeast Asia, South Asia, and China (Subositi and Wahyono 2019). *Curcuma* has been used in various traditional medicines for centuries, including to treat digestive disorders, pain, inflammation, wounds, cancer, aging, and others (Dosoky et al. 2018). Rahaman et al. (2021) also revealed that the genus *Curcuma* has been widely used for therapeutic purposes in traditional medicine worldwide, one of which is anti-inflammation.

Curcuma sumatrana Miq. is one of the species of the genus *Curcuma* endemic to West Sumatra, whose existence was only rediscovered in 2011. Previously, *C. sumatrana* was described by Miquel in 1861 in its original description, "Sumatra occid in Pariaman". This refers to a collection by Dielpenhorst, but the collection number was not stated. The distribution of *C. sumatrana* itself was found in the areas of Maninjau, Sianok, Anai Valley, Kayu Tanam, and Ulu Gadut (Adriani et al. 2011). Currently, *C. sumatrana* is experiencing a decline in the population in the environment and is even threatened with extinction. This is because *C. sumatrana* is a wild plant rarely used by the public. Only a small number of people in the Maninjau area use its boiled water as an itching medicine. Thus, *C. sumatrana* is categorized as Vulnerable according to the Red List Category and

Criteria: Bab (iii); D1 ver 3.1 (Nurainas and Adriani 2019).

To maintain its sustainability as well as to provide supplies continuously, the first step that can be taken is to conduct a study of anatomical microscopy and powder of *C. sumatrana* with the aim of characterizing the anatomical structure and potential phytochemicals in *C. sumatrana*. This is based on the fact that several species of the *Curcuma* genus have the potential to be medicinal, such as *Curcuma longa*, *Curcuma zedoaria*, *Curcuma aeruginosa*, *Curcuma manga*, *Curcuma zanthorrhiza*, *Curcuma aromatica*, *Curcuma caesia* and others.

Several studies on the anatomical structure of the Zingiberaceae family have been carried out by researchers, including Trimanto et al. (2018), who reported on the morphology, anatomy, and histochemical tests of *C. aeruginosa* rhizomes, *C. longa*, and *C. heyneana*. The observation of anatomical structures of the rhizome showed that the starch grains were medium size and that the shape of starch was oval. Rhizomes of *C. longa* and *C. aeruginosa* have shown a positive correlation for starch, protein, lipids, alkaloids, flavonoids, and tannins. In addition, *C. heyneana* showed the highest protein density value while *C. longa* exhibited the highest density value of lipids, alkaloids, flavonoids, and tannins.

Previously in 2014, Uma and Muthukumar (2014) reported an anatomical and morphological comparative study among the root of 23 species from three tribes and

eight genera of Zingiberaceae. The prominent anatomical characters in the roots were as follows: all the gingers examined had a piliferous epidermis, followed by an exodermis, which contained one or more layers of compact, suberized cells. The cortex had two regions (outer and inner layers) with intercellular air spaces that were radially extended and linear, which were observed in *Curcuma* sp. Phloem strands in *Curcuma* sp. often extended radially inwards, forming phloem islands. The peripheral ground tissues of the stele were mostly fibrous and occasionally parenchymatous. The medulla commonly occupied the centre of the stele. Oil cells were found in members of the tribe Zingiberaceae. In addition, Roy et al. (2013), in their research revealed that morphologically, the rhizomes of *C. caesia* were grey in color, while yellowish-orange to orange in *C. longa*. Moreover, the hypodermal layer of *C. caesia* is constituted by one or two-three layers of cells. Anatomically, hypodermal layer of *C. caesia* is constituted by one or two-three layers of cells.

This study aimed to investigate the anatomical structure and microscopic characteristics of the leaves, roots, and rhizomes of *C. sumatrana*. This research leads to future phytochemical and pharmacological studies, which will contribute to the development of natural products across various industries, from agriculture and food production to pharmaceuticals and cosmetics. The exploration highlights the need for sustainable cultivation practices that can reduce environmental impact and provide a more stable supply chain, which is crucial in product development.

MATERIALS AND METHODS

Plant material

A sampling of *C. sumatrana* was carried out in June 2021 in the Kambang area (1°38'41.2"S 100°49'36.7"E),

West Sumatra, Indonesia. The sample was identified by a botanist, Dr. Nurainas from the Department of Biology, Faculty of Mathematics and Natural Sciences, Universitas Andalas, Padang, Indonesia. The herbarium sample was deposited at ANDA herbarium with the voucher number 00049122.

Permanent slides

The method used in the permanent preparations was, according to Sass (1951): the paraffin modification method and safranin-alcian blue dye as a dye for plant tissue and fresh incisions in paradermal incisions. The procedure for making permanent preparations is shown in Table 1.

Furthermore, powder observations were carried out: powder was filtered with 60 mesh and then observed under a microscope. To follow other tissue fragments, it was necessary to remove excess starch before the fragments were clarified with chloral hydrate and observed directly under a microscope. The powder features were observed using the Olympus CX23 compound microscope and photographed using the DP2-BSW application.

RESULTS AND DISCUSSION

Anatomy of *Curcuma sumatrana* root

An observation of the structure of the transverse section of the root of *C. sumatrana* was found to be a single layer of epidermis with an irregular polygonal shape. The cortex consisted of seven layers of cells with a thickness of 292.73 μm , one endodermis layer with a thickness of 5.85 μm , xylem with a thickness of 34.73 μm , and a pith with a thickness of 244.59 μm . Besides that, there are also protoxylem, metaxylem, phloem, and sclerenchymatous (Figure 1).

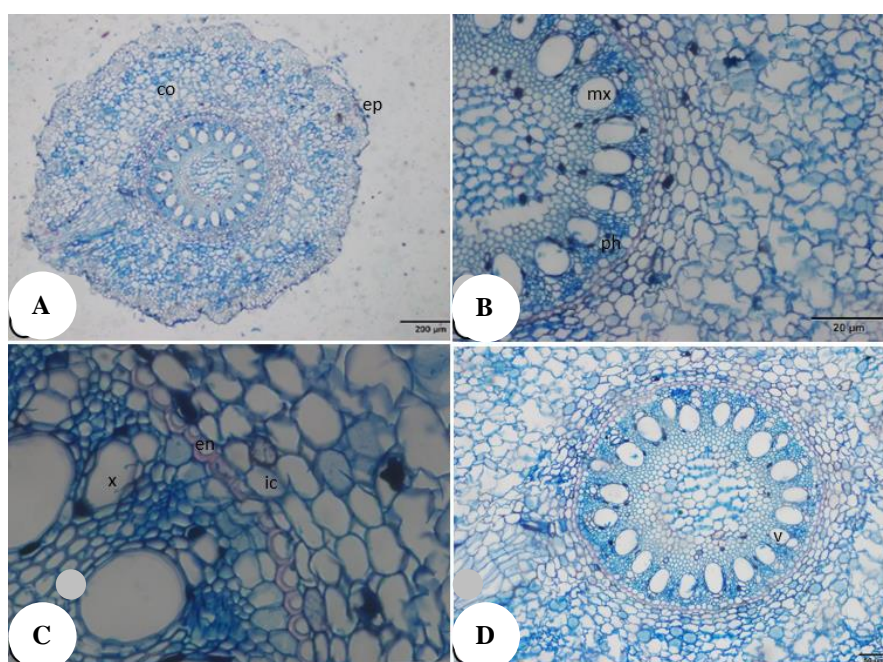


Figure 1. Root anatomy (transverse section) and tracheary elements of *Curcuma sumatrana*. Magnification of A: 200 μm , B and C: 20 μm , D: 50 μm . ep: epidermis, co: cortex, mx: metaxylem, ph: phloem, x: xylem, en: endodermis, ic: inner cortex, v: vessel

Table 1. Procedure for making permanent preparations

Procedure	Activity	Solvents	Time
Sample	Plant organs in the form of stems, roots, and leaves	-	-
Fixation	Samples were collected in vials by adding the FAA50 solution	FAA (Alcohol 96% : Aquades : Formalin 40% : Glacial acetic acid (50:35:10:5))	24 hours
Aspiration/ vacuum	Use a respirator/aspirator to remove air from tissues	-	-
Dehydration	Removing water from the network	Alcohol 70 % Alcohol 80 % Alcohol 90 % Alcohol 100 % Alcohol : xylol (1:3) Alcohol : xylol (1:1) Alcohol : xylol (3:1) Xylene (3 x) Xylene: paraffin (1:9) In incubator 58 °C	30 minutes 30 minutes 30 minutes 30 minutes 1 hour 1 hour 1 hour 1 hour 12 hours
Infiltration	Paraffin infiltration into tissues	In incubator 58 °C	12 hours
Embedding	Embedding of plant samples in pure hard paraffin	In incubator 58 °C	
Mounting	Attaching the sample to the embedding mould or wooden block	-	-
Sectioning	Slice the paraffin to form ribbons	-	-
Mounting	Attaching the ribbon to the object glass	Mayer's albumin	
Staining	Stain the tissue with safranin-alcian blue	Xylene I Xylene II Absolute alcohol I Alcohol 96% I Alcohol 96% I Safranin 1% in alcohol 70% Alcohol 96% Alcian blue 1% in alcohol 96% Alcohol 96% Absolute alcohol II Absolute alcohol III Xylene III Xylene IV	5 minutes 5 minutes 5 minutes 5 minutes 5 minutes 1-3 hours 5 minutes 5 minutes 5 minutes 5 minutes 5 minutes 5 minutes 5 minutes
Mounting	Coverglass sealed with a mounting agent	Entellan	-
Observation	Observe the preparation under the microscope	-	-

Findings obtained in the present study agree with those of Uma and Muthukumar (2014), who revealed that the roots of *Curcuma* sp. were uniseriate epidermis that contained unilocular pads with unicellular hairs. The exodermis consisted of multiseriate (three-layered) cells that had suberized walls. The cortex consisted of 5-15 layers, and the parenchyma consisted of 3-5 layers. Parenchyma showed no intercellular space. Furthermore, endodermis characteristics were uniseriate, anisotropic cells with thickened 'U'-shaped walls in *C. longa*, *C. zedoaria*, and *C. amada* but thin-walled in *C. aromatica*. The pericycle was uniseriate, with thin-walled cells. The vascular cylinder consisted of 12-15 arches, with vascular elements having scalariform perforated plates. Phloem bundles were arranged linearly. The vascular bundles were in sclerenchymatous connective tissue. The pith cells were polygonal, parenchymatous, and had no intercellular space except in *C. amada*.

Several studies have shown that the roots of several genera of *Curcuma* have the same root anatomical structure. However, the shape, volume, and size of cells are different. The differences in shape, amount, and size of cells can be influenced by environmental conditions and

where the plant grows. Batista et al. (2013) reported that the growth of corn (*Zea mays*) roots is affected when exposed to aluminum (Al) solution, resulting in fewer lateral roots and reduced root system development.

Anatomy of *Curcuma sumatrana* rhizome

An observation of the anatomical structure of *C. sumatrana* rhizome was carried out utilizing transverse and longitudinal incisions. Observations of the transverse incision showed that the epidermis consisted of one layer and pale brown cork cells; the endodermis layer was located between the cortex and the stele; the rhizome along with yellowish oil cells were scattered; and the parenchyma cells contained many eccentric starch grains and scattered vascular bundles (Figures 2.A, 2.B, 2.C). In addition, the longitudinal incision showed spiral-shaped vessels. The cortical area was divided into an outer and an inner layer by a thin-walled endodermis. The pericycle was located beneath the endodermis. The vascular bundles were scattered throughout the cortex, more abundant just below the endodermis, and varied in size (Figures 2.D, 2.E).

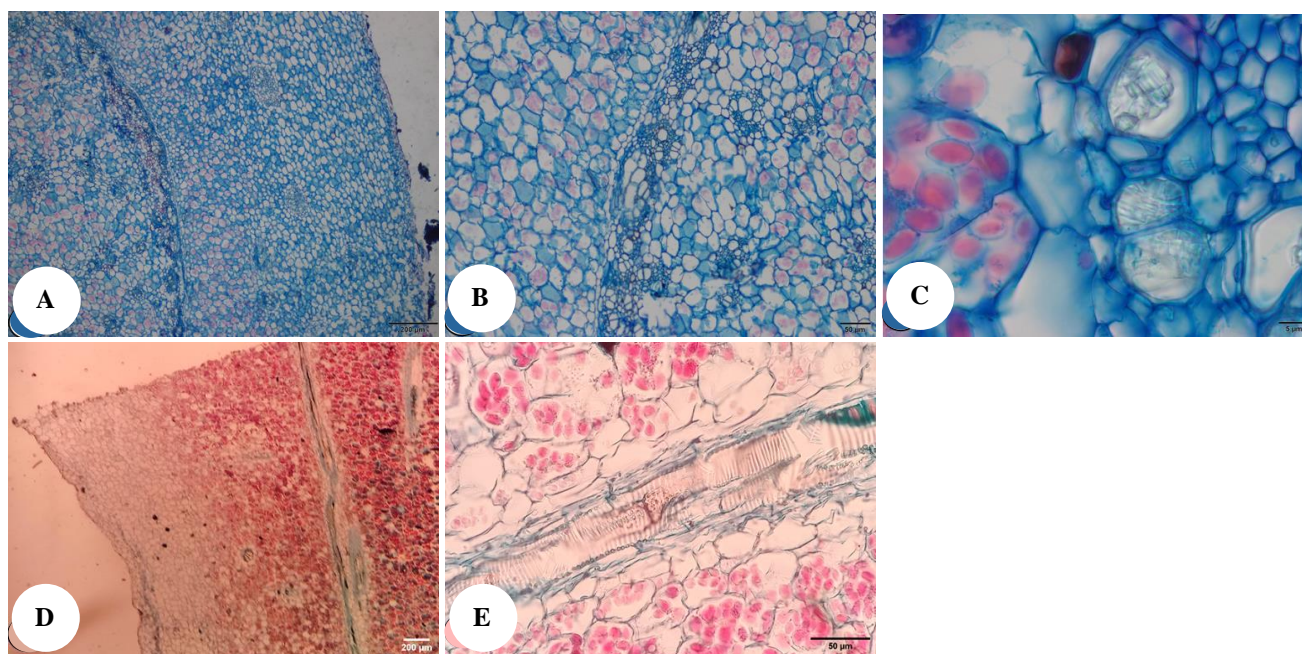


Figure 2. Anatomy rhizome of *Curcuma sumatrana*. A-C: transversal, D-E: longitudinal. Magnification of A and D: 200 μm , B and E: 50 μm , C: 5 μm . ep: epidermis, vb: vascular bundle, en: endodermis, str: starch, v: vessel

Findings from the present study were corroborated by those of Trimanto et al. (2018), who reported the presence of a thin layer epidermis of the rhizome of *C. aeruginosa* (black turmeric), particularly the ones cultivated in Indonesia. Besides that, its hypodermis consisted of 3-6 layers of small cells, while its endodermis consisted of two layers of cells. Starch grains were found in parenchyma cells. Oval starch grain shape had a medium size between 15-22.5 μm .

The carrier bundles were scattered throughout the rhizome. The type of carrier bundle in the black currant rhizome was closed collateral. Oil cells, the epidermis, and the hypodermis of the *C. longa* (turmeric) rhizome were not observed. The endodermis consisted of two layers of cells, and there was a transport bundle. Oil cells were brownish-yellow, spherical, and 70 μm in size. The carrier bundles were scattered throughout the rhizome. The type of carrier bundle in the turmeric rhizome was closed collateral. Starch grains were oval and round with a size of 20-30 μm . The epidermis of the slices of temu giring (*C. heyneana*) rhizome was a flat layer of cells consisting of 3-6 layers of small cells. Medium-sized oval starch grains measured 10-20 μm . The carrier bundles were scattered throughout the rhizome. The type of carrier bundle in the temu giring rhizome was closed collateral.

Anatomy of *Curcuma sumatrana* leave

The anatomical structure of the leaf crosswise consisted of a hexagonal-shaped epidermis with a thickness of 49.79 μm at the top and 31.72 μm at the bottom; isobilateral type mesophyll with a thickness of 48.94 μm ; vascular tissue with an area of 284.01 μm^2 ; trichomes with a height of

146.31 μm ; and prism-shaped crystals scattered in the mesophyll with a width and height 0.625-2.428 μm . Meanwhile, longitudinally, stomata were found on both sides of the leaf of the amphistomatic type with a density of 101.91 mm^{-2} ; trichomes with a height of 146.31 μm ; and oil pockets in the epidermis (Figure 3A-F). A similar finding was reported by Anuwong et al. (2014), who observed that in a transverse section of the leave of *Curcuma alismatifolia*, the epidermis consisted of a single, irregularly polygonal layer. The exodermis was composed of three layers, and the cortex was primarily made up of parenchyma cells. The pericycle was single-layered, and the vascular bundles were radial and exarch. The phloem bundles alternated with the xylem vessel members. The pith consisted of polygonal parenchyma cells with some intercellular spaces, and numerous starch grains were present within these cells.

The petiole of *C. sumatrana* was in a horseshoe-like shape, meanwhile, other types of *Curcuma* showed different shapes, for example, the petiole of *C. caesia*, *C. haritha*, *C. aeruginosa*, *C. pseudomontana*, *C. zanthorrhiza*, and *C. amada* were 'U'-shaped (Anu and Dan 2020) whereas *C. aurantiaca* and *C. oligantha*, *C. aromatica*, *C. vamana* and *C. zedoaria* were 'V'-shaped. The petiole anatomical characters in the genus *Curcuma* varied, and it was not easy to identify and limit the taxa based solely on the shape of the petiole line. Talip et al. (2017) revealed that the anatomical characteristics of leaf petioles have taxonomic value and are valuable for species identification and classification. However, it is also necessary to consider relevant molecular, ecological, and plant morphological data.

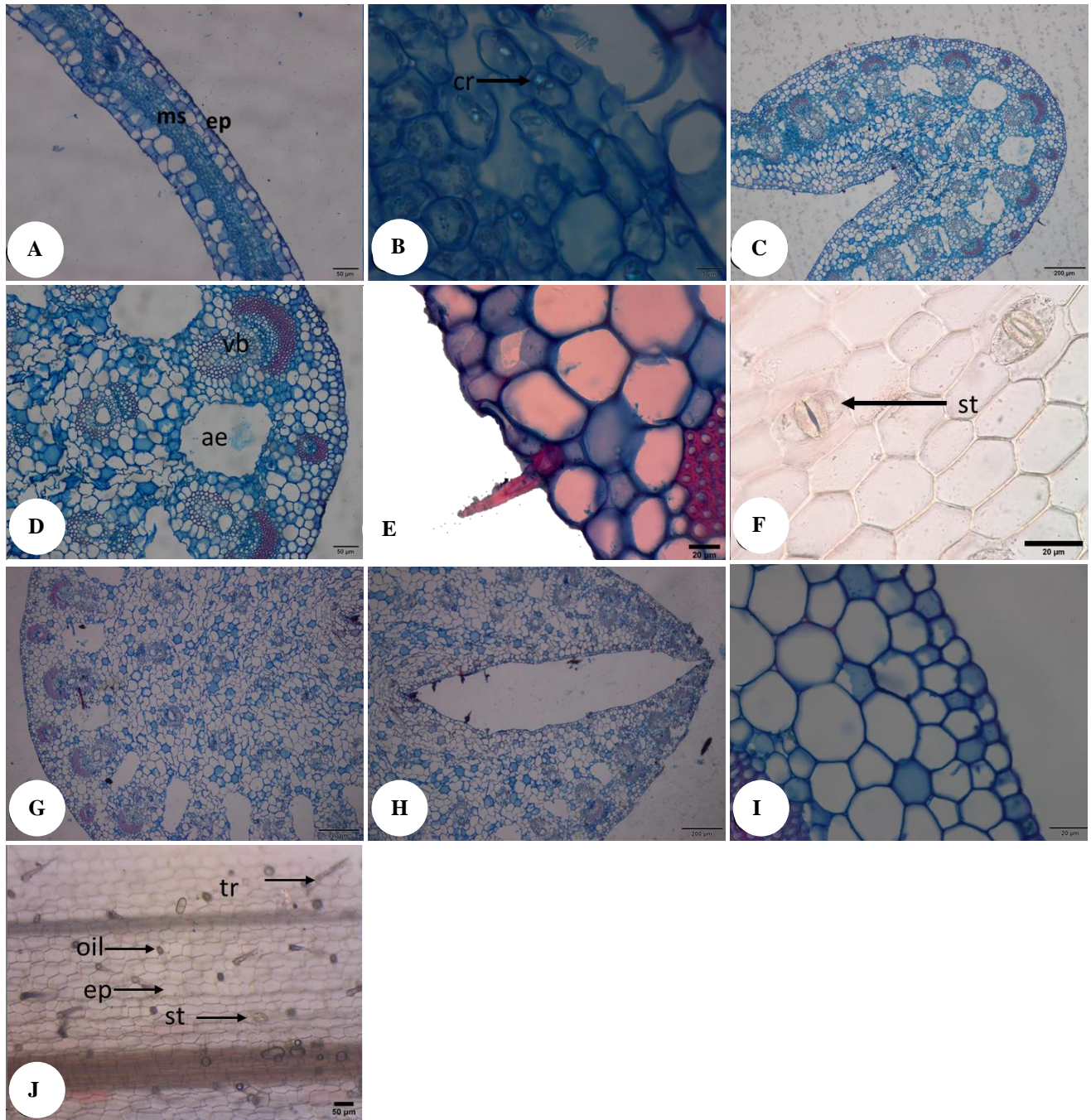


Figure 3. Leaf anatomy of *Curcuma sumatrana* (transverse section) and (longitudinal section k,f). A-F: lamina; G-J: petiole. Magnification of A, D, and J: 50 µm, B: 5 µm, C, G, and H: 200 µm, and E, F and I: 20 µm). ep: epidermis, ms: mesophyll, st: stomata, ae: aerenchyma, fb: fiber, tr: trichomes, par: parenchyma, oil: oil glands, vb: vascular bundle, cr: crystal

The epidermis on the petiole of *C. sumatrana* was in the form of a uniseriate circle with the same adaxial and abaxial cell sizes, and non-glandular trichomes were found (Figures 3.G-3.K). Anu and Dan (2020) reported that the epidermis with circular cells was found in *C. caesia*, *C. oligantha* and *C. pseudomontana*, while in other species, *C. aeruginosa*, *C. amada*, *C. aromatica*, *C. aurantiaca*, *C. haritha*, *C. vamana*, *C. zanthorrhiza*, *C. zedoaria*, and *C. longa* the cell shape was different, such as elliptical, rectangular or irregular, with a cuticular outer wall. Unicellular non-

glandular trichomes were found on the adaxial and abaxial surfaces of *C. aurantiaca*, with high density on the transverse incision. On the other hand, other species lacked trichomes. The presence or absence of trichomes in the petiole epidermis is taxonomically crucial when the trichome type, distribution, and density provide identification at the genus and even species level. The trichome characters are reported to be taxonomically useful at various levels in Leguminosae, Lamiaceae, Rosaceae, and Asteraceae (Mabel et al. 2013; Atalay et al. 2016).

Powder characteristic of *Curcuma sumatrana*

The powder analysis was conducted to differentiate *C. sumatrana* from other species in *Curcuma*, concerning its characteristic. The powder rhizome was pale yellow with a characteristic odour. Examination of the rhizome powder found epidermis, cork, parenchyma, spiral, and scalar vessels, insulated fibers, simple starch granules, and oil droplets (Figure 4.C). The diagnostic character of starch was abundant in the form of flat to oval, simple starch granules of 27-60 μm long and scattered oil droplets. Besides that, 5-9 layers of thin wall, polygonal pale brown cork together with lignified spirals, and scalar vessels associated with parenchyma containing simple starch granules were found. In addition, sparse epidermis and yellowish septate fibers were also observed. Meanwhile, a microscopic examination of the powder on the leaves of *C. sumatrana* showed epidermis, non-glandular trichomes, stomata, spiral xylem, and crystals (Figure 5).

Observations of *C. longa* rhizome powder that was carried out by Amel (2015) revealed that the parenchymal cell fragments had many irregular shapes. The parenchyma fragments had an oval shape with slightly irregular thin walls, fibers, scattered oil droplets, pointed trichomes with thickened walls, and square vessels with spiral thickening. Cork fragments were pale brown with thin walls and polygonal. Oxalate crystals were prismatic, oval in shape and irregular starch in considerable amounts.

Abraham et al. (2018) stated that the rhizome powder *C. longa* was yellow. Microscopic analysis of the powder revealed the presence of fibers having an average length of

$353.33 \pm 116.71 \mu\text{m}$, ranging from 560 μm to 140 μm . There were mostly oval simple starch grains and round in shape abundantly found. The average dimensions of the starch grains were $20.52 \pm 6.73 \mu\text{m}$ by $14.12 \pm 4.72 \mu\text{m}$. Spiral vessels with diameters of 42 μm to 56 μm were also observed. Cells with oleoresin had an average length of $107.33 \pm 28.92 \mu\text{m}$ and an average breadth of $74.67 \pm 11.43 \mu\text{m}$.

Fatima et al. (2020) revealed that the *C. longa* powder had parenchyma with orange-yellow or yellowish-brown secretory cells, starch granules, xylem vessels, reticulate vessels, parenchyma, cork cells, fibre, trichome, and single xylem vessel. In another observation conducted by Chen et al. (2022) on the root and rhizome powder of *C. sahynehensis*, it was noted that the powder has a dark-brown color with a light spicy taste and aroma, exhibiting a specific odour. Microscopic examination revealed the presence of numerous fragments of lignified, lemon-yellow epidermal cells with polygonal and irregular shapes, as well as elongated-polygonal fragments of epidermises. There were thickened spiral vessels and scalariform vessels in fragments of xylem vessels. Additionally, red-brown oleoresin masses were also detected. Numerous starch granules were observed, which were ovoid or oval in shape and had diameters ranging from 15-20 μm . The generally branched hilum of starch granules appeared punctate or short-streaked, with the hilum located at the small end of the seed being ovoid. These granules formed well-defined concentric lines or were absent.

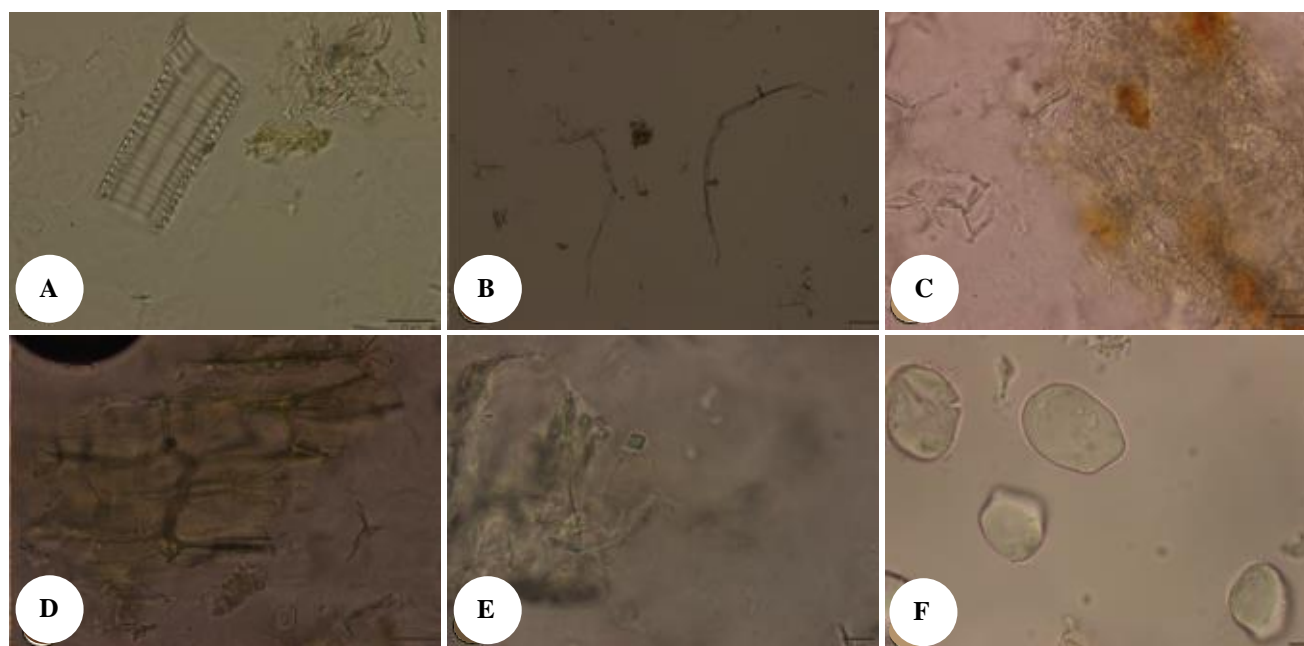


Figure 4. Rhizome microscope powder of *Curcuma sumatrana*. Magnification of A, B and D: 20 μm , B: 50 μm , and E and F: 5 μm . v: vessel, fb: fiber, oil: oil glands, co: cortex, cr: crystal (str) starch

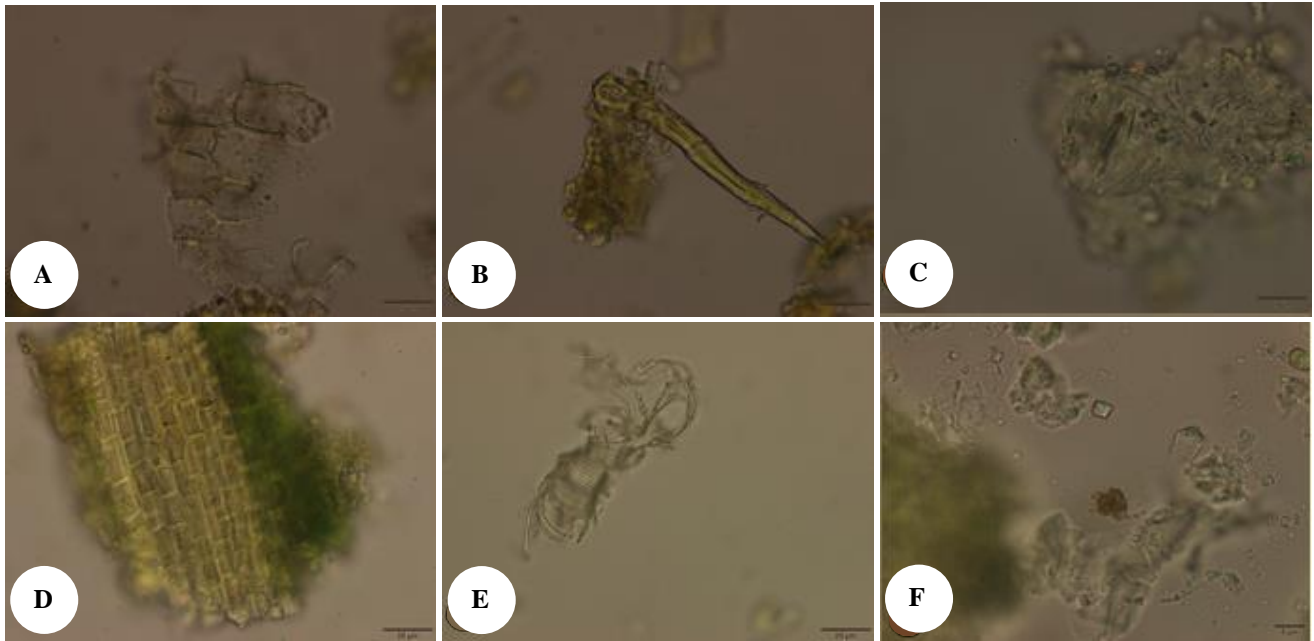


Figure 5. Leaf and flower microscope powder of *Curcuma sumatrana*. A-C: flower, D-I: leaf. Magnification of A-E: 20 μ m, and F: 5 μ m. ep: epidermis, tr: trichomes, st: stomata, md: midrib epidermis, v: vessel, cr: crystal

Discussion

The anatomical structure of *C. sumatrana* and other species belonging to the *Curcuma* genus showed no difference. The genus *Curcuma* generally had the same structure and character (Anu et al. 2020). One of the differences in the morphology structure of the rhizome of *C. sumatrana* and the genus *Curcuma* was seen in the color of the rhizome itself. The rhizome of *C. sumatrana* was pale purple in color, whereas *C. longa* was dark yellow, *C. aeruginosa* was blue, and *C. heyneana* was light yellow. Meanwhile, the anatomical structure of *C. sumatrana* and the genus *Curcuma* was the same.

The anatomical study of *C. sumatrana* roots, rhizomes, leaves, and petioles has revealed a distinctive structure that not only enhances the understanding of its botanical intricacies but also holds significant implications for authentication and justification of its use in various applications, especially as simplicia powder, medicinal agents, and microscopic powder.

The roots exhibit unique single-layered irregular polygonal epidermis, suggesting a specialized surface adaptation, potentially linked to environmental conditions or specific ecological interactions. The seven-layered cortex provides robust structural support, while the one-layered endodermis and well-defined xylem demonstrate efficient water and nutrient transport, respectively. The substantial thickness of the pith indicates a vital storage region. The intricate vascular system, including protoxylem, metaxylem, phloem, and sclerenchymatous tissue, aligns with the consistent vascular arrangements within the *Curcuma* genus (Uma and Muthukumar 2014). Furthermore, the study validates the findings of Anuwong et al. (2014) regarding the roots of *C. alismatifolia*, emphasizing shared epidermal characteristics, suberized walls in the exodermises, and the arrangement of

vascular bundles. These consistent observations bolster the argument for a shared anatomical blueprint among various *Curcuma* species.

Delving into rhizome anatomy, specific traits such as the one-layered epidermis, pale brown cork cells, and the presence of vascular bundles in *C. sumatrana* underscore its structural adaptability. The presence of eccentric starch grains in parenchyma cells suggests a potential role in nutrient storage. Noteworthy regional variations, highlighted through comparisons with Trimanto et al. (2018) study on *C. aeruginosa* rhizomes in Indonesia, emphasize the necessity of considering geographical factors in anatomical analyses.

Moving to leaf anatomy, the complex structure of the hexagonal-shaped epidermis, isobilateral mesophyll, trichomes, and prism-shaped crystals in *C. sumatrana* likely contributes to functions such as water retention, defense mechanisms, and light absorption. Similar characteristics observed in *C. alismatifolia* leaves, as reported by Anuwong et al. (2014), strengthen the argument for shared anatomical traits within the *Curcuma* genus. The discussion extends to petiole anatomy, highlighting the diversity among different *Curcuma* species. The uniseriate circle epidermis in *C. sumatrana*, contrasting with other species with varied shapes, emphasizes the taxonomic challenges associated with petiole morphology. The presence of non-glandular trichomes on both adaxial and abaxial surfaces provides additional taxonomic markers (Anuwong et al. 2014). The leaf trichomes in Proteaceae, including the basal cell, stalk cell, and terminal cells, have been found to have taxonomic value and ecological significance (Antipin and Choob 2019). Trichomes on *Cucurbita* petioles are involved in petiole movement and may function as part of the plant's biomechanical system (Zajączkowska et al.

2015). Leaf epidermal micromorphological features, including stomata and trichomes, are reliable taxonomic markers in *Capsicum annuum* (Zhigila et al. 2015).

The results indicate that the anatomical characteristics of the roots of *C. sumatrana* have a cross-sectional structure with a single, irregularly shaped, polygonal epidermis. The cortex is composed of seven layers of cells, accompanied by a single layer of endodermis, a single layer of xylem, and a single layer of pith. Additionally, there are also protoxylem, metaxylem, phloem, and sclerenchyma. The anatomical observation of the rhizome of *C. sumatrana* was conducted through transverse and longitudinal sections. In the transverse section, the epidermis consists of a single layer of light brown cork cells; the endodermis layer is located between the cortex and stele; the rhizome contains scattered yellowish oil cells; and the parenchyma cells contain numerous eccentric starch grains and dispersed vascular bundles. In the longitudinal section, spiral-shaped vessels are clearly visible. The cortical region is divided into outer and inner layers by a thin-walled endodermis, with the pericycle located beneath the endodermis. Vascular bundles are dispersed throughout the cortex, predominantly beneath the endodermis, and vary in size. The leaf anatomy in cross-section shows a hexagonal-shaped epidermis, isobilateral mesophyll, and prismatic crystals scattered in the mesophyll. Longitudinally, stomata are found on both sides of the amphistomatic-type leaves, along with trichomes and oil glands in the epidermis. The rhizome powder is pale yellow with a distinctive odor.

Examination of the rhizome powder revealed the presence of epidermis, cork, parenchyma, spiral and scalariform vessels as well as isolated fibers. Diagnostic characteristics show abundant starch in the form of flattened to oval simple granules and dispersed oil droplets. Additionally, 5-9 layers of pale brown, thin-walled, polygonal cork, lignified spirals, and scalariform vessels associated with parenchyma containing simple starch granules were also found. Sparse epidermis and yellowish septate fibers were also observed. The characteristics signify the authenticity of *C. sumatrana* powder as stated by Osman et al. (2019), who demonstrated that microscopy analysis is a simple and rapid tool for assessing the purity of raw material powder based on plant tissue characteristics.

The comprehensive anatomical exploration of *C. sumatrana* contributes not only to our understanding of its structural adaptations but also plays a crucial role in the authentication and justification of its utilization as a simplicia powder, medicinal agent, and microscopic powder. The anatomical exploration of medical plants, including their powder characteristics, serves as a key identifier for species authentication and quality control in herbal medicine (Ichim et al. 2020). This approach, which combines traditional knowledge with scientific authentication, is crucial for the sustainable and effective use of medical plants in various herbal applications, including the food and pharmaceutical industries. Similar studies have been conducted on other medicinal plants, such as *C. spectabilis* (Shehu et al. 2021). Research on the anatomy of *C. sumatrana* is important to relate its structure to the presence of phytochemicals in the plant. Phytochemical studies are

important to justify the potential of *C. sumatrana* as functional food or medicinal ingredients. This holistic approach, combining traditional knowledge with scientific authentication, strengthens the foundation for the sustainable and effective use of *C. sumatrana* in various herbal applications, emphasizing its potential in the food and pharmaceutical industries. Since this is the first report regarding the anatomical study of *C. sumatrana*, it can be used as a reference for other studies in this field.

In conclusion, this study provides the first-ever information on the anatomical and microscopic characteristics of *C. sumatrana*. The characterization of its root, rhizome, leaf, and powder structures reveals similarities with several other *Curcuma* species, such as *C. longa*, *C. zedoaria*, *C. amada*, *C. aromatica*, *C. aeruginosa*, and others. These similarities include the anatomical structure of the root, rhizome, and leaf, which consist of the epidermis, cortex, metaxylem, phloem, xylem, endodermis, inner cortex, vessels, starch, vascular bundles, stomata, aerenchyma, parenchyma, trichomes, crystals, oil glands, and mesophyll. The powder analysis of its leaf shows clear structures of xylem, epidermis, stomata, and trichomes. In contrast, the powder analysis of its root and rhizome reveals the presence of eccentric starch, spiral-type xylem vessels, fibers, oil glands, and cortex. The findings of this study can serve as a monograph for the identification and standardization of *C. sumatrana* as a medicinal material and contribute to further research on its chemical composition and potential biological activities.

ACKNOWLEDGEMENTS

The authors would like to thank Dr. Wilson Novarino, Head of the Biology Department, Faculty of Mathematics and Natural Sciences, Universitas Andalas, Padang, Indonesia, for providing all the facilities to conduct this research. The appreciation also goes to Universiti Malaysia Kelantan, Malaysia and Universitas Andalas, Indonesia for supporting the research through UMK Matching Grant (Grant Code: R/MATCH/A0700/00290A/006/2025/01428).

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