BOTANICAL CHARACTERISTICS OF HOANG CAM (*Scutellaria baicalensis* Georgi) CULTIVATED IN BAC HA, LAO CAI

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Abstract

Hoang cam (*Scutellaria baicalensis* Georgi), *has been used as a medicinal herb for over 2000 years in East Asian countries and is recorded in the Chinese Pharmacopoeia. Our study aimed to comprehensively describe the morphological and anatomical characteristics of Hoang camcultivated in Bac Ha, Lao Cai, contributing to the completion of species identification, reference, and providing data for implementing technical measures to increase the yield of medicinal herbs. The results showed that: Hoang camhas a tuberous root with few branches, young stems with four edges. Leaves are simple, opposite, lanceolate, with pinnate venation. Flowers are solitary, bisexual; corolla is purple, divided into two lips; 4 stamens, triangular anthers, superior ovary. Fruit is a schizocarp, with a persistent calyx. Seeds are oval, black. The root anatomy has a circular cross-section, with many layers of periderm covering the outside, secondary xylem, and abundant stone cells. The stem anatomy has a square cross-section, with convex corners, vascular bundles concentrated at the four convex corners, with sclerenchyma and thick tissue protecting the bundle apex, and abundant pith parenchyma. Leaf anatomy has a hairy epidermis, specialized parenchyma occupying a large area, and small vascular bundles.*

Keywords: *Morphology, anatomy, Scutellaria baicalensis Georgi, Hoang cam.*

I. INTRODUCTION

Scutellaria baicalensis Georgi, belonging to the *Scutellaria* genus of the Lamiaceae family, is commonly known as Hoang cam. The *Scutellaria* genus comprises approximately 300 species distributed across temperate, subtropical, and tropical regions of Asia, Europe, Africa, and several Pacific islands. In Vietnam, this genus includes 15 species, most of which grow naturally. Only one of these was introduced from the former Soviet Union in 1975 and is cultivated in the Medicinal Plant Garden of the Institute of Medicinal Materials in Sapa (Do Huy Bich et al., 2006). Hoang cam thrives in the cool, humid climate of high mountainous regions. Plants cultivated in Sapa grow well under average annual temperatures of 13-15°C (Do Huy Bich et al., 2006).

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The medicinal part of Hoang cam is its root, used to treat prolonged fever, colds, abscesses, hemorrhaging, jaundice, etc. (Do Huy Bich et al., 2006; Zhao et al., 2016). Hoang cam (*Scutellaria baicalensis* Georgi) has also been used medicinally in several East Asian countries, particularly China, for over 2000 years and is included in the Chinese Pharmacopoeia, European Pharmacopoeia, and British Pharmacopoeia (Zhao et al., 2016; Wojtunik-Kulesza et al., 2021; Chmiel & Stompor-Gorący, 2023). Over 40 secondary compounds have been isolated and identified from the roots of *Scutellaria baicalensis*, including flavonoids, terpenoids, essential oils, and polysaccharides (Zhao et al., 2019). Some compounds of particular interest, such as baicalein, wogonin, and oroxylin A, exhibit antibacterial, antiviral, anti-inflammatory, free radical scavenging, and enzyme inhibitory properties (Wojtunik-Kulesza et al., 2021).

Most research on Hoang cam has focused on the secondary metabolites present in the plant, with fewer studies on its adaptability and cultivation techniques to increase yield. Descriptions of the plant's morphological characteristics are still limited, and there have been no studies on its microanatomical features. Therefore, we conducted a study on the anatomy of the stem, leaf, rhizome, and root to establish a database of the botanical characteristics of Hoang cam. This will serve as a basis for identification and harvesting of the medicinal plant, contributing to the sustainable development of Hoang cam genetic resources.

II. METHODS

2.1. Research Subjects

Research subjects were 2-year-old Hoang cam plants (*Scutellaria baicalensis* Georgi) cultivated in Bac Ha - Sapa and provided by the Hanoi Center for Research on Cultivation and Processing of Medicinal Plants.

2.2. Research Methods

2.2.1. Morphological Description Method

The morphology of vegetative organs (roots, stems, leaves) and reproductive organs (flowers, fruits, seeds) of 2-year-old Hoang cam plants was described using the comparative morphological method of Nguyen Nghia Thin (2007). Vegetative and reproductive organs were observed, measured, and described in detail, with illustrative photographs.

2.2.2. Anatomical Sectioning Method

This was conducted according to the improved method of Tran Cong Khanh (1981) and Nguyen Nghia Thin (2007).

Fresh samples of roots, stems, and leaves from 2-year-old Hoang cam plants were fixed in 70% alcohol until all chlorophyll was removed from the tissue. They were then rinsed with distilled water and cut into thin sections (2-3 cell layers) using a razor blade. For root and stem samples, sections were cut perpendicular to the root or stem; for leaf samples, sections were cut perpendicular to the main vein at the midpoint of the leaf blade. After cutting, sections of appropriate thickness were bleached in Javelle water to remove impurities in the tissue, then stained in 3% carmine-alum solution for 24 hours. The samples were then rinsed three times with distilled water and stained again with 0.01% methylene blue for 10 minutes. After rinsing the samples three times with distilled water, they were preserved in glycerin. Squash preparations were made, sections were observed, photographed, and the structure of the organs was described.

Specimens were observed under a Nikon YS100 microscope with a 10x eyepiece, 4x, 10x, and 40x objectives, and a STECK JSZ5B stereomicroscope with a 10x eyepiece and 1-4.5x objectives. Photographs were taken using a Sony DSC-HX7V camera.

2.3. Research Time and Location

The study was conducted in 2023 at the Department of Botany - Faculty of Agriculture - Vietnam Academy of Agriculture.

III. RESULTS AND DISCUSSION

3.1. Morphological Characteristics of Hoang cam (*Scutellaria baicalensis* Georgi)

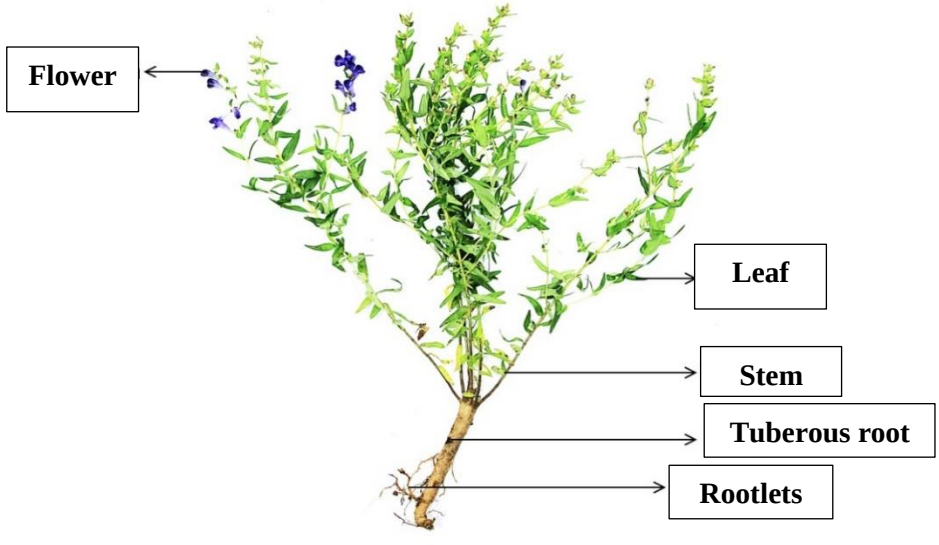


Image 1. Whole plant morphology of Hoang cam (*Scutellaria baicalensis* Georgi)

3.1.1. Morphological characteristics of the root

Hoang cam has a taproot system, a characteristic of dicotyledonous plants. The main root develops and swells to form a tuber, which is elongated and has few branches (Figure 1, 2). The length of the Hoang cam tuber ranges from 20-30 cm, with a diameter of 1.2-1.5 cm. The outer skin of the tuber is grayish-brown, rough, with small lateral roots, and the tuber flesh is dark yellow (Figure 2).

According to Do Huy Bich et al. (2006), Hoang cam has an elongated, yellow root. There has been no record of the characteristics of the tuber flesh. Our findings contribute to a more complete description of the root morphology, especially the tuber - the medicinal part of the Hoang cam plant.

Image 2: Morphological characteristics of the tuber of Hoang cam

A. Morphology of the tuber and transverse section of the tuber; B. Transverse section of the tuber

3.1.2. Morphological characteristics of the stem

Hoang cam (*Scutellaria baicalensis* Georgi) is a Herbaceous plant, perennials but the stem only exists in 1 year, most of it fade after reproductive stage. The new chit will grow up from the remaining truck above of root. It will become new stem bearing inflorescence on top

The stem above ground has an upright body shape, with a lot of branch (picture 3A0, the height is about 30-60cm, sometime could be 80 cm. it will be cover with white hairy (picture 3D), the youth stem color is light green, has 4 edges, has many epidermal hair coved (Picture 3B, D); the old stem color gradually become gray brown, the cross-sectional increasingly rounded towards base of stem, epidermal hair also becomes less (picture 3C).

The 4 edges of youth stem characteristic recorded on our Hoang cam (*Scutellaria baicalensis* Georgi) is a feature of Lamiaceae family described Phung Thi Thu Ha and ad (2021). Our research description contributes to greater detail about Morphological characteristics of Hoang cam (*Scutellaria baicalensis* Georgi) compared to description of Do Huy Bich and ad.

Picture 3. Stem Morphological characteristics of Hoang cam (*Scutellaria baicalensis* Georgi)

A. branched stem*; B. Youth* stem*; C. Old* stem*; D. Youth* stem *coved by* epidermal hair

3.1.3. Leaf morphology characteristics

Picture 4. Leaf morphology of Hoang cam (*Scutellaria baicalensis* Georgi)

A. Leaf arrangement; B. Top leaf morphology *(left) and bottom* leaf *(right); C.* Epidermal hair on leaf

Hoang cam (*Scutellaria baicalensis* Georgi) leaf is single form, cross-shaped (Picture 4A, B), petiole short and flat, size 1.5 x 2.0 mm (Picture 4B). Leaf blade is a spear shape, Oblong shape or lanceolate shape. The top is darker green than the bottom. Leaf blade size is 2.5-4.5 x 0.5-1.2 cm; leaf base is round or obtuse, leaf edges intact, slightly curved down (Picture 4B), leaf has epidermal hair coved both sides, leaf edge have a lot of hair (Picture 4C), has an easy-to-receive glands; feathery veins, main veins are prominent, concave on top, convex on bottom; Side veins 3-4 pairs, close to the edge, clear at the base of the leaves, faint on the upper leaves, third veins are difficult to discern (Picture 4B)

Our description of leaf morphology is similar to that of Do Huy Bich and ad (2006), some details are more complete. Single, symmetrical Characteristics leaves on our Hoang cam (*Scutellaria baicalensis* Georgi) is a feature of Lamiaceae family described Phung Thi Thu Ha and ad (2021).

3.1.4. Flower morphology characteristics

Flowers solitary, bisexual, symmetrical on both sides, growing from the leaf axils at the top of the branch (Picture 5A, B). However, Following recorded by Do Huy Bich and ad (2006), Hoang cam (*Scutellaria baicalensis* Georgi) has cluster-like flowers, different from our records.

Bracts serve as nutritional leaves, size 1.0-3.0 x 0.5-1 cm, The closer to the tip, the smaller the leaf, always longer than the sepal, and durable (Picture 5A), Flower stalks are round size 3 x 1 mm, has many short white villi, with filamentous appendages on both sides of the flower stem base (Picture 5I)

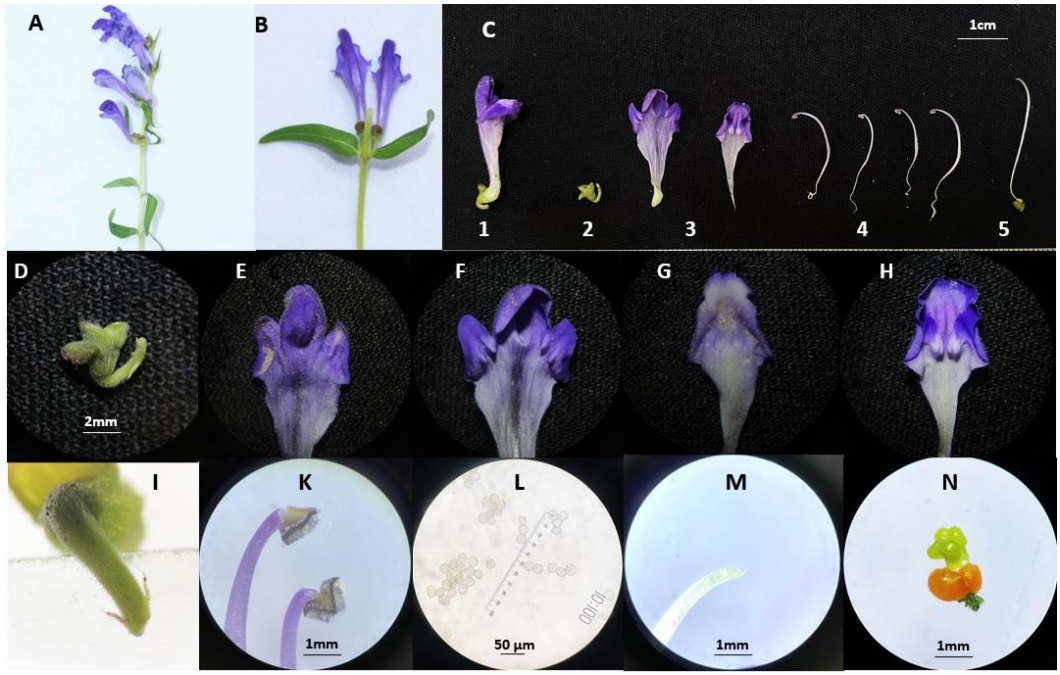
The sepals form a bell-shaped tube, size 4 x 2 mm with 2 lips, The outer surface is covered with many white epidermal hairs, the inner surface is hairless; The sepals coexist with fruit, The flower crest grows large, size 6 x 7 mm (Picture 5C2, D).

The flower corolla forms a bell-shaped tube, dark purple color, The color fades from tip to corolla base, length 2.0-2.5 cm; The outer surface is covered with epidermal hairs; The base of the corolla tube curves upward, the top split to 2 lips (Picture 5C1), The upper lip divided into 3 deep petal, middle petal is the biggest, petal tip is rounder than 2 other side petal; each petals have 2 bumps on the inside surface (Picture 5E, F); The lower lip is divided into 2 shallow petal, each petal has a convex crest clearly visible on the inside (Picture 5G, H)

Flower has 4 stamens, The stamens curve towards the lower lip, not exposed from the corolla, The stamens stick to the corolla tube 3-4 mm at the throat of the upper lip, the 2 middle stamens are shorter than the 2 side stamens, the stamens are light purple, darker on

the shorter stamens (Picture 5C4, K). The long stamens have triangular anthers, purple-black in color, with many white hairs on the long edges (Picture 5K) The Short stamens with lanceolate anthers, purple-black in color, with many white hairs on two edges of the lanceolate anthers (Picture 5K). Anthers are divided into 2 cells, 4 pollen sacs. Long stamens have 7 mm long free filaments, short stamens have 5 mm long free filaments. Pollen grains are spherical, 22-25µm in diameter, with 3 grooves, 3 pollen pores (Picture 5L).

Pistil length is 2.7 cm, style curved in the same direction as the stamen, white; style adheres to the upper lip of the corolla; stigma sharp, split into 2 (Picture $5C_5$, M). The ovary is above, light green, smooth; below has a recognizable orange nectar disc, on the nectar disc are scattered white spots, the large anterior lobe makes the ovary curved. The two posterior cells of the ovary form a false septum, forming a 4-celled ovary, clearly convex, each cell containing 1 ovule; the base of the style is attached to the bottom of the ovary (Picture 5N)



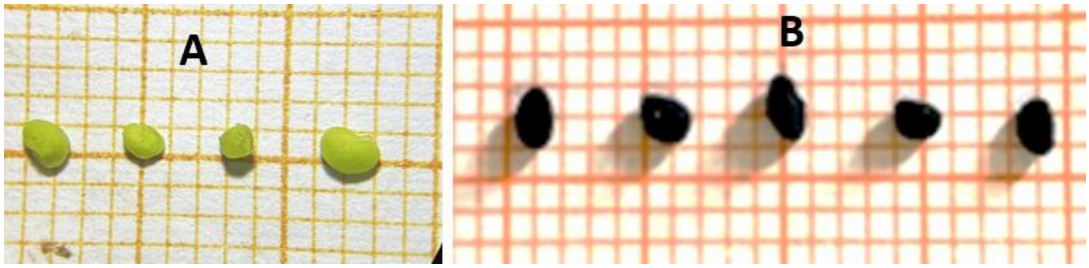
Picture 5. Hoang cam (*Scutellaria baicalensis* Georgi) flower morphology *A. Flower on the plant; B. two flowers growing from opposite leaf axils; C. Flower composition analysis; (1. flower morphology; 2. Calyx; 3. Corolla (the upper lip and the lower lip); 4. Set of 4 stamens; 5. Pistil set); D. Bell-shape calyx; E.The* upper lip *surface; F. The* upper lip inside*; G. The lower lip surface; H. The lower lip inside; I. Pedicel; K. Long and short stamens shape; L. Pollen shape; M. Splited pistil. N. Ovary*

3.1.5. Morphological characteristics of fruit and seeds

Fruit is an achene, use to have 4 seed so that called 4-core achene, sometimes does not contain enough 4 seeds. Fruit length is 5.5-6.5 cm, width 4-5cm, have fruit calyx (Picture 6)

Picture 6. Hoang cam (*Scutellaria baicalensis* Georgi) fruit morphology

Hoang cam (*Scutellaria baicalensis* Georgi) **has ovoid seed**, black, size 2,0 x 1,5 mm, rough seed coat, narrow hilum at the base, seed without endosperm. (Picture 7).



Picture 7. Hoang cam (*Scutellaria baicalensis* Georgi) seed morphology
A. Young seed; B. Mature seeds

Following Do Huy Bich and ad (2006) recorded, Hoang cam (*Scutellaria baicalensis* Georgi) is spherical shape, different with ours. Our description of plant morphological characteristics is more detailed and complete than the Do Huy Bich and ad (2006) previous description, contributing to supplementing the database of morphological characteristics for the species.

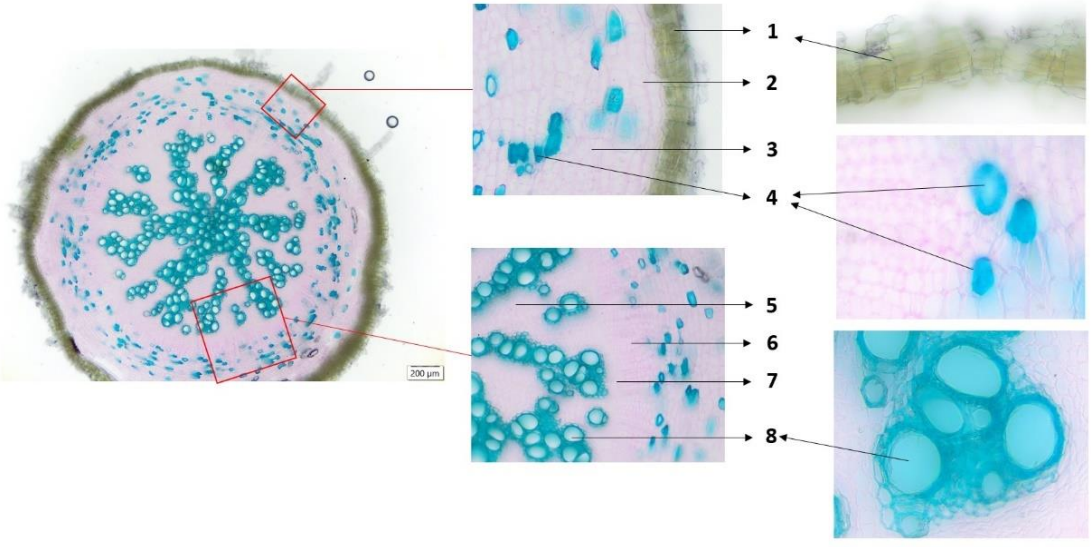
3.2. Hoang cam (*Scutellaria baicalensis* Georgi) *microanatomy* features

3.2.1. Root microanatomy

Microscopic cross-section of root has circular cross-section. Covering the outside of the root is secondary epidermal tissue consisting of 7-8 layers of cells, rectangular cells, arranged radially, has cork cambium secondary wall,

The cork layers peel off piece by piece and are replaced by new cork layers (1). Next is the mesophyll/ cortex (2) consisting of 2-3 layers of rectangular cells arranged radially with cork, sometimes with sclerenchyma cells (4) arranged alternately. Soft tissue (3) consists of layers of nearly circular cells, thin primary walls, with many scattered and interspersed stone cells (4). The vascular cambium (5) are wide, consisting of 2-5 rows of polygonal cells arranged radially. Secondary phloem (6) consists of irregular polygonal cells, stained pink, arranged alternately with green-stained wood bundles. Xylem cell (8) is discontinuous, xylem vessels are polygonal, round or oval, of varying sizes, thick secondary walls, lignified; soft tissue lignifies into hard tissue. vascular bundles (7) is interspersed between phloem and xylem cells (Picture 8).

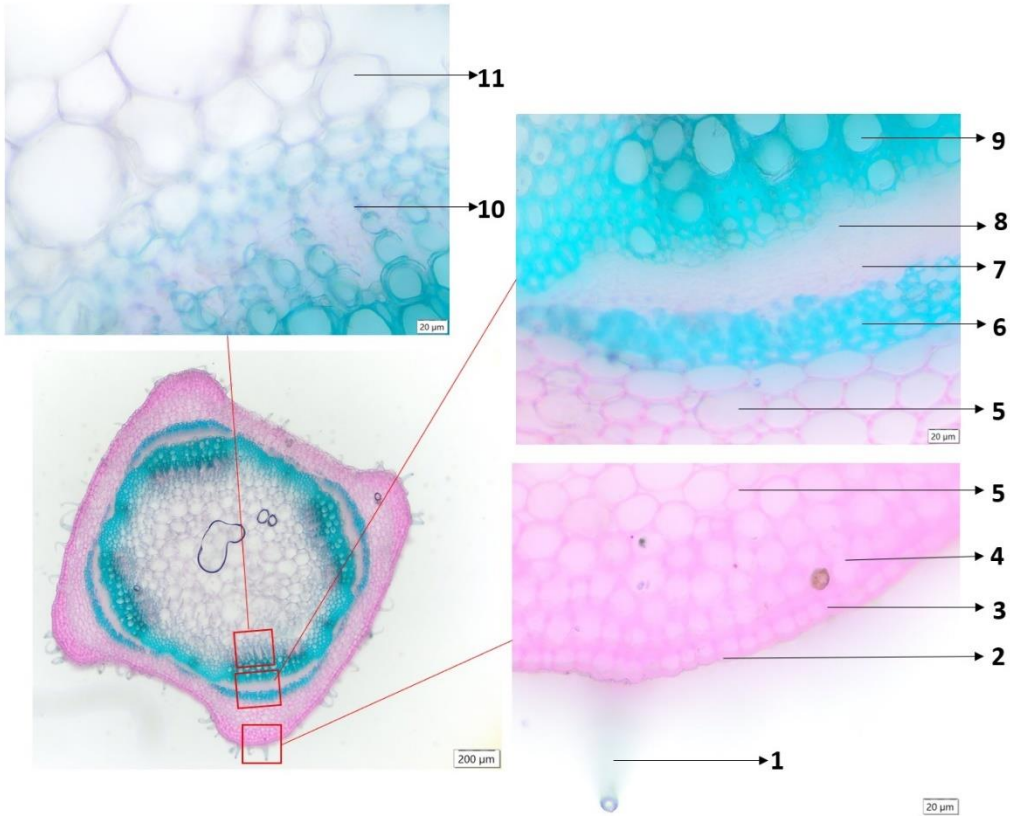
Root microanatomy of Hoang cam (*Scutellaria baicalensis* Georgi) in our study is similar to root microanatomy of *S. tonkinensis* species following Do Thi Xuyen and ad description (2022). However, the degree of lignification and sclerotization in the columnar region of the roots of S. tonkinensis was greater than our Hoang cam (*Scutellaria baicalensis* Georgi) roots.



Picture 8. *Root microanatomy*

(1. epidermis*; 2.* mesophyll*; 3. Soft tissue; 4.* Sclerenchyma cells*; 5 vascular cambium, 6.* Secondary phloem*; 7.* vascular bundles*; 8. Secondary xylem cells)*

3.2.2. Stem microanatomy



Picture 9. Microsurgery of the Hoang cam (*Scutellaria baicalensis* Georgi) stem *Protective fur, 2. Cutin, 3. epidermal cells, 4. Thick tissue, 5. Soft tissue, 6. Erection tissue; 7. Secondary phloem; 8. cambium; 9. Secondary wood, 10. Primary wood; 11. Soft intestinal tissue)*

The cross-sectional microsurgery of the Hoang cam (*Scutellaria baicalensis* Georgi) body has a square shape and convex corners. Epidermal cells (3) rectangular or polygonal, irregular, cutin-coated outer wall (2). On the epidermis, there are protective fur (1). Intermittent angular thick tissue (4) consists of 1-7 layers of polygonal or near-round, irregular cells, heavily concentrated in four convex corners. Soft tissue (5) consists of about 3-6 layers of polygonal, pale pink, thin-walled cells. The erection tissue (6) forms clusters of 1-5 layers at 4 convex corners. Secondary phloem (8) is polygonal, small-sized, thin-walled, winding, and messy arrangement. Secondary wood (9) is numerous, arranged regularly in radial rows, including woody thick-walled veins and woody soft tissue. Primary wood (10) is few, cornered at the bottom of the secondary wood. Medullary soft tissue (11) consists of polygonal or near-round, large, thin primary walls. (Picture. 9).

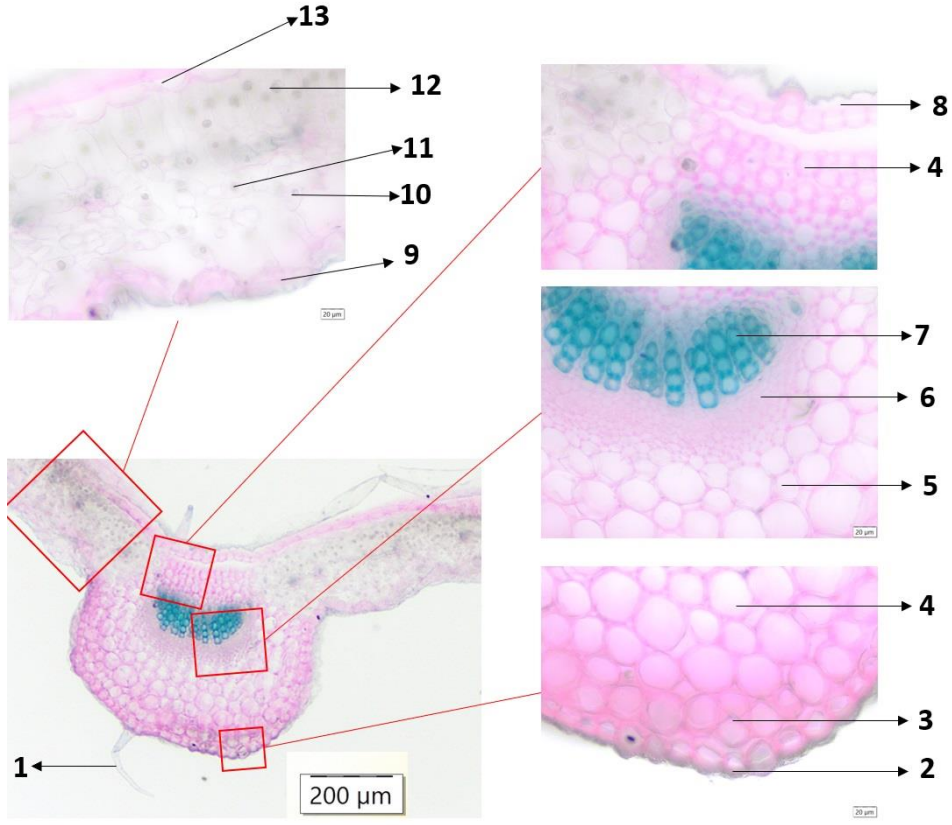
The microsurgery of the Hoang cam (*Scutellaria baicalensis* Georgi) in our study is similar to the stem structure of *S. tonkinensis* in the description of Do Thi Xuyen & et al. (2022) and the *S. barbata* in the description of Do Thi Lan Huong (2015).

3.2.3. Leaf microsurgery

Leaf veins: Microsurgery of the Hoang cam (*Scutellaria baicalensis* Georgi) leaf has a prominent main vein on the underside and a slightly concave top. From bottom to top, it has a structure including Epidermal fur (1) formed from the epidermis. The lower epidermis (3) consists of a layer of cells, stacked on top of each other, and the outer wall is covered with cutin. Thick tissue (4) consists of 2-4 layers of circular or polygonal cells, a thick primary wall, dark pink catch. Soft tissue (5) consists of many layers of large, irregular cells, thin primary walls, catching pink. The phloem and wood are concentrated in arc-shaped bundles, curved in the direction of the leaf veins, the phloem (6) on the outside consists of thin-walled cells, smaller in size than soft tissue, and the wood (7) on the inside consists of thick-walled cells, woody, and catching blue. The upper thick tissue (4) consists of 3-4 layers of cells, polygonal, thick walls catching dark pink. The upper epidermis (9) consists of a layer of stacked cell walls, and the outer wall is covered with cutin.

Leaf plate: the thickness of the leaf plate accounts for 1/4-1/3 of the thickness of the leaf veins . Covering the two sides of the leaf plate is the upper skin (13) and the lower epidermis (9) corresponding to the upper and lower sides of the leaf plate, both consisting of 1 layer of cells, the outermost wall covered with cutin. Located close to the lower epidermis is porous tissue, also known as defective tissue (10), consisting of thin-walled cells, of unknown shape, arranged far apart to leave many intercellular spaces, interspersed with polygonal calcium oxalate crystals (11). Gray tissue (12) is located close to the upper epidermis, consisting of 1-2 layers of rectangular cells, arranged close to each other vertically. (Fig. 10).

The microsurgery of the Hoang cam (*Scutellaria baicalensis* Georgi) leaf in our study is similar to the leaf structure *of S. tonkinensis* in the description of Do Thi Xuyen & et al. (2022).



Picture 10. Microsurgery of the Hoang cam (*Scutellaria baicalensis* Georgi) leaf

(1. Epidermal fur; 2. Cutin ; 3. The epidermis under the leaf veins; 4. Thick tissue; 5. Soft tissue; 6. Phloem; 7. Wood; 8. Epidermis on the leaf veins; 9. Sheet under the leaf slab; 10. Porous tissue; 11. Calcium oxalate crystals; 12. Hedge; 13. Upper epidermis)

Through the botanical and anatomical characteristics of the upper and lower parts of the ground, it is also shown that the Hoang cam (*Scutellaria baicalensis* Georgi) is very sensitive to environmental conditions. Therefore, creating optimal conditions for the growth and development of the Hoang cam (*Scutellaria baicalensis* Georgi) including factors such as light, temperature, humidity, nutrition, altitude, etc. is essential for the cultivation of precious medicinal herbs with maximum yield and quality.

Our description of the morphological and microsurgical characteristics of the Hoang cam (*Scutellaria baicalensis* Georgi) contributes to the completion of the description of the Hoang cam (*Scutellaria baicalensis* Georgi) for identification, characteristic lookup, and also provides reference for further research to influence technical measures to increase yields, quality of medicinal materials.

IV. CONCLUSION

Hoang cam (*Scutellaria baicalensis* Georgi) is a perennial herbaceous plant, with a pile root system, the main root swells into a bulb, and the flesh of the bulb is dark yellow. The young stem has 4 sides, light green, and the old stem is gradually rounded, gradually turning grayish-brown. The leaves are single, opposite, lanceolate, with very short stalks, the feather vein, and the main vein are prominent. The flowers are solitary, hermaphrodite, symmetrical on both sides, the septum is green, divided into 2 lips, and the rosary is purple, also divided into 2 lips. 4 Stamens, triangular anthers. The upper pot has 2 cells, and the back has a partition into 4 cells. There is a co-leader station. The seeds are black and ovate.

The root microsurgery has a circular cross-section, the outside has many layers of cork, secondary wood and many stone cells. The microsurgery of the stem has a square cross-section, and convex corners, the leading bundle is concentrated at 4 convex corners, the top of the leading bundle has a protective erection and thick tissue, and the intestinal parenchyma is numerous. Leaf microsurgery is covered with fur, specialized soft tissue occupies a large area, and the size of the wood bundle is small.

The results of the morphological and microsurgical characteristics of the vegetative and reproductive organs of the Hoang cam (*Scutellaria baicalensis* Georgi) are the basis for identifying, searching for species and providing reference data to influence technical measures to increase the yield of medicinal herbs.

ACKNOWLEDGMENTS

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