Pharmacognostic Identification and Demonstrative Garden for Planting and Producing Medicinal Herbs for Primary Health Care

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ABSTRACTS

This research reports the identity of popular and useful medicinal plants which have been sampled. These plants were selected based on the parts used, viz., leaves (6 species), flowers and floral parts (4), fruits (8) and seeds and seed parts (7). Each medicinal plant included the botanical name, family name, common name, part used, active constituent, utility, characteristic of powdered drug, microscopic character of the powder and also powdered drugs that have been registered and currently being used. The reference details of each species are also given.

Key words: Primary health care, Pharmacognostic identification, Demonstrative garden

INTRODUCTION

Evaluation of medicinal plant means the approval of quality and identity of that medicinal plant which contains no adulteration or contamination that can reduce the efficiency of its medicinal capabilities. First of all, the identification of medicinal plant has to be done. Macroscopic identification is the investigation of shape, size, color and taste by the organoleptic (physical) method (hands, ears, eyes, nose and tongue) to study and develop skills to generate the expertise for medicinal plant identification, using both fresh and dry specimens. Secondly, microscopic identification is done by investigating the specimens through microscope (Fahn, 1969; Youngkens, 1951). The preparation of samples is to cut the specimens to pieces or grinding to powder, then dying with specific stain solution to see more clearly similarities and differences about cell type, characteristic and component. Thirdly, the constituent of medicinal plant has to be studied. These plant constituents are synthesized by plants. The constituents that are extracted from plants are mostly related to taste and properties which involves tradition Thai medicine. Taste is important in medicinal plants in traditional Thai medicine. Tastes and its constituents are: bitter-sour taste such as tamarind leaf which contains tannins; sweet taste as Indian licorice leaf which has sugar; nutty taste, e.g., water mimosa and beans which contain fat proteins; salty taste, e.g., galingale which has salt; sour taste, e.g., tamarind fruits which contain organic acids; bitter taste as Cassia and Momordica, which have

alkaloids and glycosides; poison-like taste as Nasutus, Cannabis, Jimson weed and Diospyros; mucilaginous taste as mucus and starch; oily taste as in sesame oil; hot and spicy taste as acrid gingers; bitter-nauseous taste as champak, ilang-ilang and henna; insipid taste as gourd, morning glory, caricature plant and antidote vine. Nevertheless, each plant contains different quantities of components. Furthermore, the quantity of constituents in the same species may differ due to environmental condition, age and growth rate. The constituents in medicinal plants studied should clarify the origin of specimens and rechecking is needed if the geographical condition differs.

Principal constituent syntheses in medicinal plant cells consist of the type and quantity of constituents that may be different or similar in each species. The main factors are geographical and environmental condition and growth rate.

Photosynthesis is the essential function for plant growth.

$$6\,CO_2 + 6H_2O \xrightarrow[\text{UV light}]{\text{Chloroplast}} C_6H_{12}O_6 + 6O_2 + \text{energy}$$

The process starts when plants suck water through their xylem, then reacts with carbon dioxide with light to cause photosynthesis. The first output is carbohydrates that pass on to other processes such as glycolysis, tricarboxylic acid cycle, Kreb's cycle, etc. The final products are amino acids, fatty acids, glycerol, alkali acids, alkaloids, glycosides, mucilage, gum, latex, tannin and volatile oils, etc. The medicinal plant components are also derived from biosyntheses by each species which are often influenced by habitat or geographical source. The same species grown in a different location may produce different components and have different active constituents. Consequently, the preliminary data of the species such as origin, growth rate and habitat have to be considered before identification of active constituents is done. Furthermore, when the habitat has changed, the identification also has to be rechecked. Cultivated plants and commercial origin with clarified identity may need only single test.

Constituents of medicinal plants can be considered as characters and effects of metabolism. The characters of these constituents are primary constituents such as carbohydrates, proteins, etc. and secondary constituents such as acids, mucilage, gums, resins, latex, tannins, alkaloids, glycosides, volatile oils, sap, etc. In addition, the effects of these constituents are divided as active constituents, which have pharmaceutical value such as starches, sugars, etc. and therapeutic effects such as alkaloids and glycosides. Inert constituents which have no direct effects but catalyze or inhibit the active constituents include cellulose and mucilage.

Preparation of medicinal plants

The medicinal plant parts used have most of active constituents. In addition to the part used, the period of collection is also considered.

Roots: collect before flower blooms.

Barks and woods: collect before new buds develop.

Leaves: collect before flower blooms, daytime or early morning, collection varies according to the required component.
Flowers: collect when flower blooms.
Fruits: collect when mature but not fully-ripe.
Seeds: collect when fruits are fully-ripe.

Age and growth factors should also be considered to retrieve suitable constituents in the expected quantity before harvesting. After harvesting, the specimens are processed by :

Harvesting ⟶ Garbling ⟶ Curing ⟶ Extractions of active constituents

Drying of medicinal plants

The method chosen to dry the specimens aims to preserve the constituents that need to be extracted.

Air dry: Plants that contain volatile substances.
Sun dry: Plants that contain general constituents (temperature < 60°C).
Oven dry: Plants which are hard to dry (temperature 40°C or < 60°C).

Storage of medicinal plants (Youngkens, 1951)

The factors considered for storage of medicinal plants aim to preserve the active constituents and protect from unnecessary decay conditions. Plants should be protected from wind that may contain fungus and insects, light that may stimulate fungus growth, humidity should be less than 10% (3-10%), airtight or in vacuum.

Purification of medicinal plants

Purification of medicinal plants has to be done before that medicine is used. Adulteration is adding the other constituents intentionally and contamination, adding other substances unintentionally. These additions are made to add active constituents for better pharmaceutical effects. Samples are compared with authentic drugs and tested for medicinal plant quality; chemical and physical characters and properties of uses. Moreover, the scientific or botanical names of medicinal plants have to be accurate (Keng, 1969; Merill, 1954). The Genus and species of plant name in Latin, which is usually not stable. Local or common names are totally unreliable and may change with location (Smitinand, 1980). Thus, botanical names have to be used as the standard of International Code of Botanical Nomenclature: ICBN (Bailey, 1969). The botanical names compose of 2 main parts which are Genus and species, including author's name such as:

Ipomea batatas Lamk. : common name = sweet potato (English)
Rheum officinale Bail. : common name = rhubarb (English)
Rheum rhaponticum Linn. : common name = rhubarb (English)

The classification of medicinal plants needs to agree with ICBN. Expertise and skills in identification of plant parts is very useful, especially occurrences, shapes,

sizes, fractures, markings, textures, colors, odors and tastes of medicinal plant parts made into drugs.

Identification of underground and aboveground parts of medicinal plants (Youngkens, 1951)

The characteristics used to identify the underground and aboveground parts of medicinal plants are occurrence, shape, size, fracture, marking, color (both outer and inner) and odor (species-specific). Plant odor depends on the volatile oils in each plant such as aromatic, spicy, balsamic, alliaceous, camphoraceous, terebinthinate, cinnamaldehyde and citral. Furthermore, taste can also identify the active constituents in some medicinal plants. The examples of tastes and constituents are: bitter-sour taste as tamarind leaves which contain tannin; sweet taste as Indian licorice leaves with sugars; nutty taste, e.g., water mimosa and beans which contain fat; salty taste as galingale which has salt; sour taste, e.g., tamarind fruits contain organic acids; bitter taste as *Cassia and Momordica* have alkaloids and glycosides; poison-like taste as *Nasutus, Cannabis, Diospyros* and Jimson weed mucilaginous; special taste as mucus and starch; oily taste, e.g., sesame oil; hot and spicy taste, e.g., gingers have acids and phenols; bitter-nauseous taste makes one nauseous; insipid taste have trace minerals and antidotes. In addition to major plant parts, leaves can be often used to identify medicinal plants.

Leaf identification

The identification of commercial plants should be studied in detail by the morphologies of the leaf, e.g., blades or lamina, petioles and stipules. In addition, the type and arrangement, apex, base, margin, texture, venation and size of leaves are all important. Leaf morphologies of epidermal tissue, mesophyll and vascular bundles are important to identify the medicinal plants, also the presence of adulterations and contaminations.

Flower identification

Flowers are the extra part of stem that grow limitedly with reproductive organ as appendage for reproduction. Flowers have four floral parts which are gynoecium, androecium, corolla and calyx and are attached above the receptacle. These details are important for pharmacognostic identification of medicinal plants.

Fruit and seed identification

Fruits are the results of pollination between male part (stamen) and female part (pistil). The fruits can grow in the ovary in the same flower or different flowers. Ovules that develop to be the seeds are called true fruit. Fruits may also develop from other parts of the flower, called accessory fruits, and parthothenic fruits. Fruits can be separated into 3 groups as follows: a) simple fruit is developed from solitary flower with one ovary, b) aggregate fruits are developed from multiple ovaries in single flower, growing to one fruit and c) multiple fruits are developed from inflorescence flowers. Fruit type also can be divided into fleshy and dry fruits.

Pharmacognostic identification of fruits is done by identifying type, shape, size, organoleptic characteristic, marking, wrinkle, ridge, reticulate and specific characteristics : e.g., fracture, ovary attachment and seed quantity.

Pharmacognostic identification of seeds will be done by identifying type, shape, size, macroscopic characteristics : e.g., waxed, pitted, testa, helium, raphe and micropyle; microscopic characteristics such as perisperm, endosperm, embryo, radicle and seed coat (aril). The sample of the seeds with aril is mace. These characters will help identify the various seed types.

The underground medicinal plant parts are root, rhizome, tuber and corm, and aboveground parts are bark, wood, stem, leaf, flower, fruit and seed. Organoleptic identification is used to identify external and internal characters by considering shape, texture, fracture, marking, color, odor and taste. Expertise requires experience to properly identify the useful parts or benchmark of each medicinal plant effectively. In addition, the identification of powdered medicinal plants should be considered to confirm the identity and quality of each plant. A microscope is used to see more details of tissues to discover the compositions of cells and cell components. Cell components include shape, size and color, starch grains, crystals, oil granules, aleurone grains inside. These studies will help discover and discard adulterations and contamination which are often present. This needs expertise in parmacognosy and plant taxonomy.

OBJECTIVES

The objective of this study was to find and standardize tissues of powdered medicinal plants. The identification of different parts of powdered medicinal plants of 25 plant samples was made, components such as starch grains and crystals were studied. The hypothesis is that different tissues of powdered medicinal plants are different in type, shape, size, color and component. The results from this study will benefit further research about medicinal plants. The results will also be used as follows:

1. Used as the subjects in these courses; Pharmacognosy I, Medicinal Plants for Primary Health Care, Basic Knowledge of Traditional Thai Medicine, Medicinal Plants, Medicinal Plant for Health and other related courses,
2. Used as a manual to standardize the identification of medicinal plants,
3. Used as a guideline for other researches,
4. Used as a standard to investigate the adulteration and contamination in various parts of medicinal plants,
5. To reduce the problems of overdose and misuse of drugs,
6. To improve the primary health care by using medicinal plants.
7. To reduce drug imports from foreign countries and reduce spending which will affect Thailand's economy.

METHODOLOGY

Methods

1. Identify the taxonomic aspects of the medicinal plants, to plant and propagate them to use in primary health care.
2. Identify the pharmacognostic aspects of medicinal plants.
3. Establish medicinal plants in a demonstrative garden to harmonize with nature and encourage people to see the benefits from both scenic and pharmaceutical uses.
4. Propagate medicinal plants and provide accurate information for their uses.
5. Save on the health care costs and self-sustainable natural resource use.
6. Develop and demonstrate the effective medicinal plant gardens and conserve Thailand's natural medicinal plants.
7. Establish medicinal plant herbaria for students, researchers and interested persons.

Rationale and conceptual framework

After demonstration gardens had been established, medicinal plants were identified for their pharmacognostics. 25 samples of part used from medicinal plants were studied. Constituents such as starch, crystal and other substances found were studied. The cell portraits of powdered authentic plants are drawn and described.

Materials and equipment

1. Oven (temperature adjustable)
2. Medicinal plants
3. Plant grinder, sieve no. 60
4. Powdered medicinal plants
5. Stain solution for tissues/cells
6. Simple microscope and compound microscope
7. Slides and cover slides
8. Micrometer : ocular micrometer and stage micrometer
9. White paper, 2B pencil, drawing pen, glue
10. Photocopy machine

Preparation of medicinal plant powder

Medicinal plant powder is prepared for study under a microscope. The powder is made from different parts. Plant parts were chopped into pieces, then dried in an oven at 40-60°C (the substances may disintegrate if the temperature is too high.), ground in a sieve. no. 60. The microscopic characteristics of plant powder can be examined by using a compound microscope.

Preparation of stain solutions

The stains are solutions that are appropriate for each kind of cell to distinguish the tissue. The stain solutions for medicinal plants powder are specific to each constituent as described below.

1. Distilled water: tests parenchyma cells, starch, crystals and other basic cell components.
2. Picric acid in alcohol: dyes aleurone grains in yellow.
3. 2% Iodine solution: dyes starch grains in blue or violet, tragacanth in green and aleurone grains in yellow.
4. Sudan III in alcohol: dyes oil granules, oleoresins, Asafoetida and resins in orange.
5. 1-2% Phloroglucinol solution in alcohol + 20% hydrochloric acid: dyes lignin, fibers and sclereids in pink or red, suberine and cutin in orange-red, e.g., collenchyma, epidermis. This solution may destroy the microscope lens.
6. Saturated aniline sulfate solution : dyes lignin fiber in pink. This solution does not present cells clearly but saves the lens.
7. 75% Chloral hydrate solution: dyes cell structures (pollen grains, cell walls) by clearing the cell components, e.g., chloroplasts, starch grains, etc.
8. 10% Ferric chloride or ferric chloride T.S. : dyes tannin in green or blue-green, depending on types of tannin.
9. Ruthenium red solution: dyes mucilage or Asafoetida in pink.
10. Tincture of alkana: dyes resins in red.
11. Diluted ammonia solution: dyes purgative herbs in gold and turns to red, under UV light a glowing red-green.
12. 20% acid: reacts with chalk to produce CO2
13. Lime water: dyes agar and tragacanth in yellow.
14. Alcohol: dyes *Acacia* in blue.
15. Some alkaloid reagents: react with some alkaloids resulting in colors, crystals and precepitates, depending on the alkaloids and reagents used.

Preparation of tissue slides

Tissues slides were made to study the medicinal plants. First, add few drops of stain solution on slide, use a pin to put some powder and mix with the solution. Second, leave the slide for 10-20 minutes and cover with a cover slide (no air bubbles). Third, blot excess drops and observe under a microscope to see the cell shapes. Then draw the cell portraits and emphasize the thickness, depth and characteristics of the cells. Finally, measure the sizes with an accurate ocular micrometer.

Micrometer

A micrometer is used to measure small objects under a compound microscope, it is composed of ocular and stage micrometers.

Authentic powder of medicinal plants

Authentic medicinal plants which are correctly identified for each part used is made into a section or ground to a powder. These preparations are investigated for shape, size and color. In addition, plant constituents are also reported.

Identification of powdered medicinal plants

The first step is to recognize the color, smell and taste. The next step is to

study cell/tissue characters of authentic medicinal plants under microscope to use as standard for purification of medicinal plants. The hypothesis is that the same type of cells from different plant sections and same type of cells from different plant species may be similar or different in size and shape. Thus, authentic medicinal plant material needs to be studied. Cell/tissue studies are done to clarify microscopic morphology. In the case of powdered medicinal plants, the study process is explained below.

Leaves: Freshly-ground are green and turn brown if left to dry out. The components found in leaves are:

- Chloroplasts in mesophyll, except some cotyledons
- Stomata in lower epidermal tissue, numbers are less than upper
- Hairs or trichomes
- Fibrovascular elements are small
- Epidermal cell walls with cutin
- Calcium oxalate crystals and starch grains may be present
- * No aleurone grains

Flowers: The components found in flowers are:

- Pollen grains are often species-specific, 10 – 200 μ in size, round, oval, polygonal, irregular shape, similar thickness of walls in the same family.
- Fibrous layer of epidermal tissue
- Papillae on stigma
- Epidermal tissues of inner petals with or without papillae.
- Mesophyll may have different colors, crystals, secretory sacs and xylem.
- Calcium oxalate crystals and starch grains may be present.
- Epidermal tissues of calyx are thicker than petals, hairs or trichomes, mucilage and crystals may be present including phloem, xylem and stoma present.

Fruits: The components found in fruits are:

- Epicarp found epidermis, stomata and hairs or trichomes.
- Mesocarp found in thin cell walls, sclerenchyma, oil vessels and food storage cells when dry.
- Endocarp has specific stone cells, sclerenchyma, pigments and food storage cells
- Lignified elements
- Secretory cells
- Oil reservoirs
- Seed coat has one or multi-layered cell walls, starch grains, calcium oxalate crystals, aleurone grains and oil globules differ according to species.

Seeds: The components found in seeds are:

- Seed coats have sclerenchyma, fibrous cells and stone cells.
- Lignified trichomes are present in red after staining, such as milkbush and upas.
- Pigment cells are found in single or many rows.

- Oil cells, oil globules, crystals, aleurone grains are present.
- Cotyledons and embryos
- Endocarp may be present.
- Palisade mesophyll is present in beans and mucilage cells present in ramie grains.

* No stomata and mesophyll

RESULTS

Identification of authentic medicinal plants

Identification of powdered medicinal plants means to identify cell/tissue morphology under a microscope and with chemical tests of the characters or active constituents of medicinal plants for pharmaceutical use.

After the powder of medicinal plants has been tested and analyzed to verify species, the powder will be tested for purity and quality.

Any doubt about the plant species, microscopic examination of its cells has to be done. This process is also used to check for adulterants. The tissues of medicinal plants are different in type, shape, size, color and components, viz., crystals, starch grains, pollen which are unique to each species. A micrometer is used to measure cell size. Microscopic studies need stains to dye different cells/tissues present.

Authentic powdered of medicinal plants means the sample of medicinal plants has been identified, origin known and age determined.

Sources of 25 authentic medicinal plants species

Leaves: Vasica, Senna Leaves B.P.C., Coca leaves, Peppermint, Mitragana and Formosa Green Tea

Flowers: Cannabis, Crocus, Cloves B.P.C. and Hops

Fruits: Mombasa Chilies, Senna Pods, Coriander, Fennel B.P.C., Illicium (epicarp), Kamala, Cubeb and Long Pepper

Seeds: Siam Cardamom, Areca, Coffee, Linseed, Nutmeg B.P.C., White Pepper and Nux-Vomica B.P.

Identification of powdered medicinal plants

Put some powder of a medicinal plant on a slide which has a stained solution, leave for 1/2 minute, and cover with a cover slide (no air bubbles). Later, observe under a microscope to see the tissue characters, draw the cell portraits and emphasize the thickness and characteristics of the cells. Finally, measure the sizes 400X compound microscope with an ocular micrometer.

Data Analysis

This study was done by qualitative analysis, without statistics. The descriptive analyses were done by scientific methods to investigate the characters, properties and components of plant cells to identify and clarify with stain tests. The results are

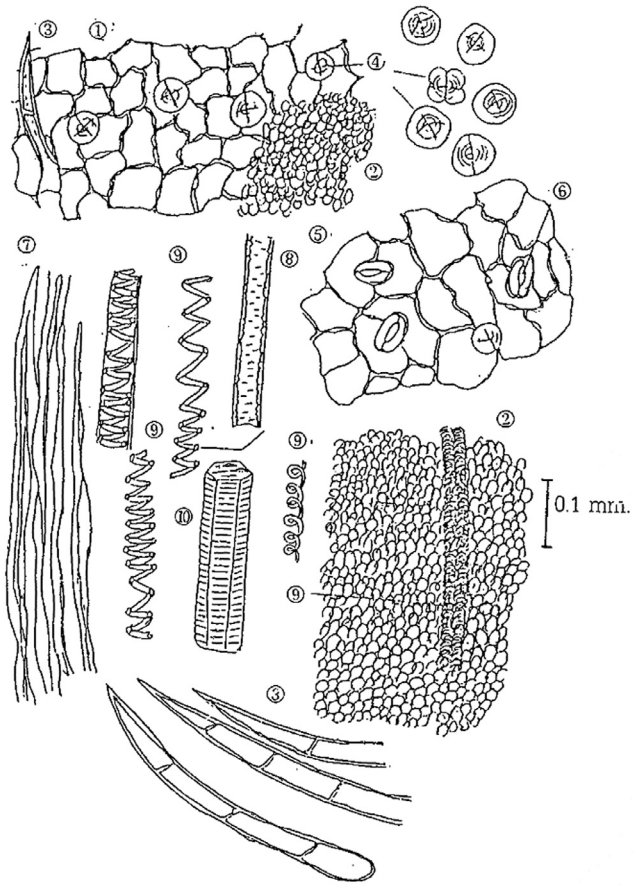
reliable and portray the morphology, type and sizes of cells.

Interpretation

This study was aimed to identify authentic medicinal plant cells/tissues as standard samples and isolate the morphology, size and type of cells to verify the quality of the medicinal plant. The investigation of powdered medicinal plants generates scientific skills and expertise.

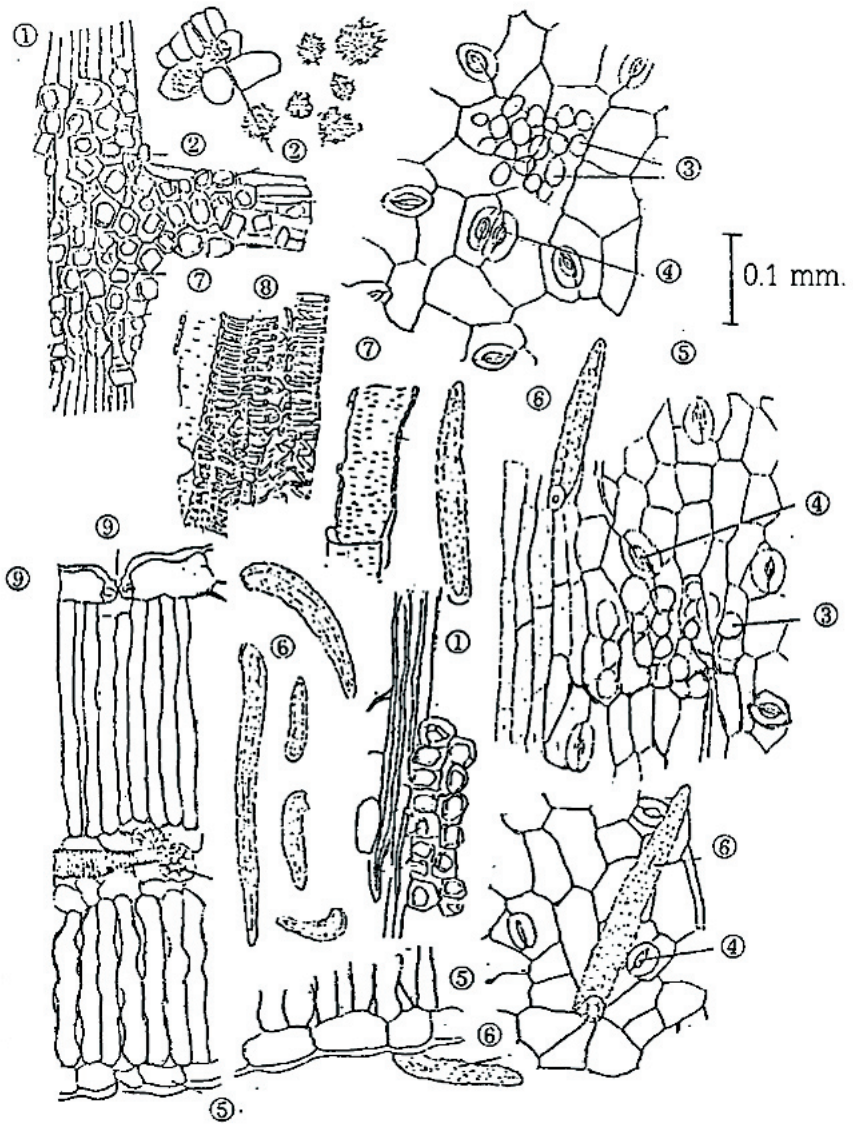
The details of standard pharmacognostic characteristic are as follows :-

Figure 1. Description of Tissue from powdered : Vasica
Adhatoda vasica Nees., Family Acanthaceae.



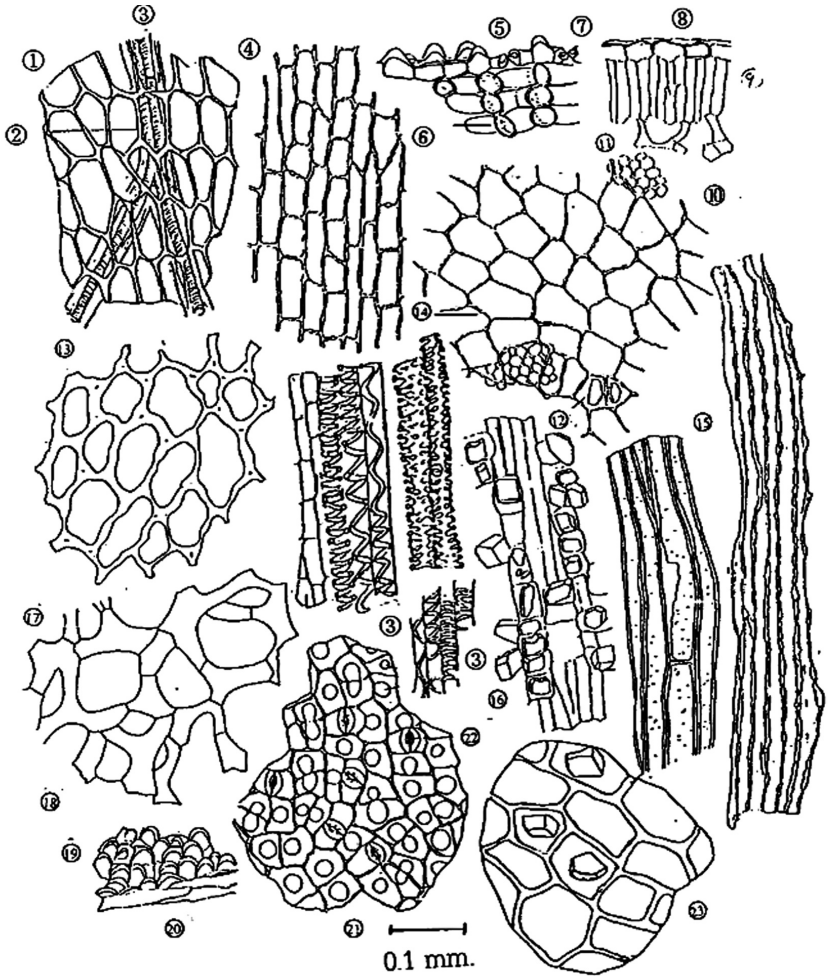
① upper epidermis in surface view
② palisade parenchyma or greenish mesophyll
③ multicellular trichomes
④ glandular trichomes
⑤ lower epidermis in surface view
⑥ guard cell : diacytic stoma
⑦ lignified fibers
⑧ pitted vessel
⑨ spiral vessels
⑩ scalariform vessel

Figure 2. Description of Tissue from powdered : Senna leaves B.P.C.
Cassia angustifolia Vahl., Family Caesalpinioidae.



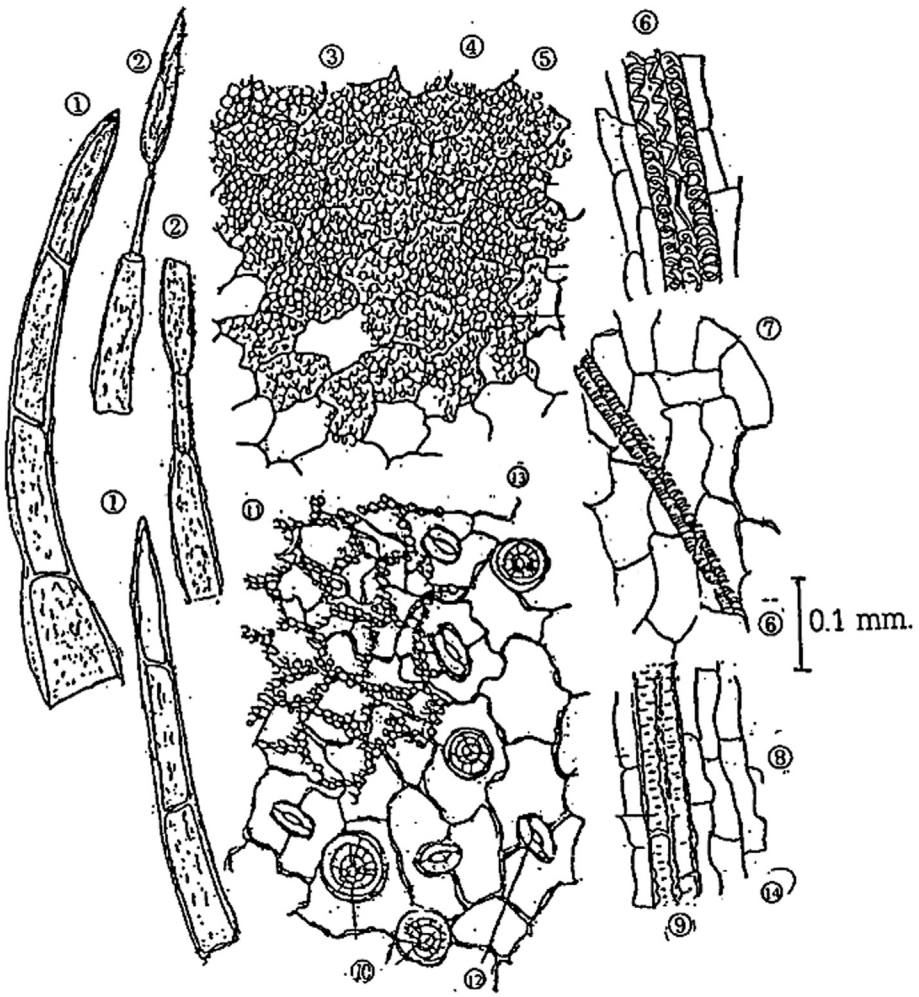
① bundle of fiber over vein
② calcium oxalate erystals
③ palisade cells
④ paracytic stoma
⑤ lower epidermis
⑥ trichome
⑦ part of a pitted vessel from one of the large veins
⑧ reticulate vessels
⑨ upper epidermis

Figure 3. Description of Tissue from powdered : Coca leaves
Erythroxylon truxillense Rusky, Family Erythroxylaceae.



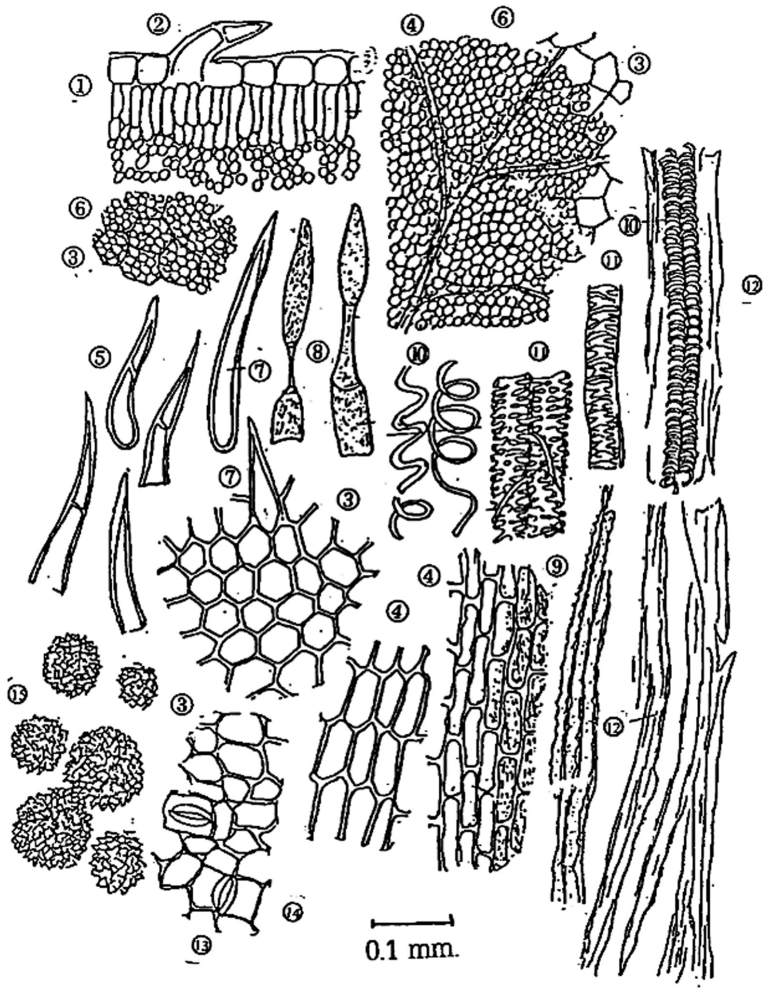
① upper epidermis overvein
② fibrovascular tissues
③ spriral vessels in surface view
④ epidermis over vein
⑤ stoma
⑥ papillae
⑦ lamina in section view
⑧ upper epidermis
⑨ palisade mesophyll
⑩ upper epidermis in surface view
⑪ starch grains
⑫ calcium oxalate prisms
⑬ collenchyma in transverse section
⑭ reticulate vessels
⑮ lignified fiber
⑯ crystal fiber
⑰ spongy mesophyll in surface view
⑱ lower epidermis
⑲ papillae
⑳ lower epidermis in oblique surface view
㉑ lower epidermis in oblique surface view
㉒ paracytic stoma
㉓ parenchyma

Figure 4. Description of Tissue from powdered : Peppermint
Mentha piperita Linn., Family Labiatae.



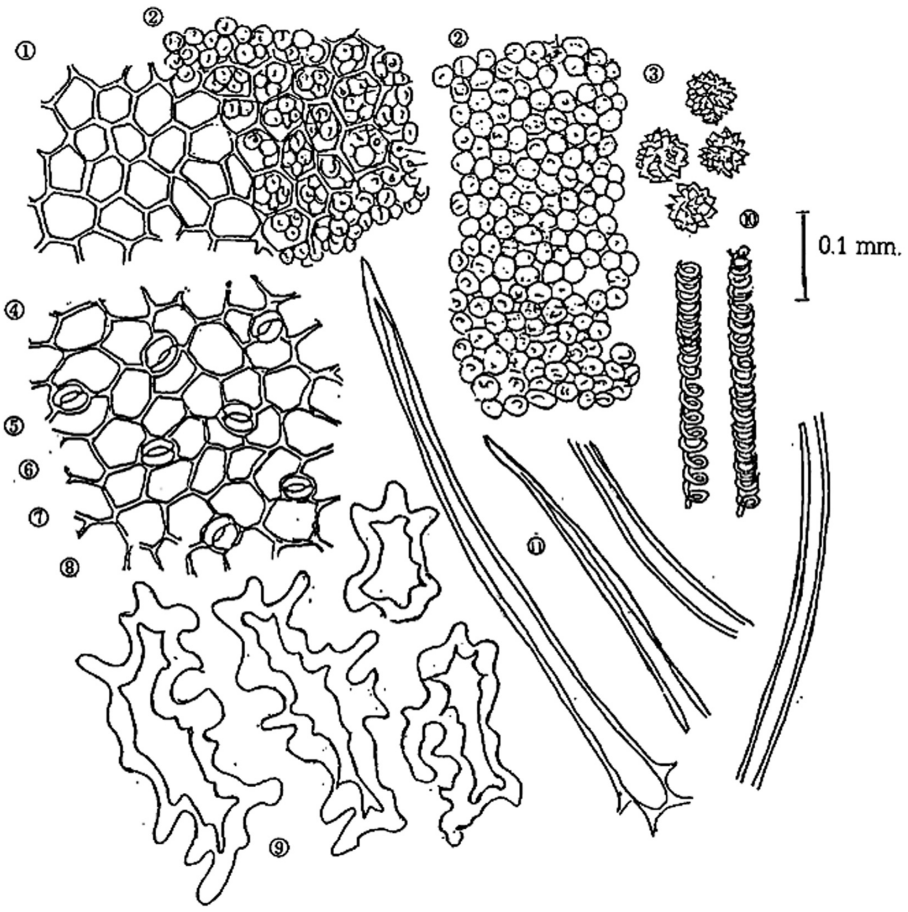
① multicellular non glandular
② collapsed trichomes
③ upper epidermis in surface view
④ epidermal cells
⑤ palisade cell
⑥ spiral vessel
⑦ epidermal cells
⑧ epidermis over vein
⑨ pitted vessel
⑩ glandular hairs
⑪ spongy parenchyma
⑫ diacytic stomata
⑬ lower epidermis
⑭ xylem parenchyma

Figure 5. Description of Tissue from powdered : Mitragyna
Mitragyna speciosa Korth., Family Rubiaceae.



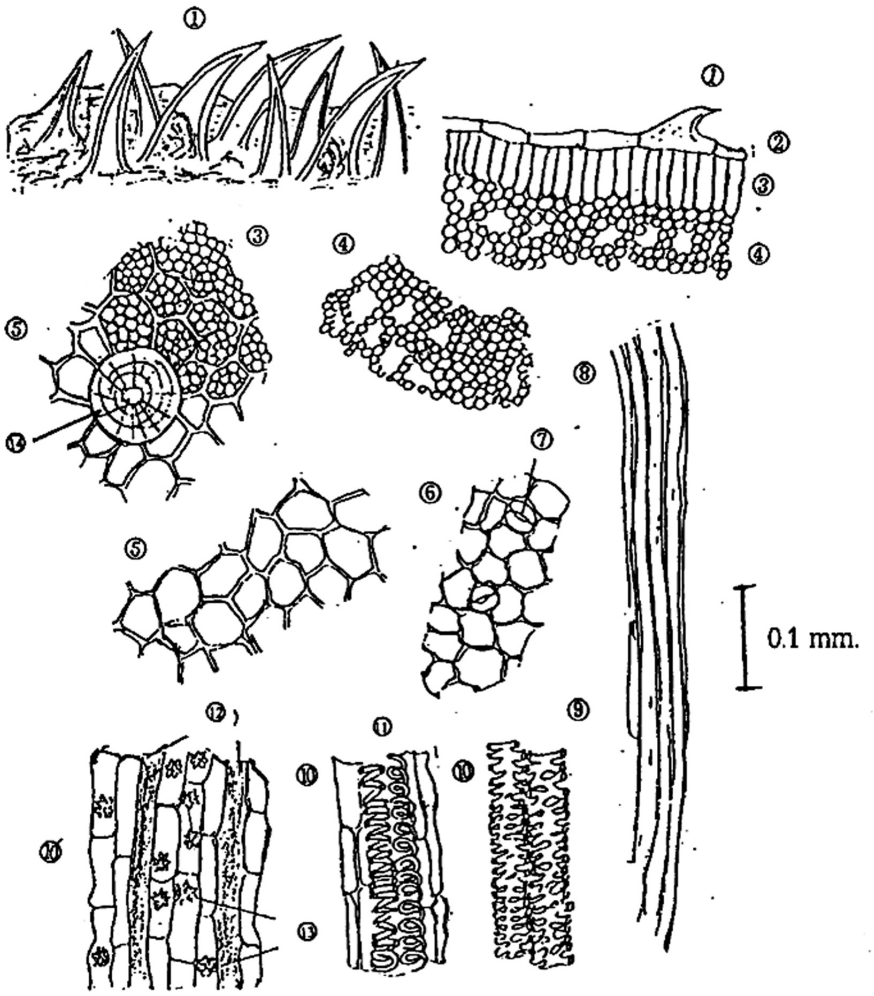
① lamina in section view
② multicellular trichomes
③ epidermal cell
④ epidermal cell over vein
⑤ palisade cell
⑥ unicellular trichomes
⑦ collapsed trichomes
⑧ reddish brown pigment
⑨ spiral vessel
⑩ reticulate vessel
⑪ fiber cell
⑫ lower epidermis
⑬ rosette aggregate calcium oxalate

Figure 6. Description of Tissue from powdered : Formosa Green Tea
Camellia sinensis (L.) Kunt. Or *Thea sinensis* Linn., Family Theaceae.



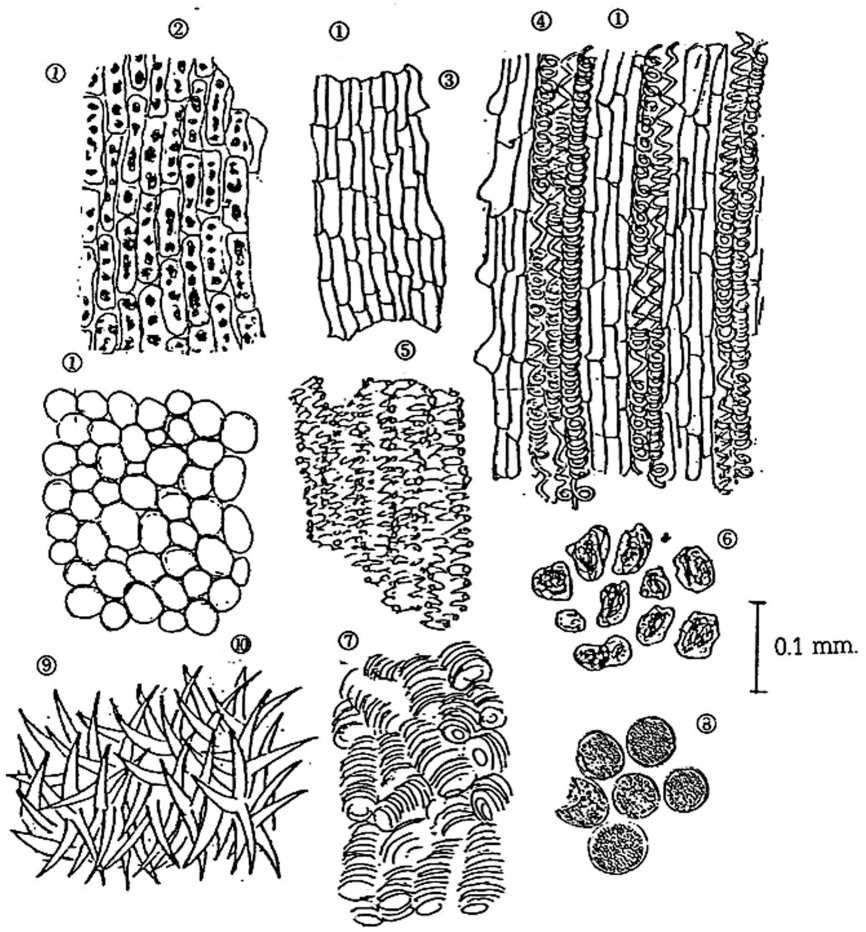
① upper epidermis
② palisade parenchyma
③ rosette aggregate calcium oxalate
④ lower epidermis
⑤ stomata
⑥ guard cell
⑦ subsidiary cell
⑧ neighbouring cell
⑨ sclereids
⑩ spiral vessel
⑪ non glandular trichomes

Figure 7. Description of Tissue from powdered : Cannabis
Cannabis sativa Linn., Family Cannabinaceae.



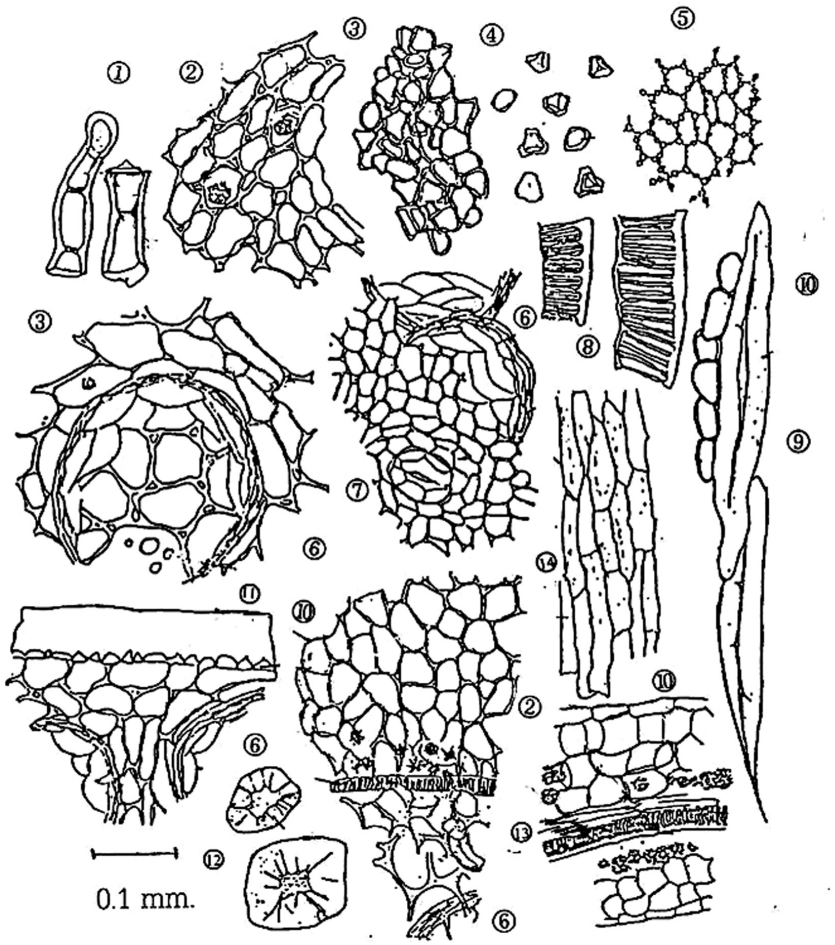
① unicellular trichomes
② upper epidermis in sectional view
③ palisade parenchyma
④ spongly parenchyma
⑤ upper epidermis in surface view
⑥ lower epidermis in surface view
⑦ anomocytic stomata
⑧ lignified fiber
⑨ reticulate vessel
⑩ xylem parenchyma
⑪ spiral vessels
⑫ laticiferous vessels
⑬ rosette aggregate crystals
⑭ glandular trichome

Figure 8. Description of Tissue from powdered : Crocus
Crocus sativus Linn., Family Iridaceae.



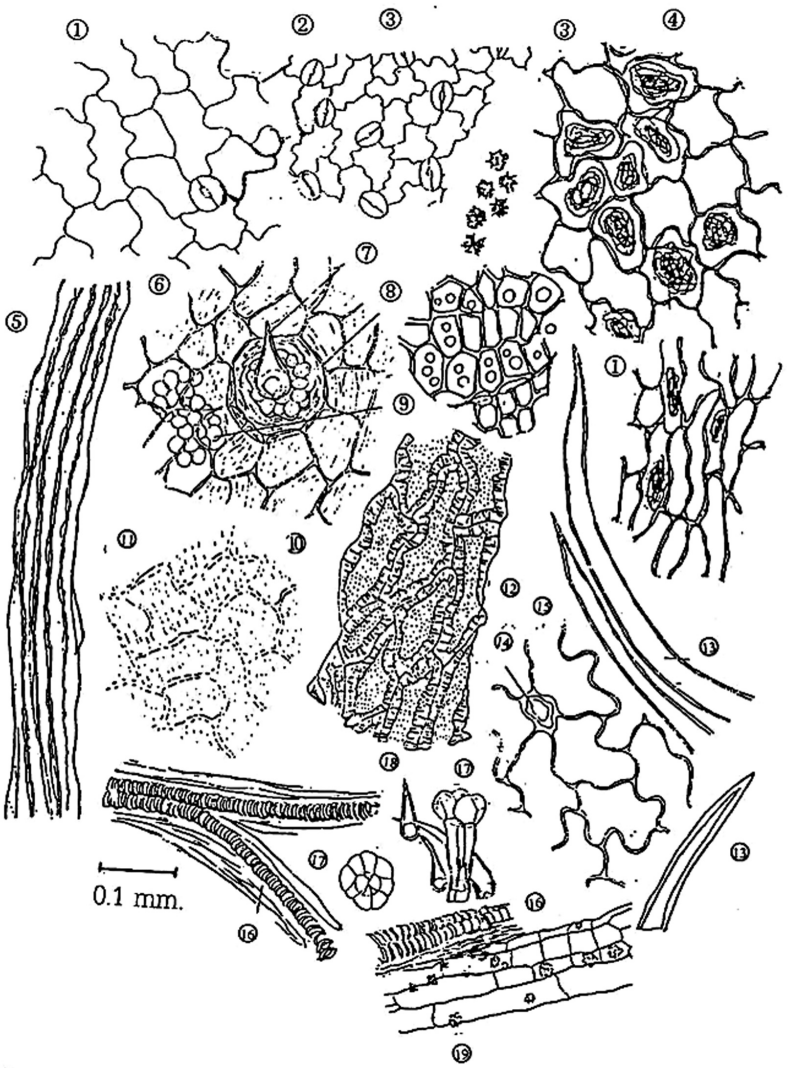
① parenchyma cells
② red matter
③ papillae
④ spiral vessels
⑤ reticulate vessel
⑥ purplish red matter
⑦ fibrous layer of anther wall in surface view
⑧ spheroidal pollen grains
⑨ distal end of stigma
⑩ trichomes

Figure 9. Description of Tissue from powdered : Cloves B.P.C.
Eugenia caryophyllus (Spreng) Bull., Family Myrtaceae.



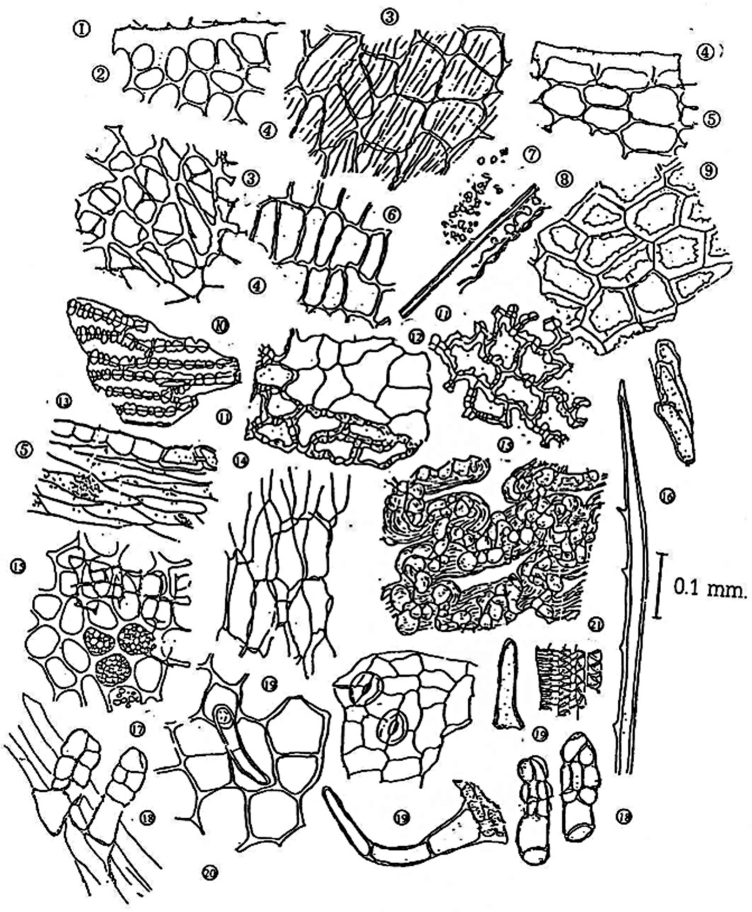
① fragments of aerenchyma from the hypanthium
② cluster crystals of calcium oxalate
③ parenchyma of the hypanthium
④ pollen grains
⑤ fibrous layer of anther in surface view
⑥ oil glands
⑦ stoma
⑧ fibrous layer of anther in section view
⑨ fiber cell
⑩ parenchyma cells
⑪ thick cuticle
⑫ stone cell
⑬ vascular strand
⑭ epidermis of the filament of the anther in surface view

Figure 10. Description of Tissue from powdered : Hops
Humulus lupulus Linn., Family Cannabinaceae.



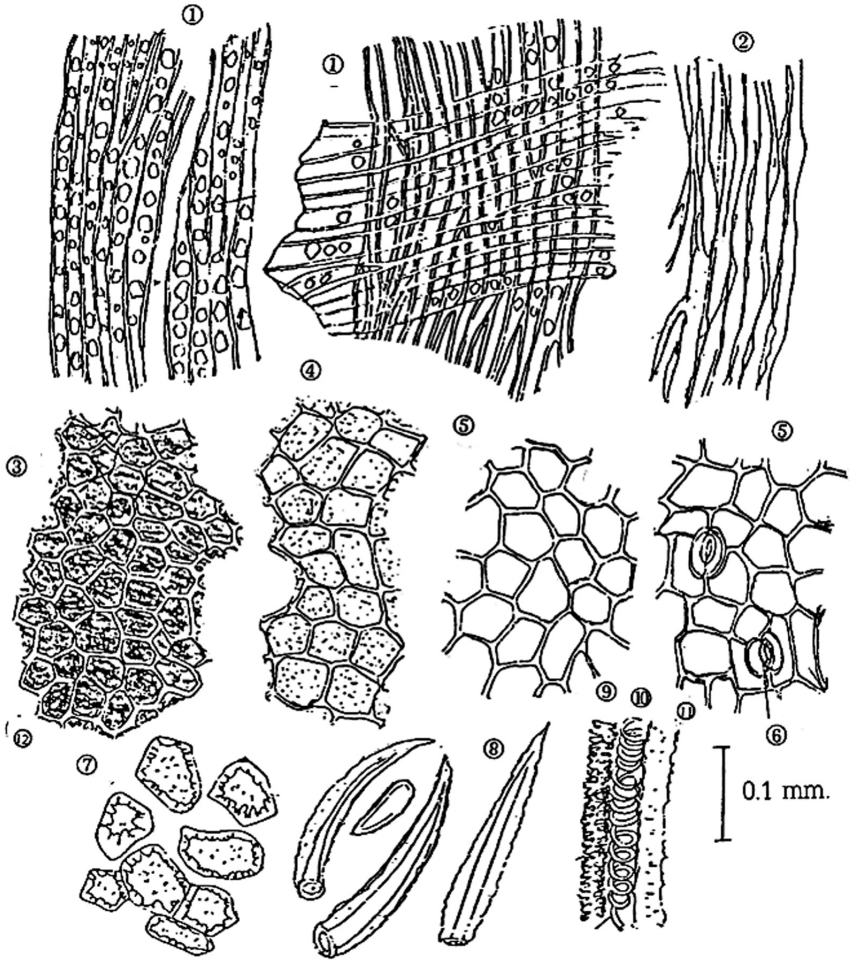
① epidermal cell
② anomocytic stomata
③ lower epidermis in surface view
④ yellowish brown content
⑤ fiber cell
⑥ leaf epidermis in surface view
⑦ cystolithic trichomes
⑧ calcium carbonate
⑨ palisade cells
⑩ striated cuticle
⑪ pericarp in surface view
⑫ sclerenchymatous tissue of testa
⑬ large unicellular trichomes
⑭ cicatrix
⑮ epidermis of bracteole or stipule in surface view
⑯ fibrovascular bundle in veins
⑰ glandular trichome from above
⑱ small unicellular trichomes
⑲ cluster of calcium oxalate

Figure 11. Description of Tissue from powdered : Mombasa Chillies
Capsicum minimum Roxb., Family Solanaceae.



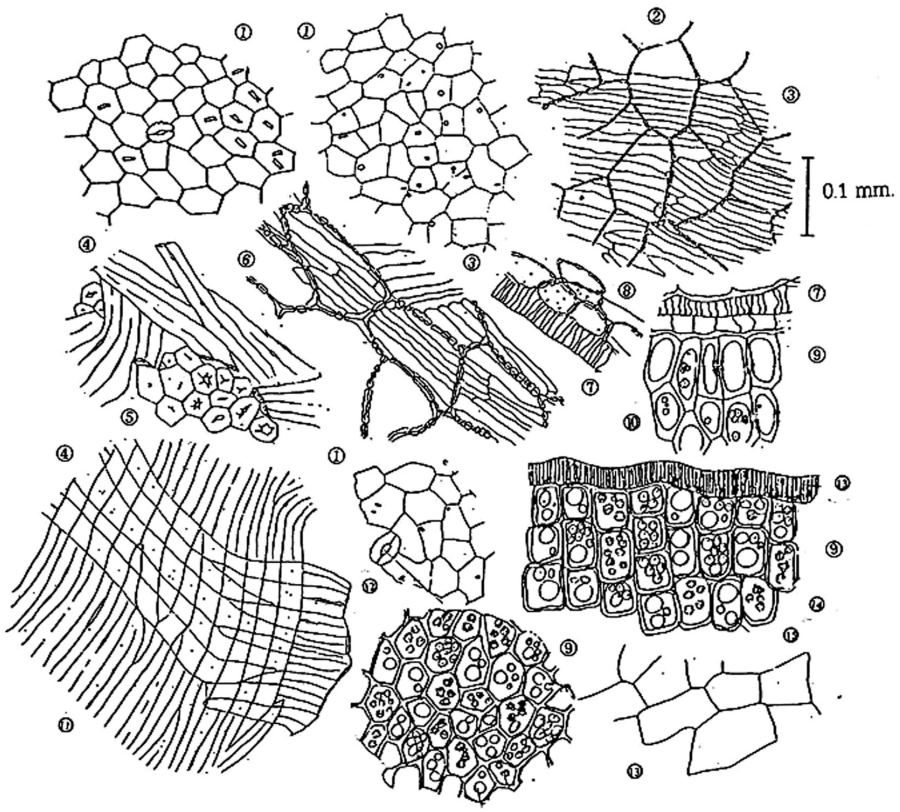
① parenchyma of the testa
② endosperm
③ epicarp in surface view
④ cuticular striations
⑤ mesocarp
⑥ epicarp showing the cells arranged in rows
⑦ microspheroidal crystals of calcium oxalate
⑧ fibrovascular tissue from the stem
⑨ epicarp from near the base of the fruit in surface view
⑩ elongated sclereids of the endocarp in surface view
⑪ sclereids of the endocarp
⑫ parenchyma
⑬ endocarp in section view
⑭ parenchyma of the mesocarp in longitudinal view
⑮ epidermis of the testa in surface view
⑯ part of a fiber from the stem
⑰ oil globules
⑱ glandular trichomes from the calyx
⑲ covering trichome
⑳ epidermis of the pedicel in surface view
㉑ spiral vessel

Figure 12. Description of Tissue from powdered : Senna Pods B.P., B.P.C.
Cassia angustifolia Vahl., Family Caesalpinioidae.



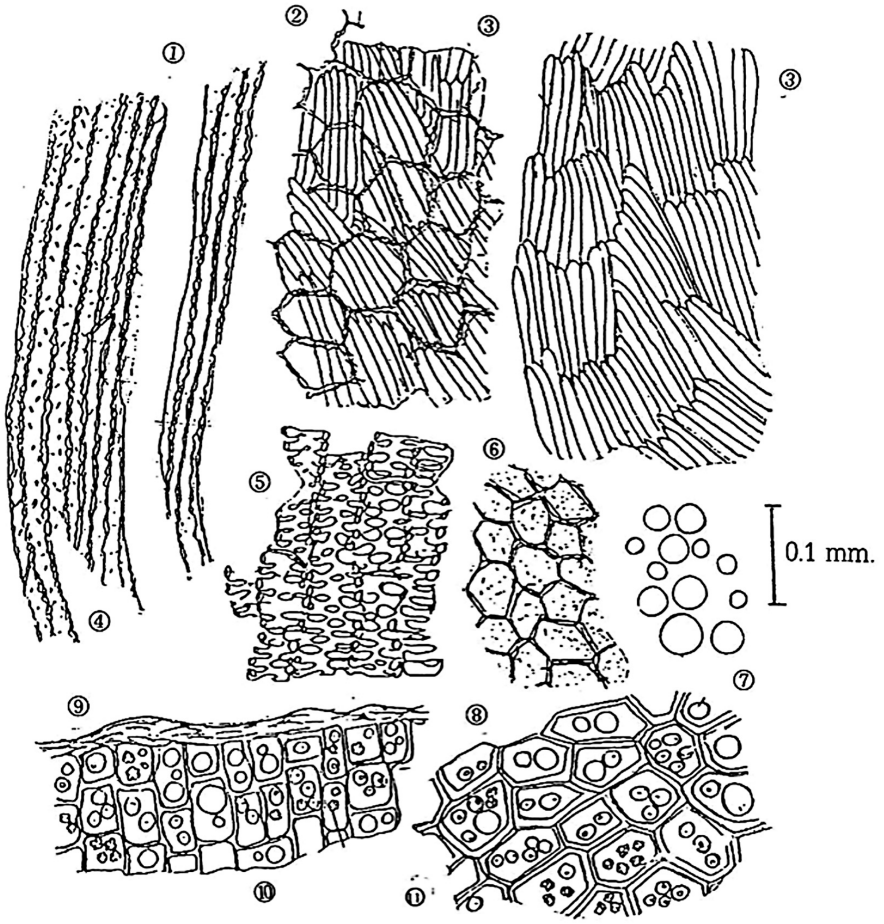
① crystal fiber from pericarp
② fiber cell
③ pericarp of fruit
④ parenchyma of endosperm
⑤ epidermis of pericarp
⑥ paracytic stoma
⑦ stone cell
⑧ unicellular non glandular trichome
⑨ reticulate vessel
⑩ spiral vessel
⑪ pitted vessel
⑫ brownish pigment

Figure 13. Description of Tissue from powdered : Coriander
Coriandrum sativum Linn., Family Umbelliferae.



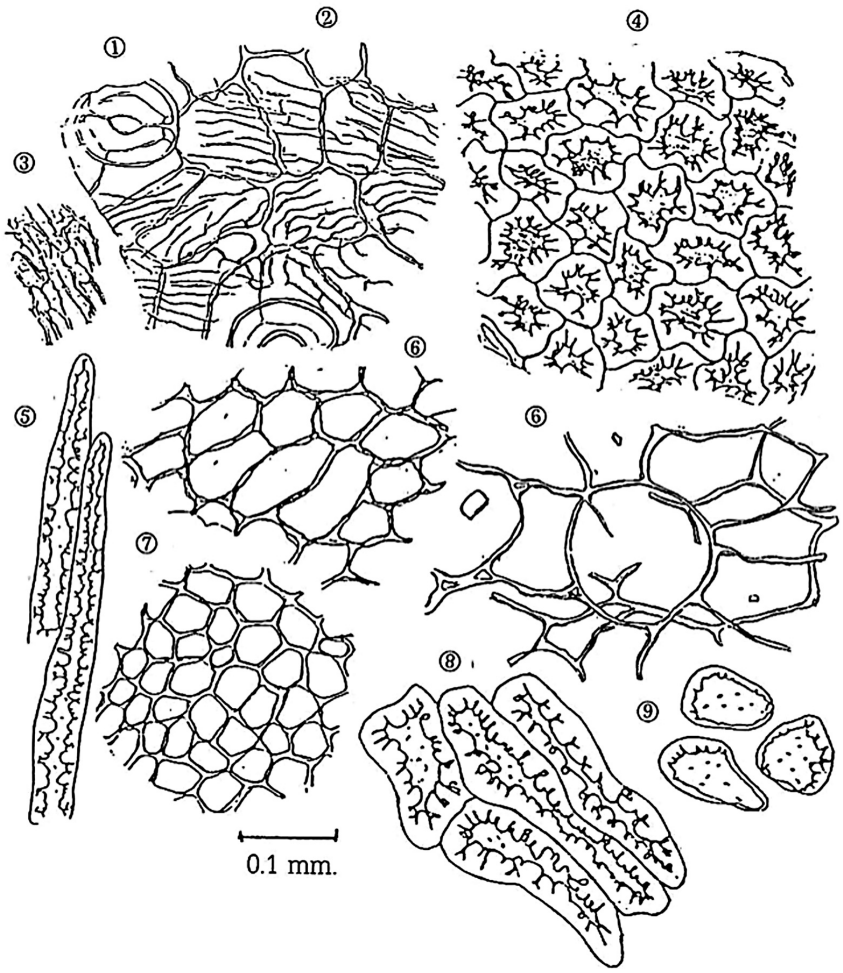
① epicarp in surface view
② fusiform sclereids of mesocarp in suface view
③ endocarp
④ fusiform sclereids of mesocarp in surface view
⑤ fusiform sclereids of mesocarp in section view
⑥ rectangular sclereids of mesocarp
⑦ endocarp in section view
⑧ mesocarp
⑨ endosperm
⑩ microspheroidal calcium oxalate crystal
⑪ lignified fibers
⑫ stomata
⑬ seed coat
⑭ aleurone grain
⑮ oil globules

Figure 14. Description of Tissue from powdered : Fennel B.P.C.
Foeniculum vulagare Mill., Family Umbelliferae.



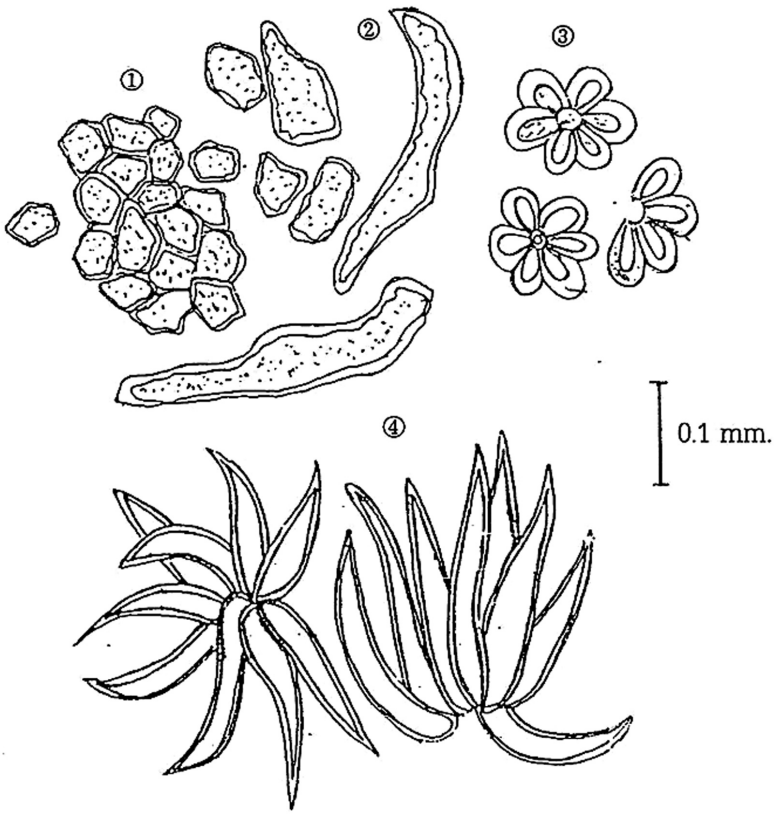
① fiber cell
② lignified mesocarp
③ lignified endocarp
④ pitted tracheids
⑤ reticulate vessel of mesocarp
⑥ epithelium of vittae in surface view
⑦ oil globules
⑧ aleurone grain
⑨ seed coat
⑩ endosperm in section view
⑪ endosperm in surface view

Figure 15. Description of Tissue from powdered : Illicium
Illicium verum Hk., Family Magnoliaceae.



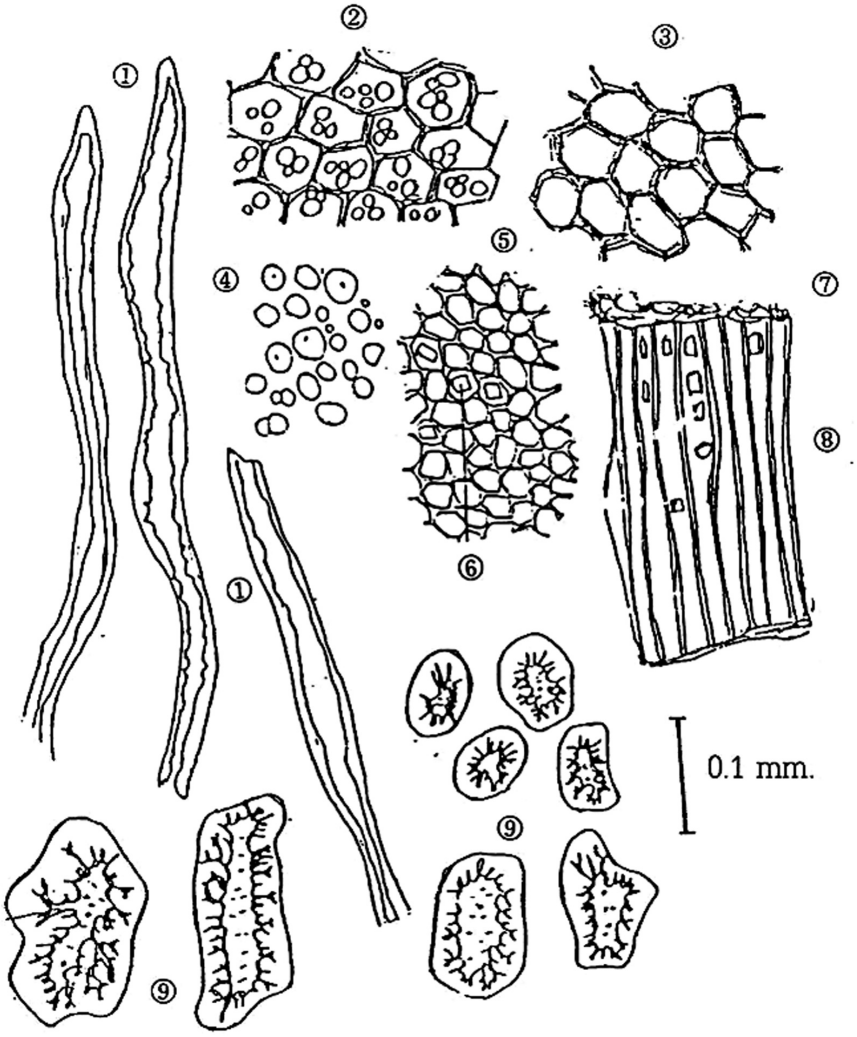
① paracytic stoma
② epicarp in surface view
③ striated cuticle
④ lignified outer epidermal cells
⑤ fiber cell
⑥ parenchyma of mesocarp
⑦ parenchyma of endosperm
⑧ lignified outer epidermis of seed coat
⑨ stone cell of seed coat

Figure 16. Description of Tissue from powdered : Kamala
Mallotus philippensis (Lml.) M.-A., Family Euphorbiaceae.



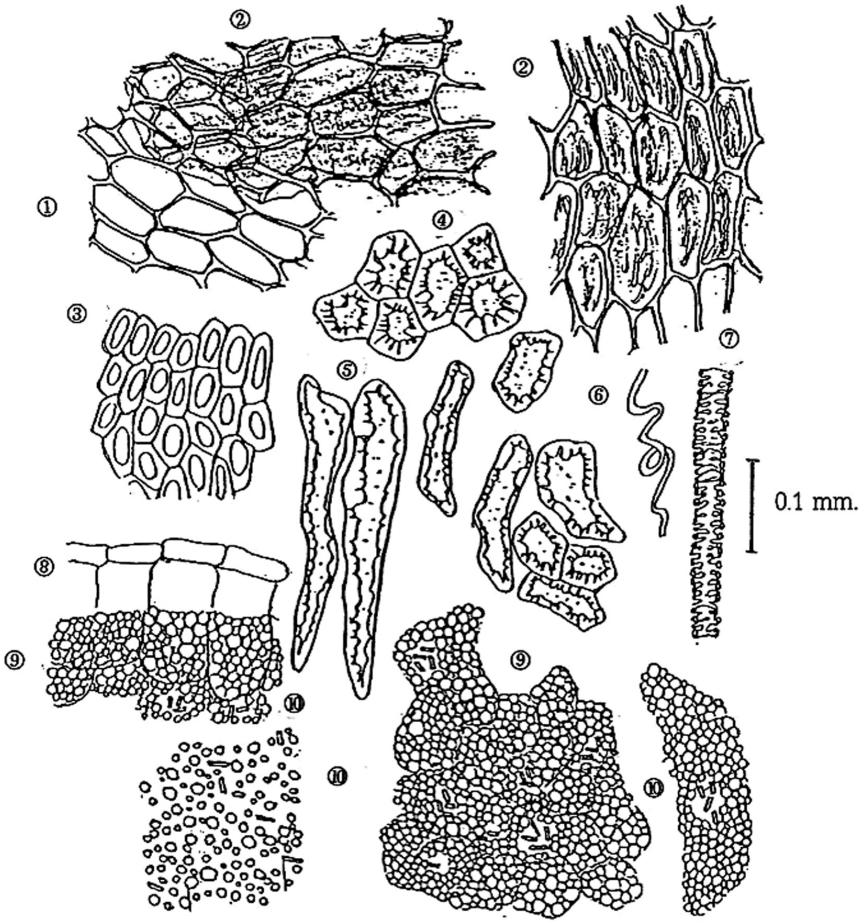
① stone cells of pericarp
② sclerenchyma fiber of pericarp
③ reddish brown-yellow glandular trichome
④ non glandular stellate aggregate trichomes

Figure 17. Description of Tissue from powdered : Cubeb
Piper cubeba Linn., Family Piperaceae.



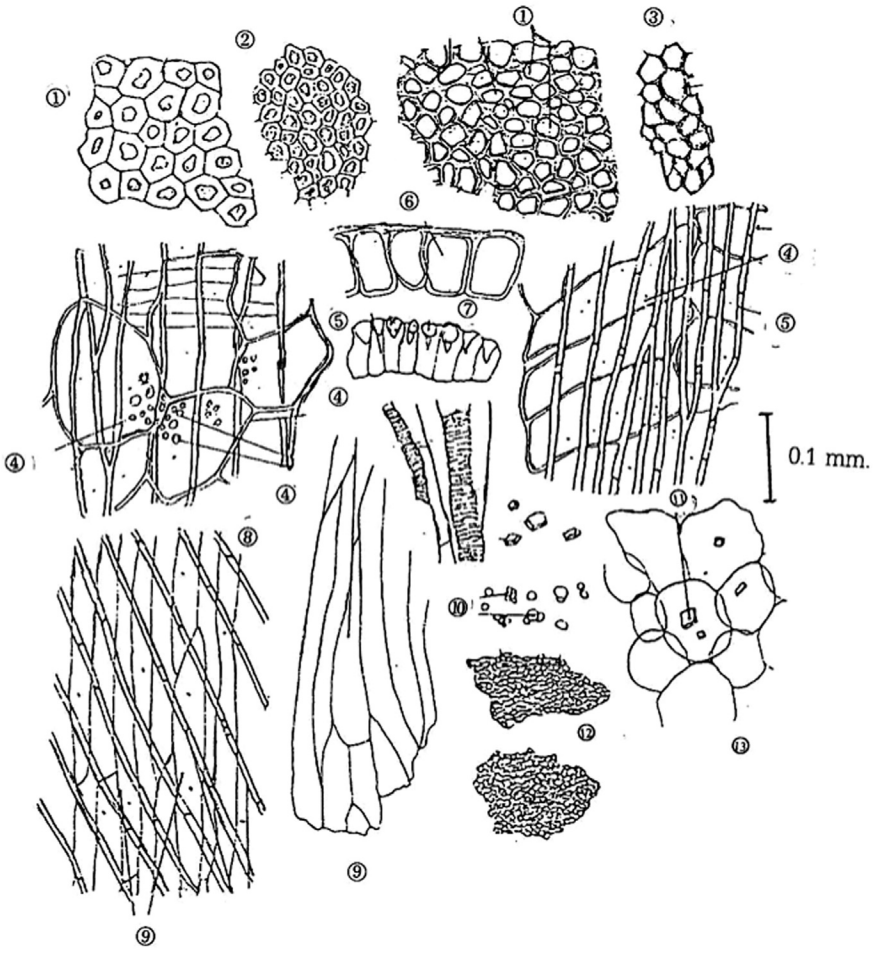
① lignified fiber
② perisperm
③ thin wall perisperm
④ starch grains
⑤ spermoderm in surface view
⑥ small calcium oxlate prisms
⑦ spermoderm in section view
⑧ yellowish brown wall
⑨ thickened stone cell

Figure 18. Description of Tissue from powdered : Long Pepper
Piper longum Linn., Family Piperaceae.



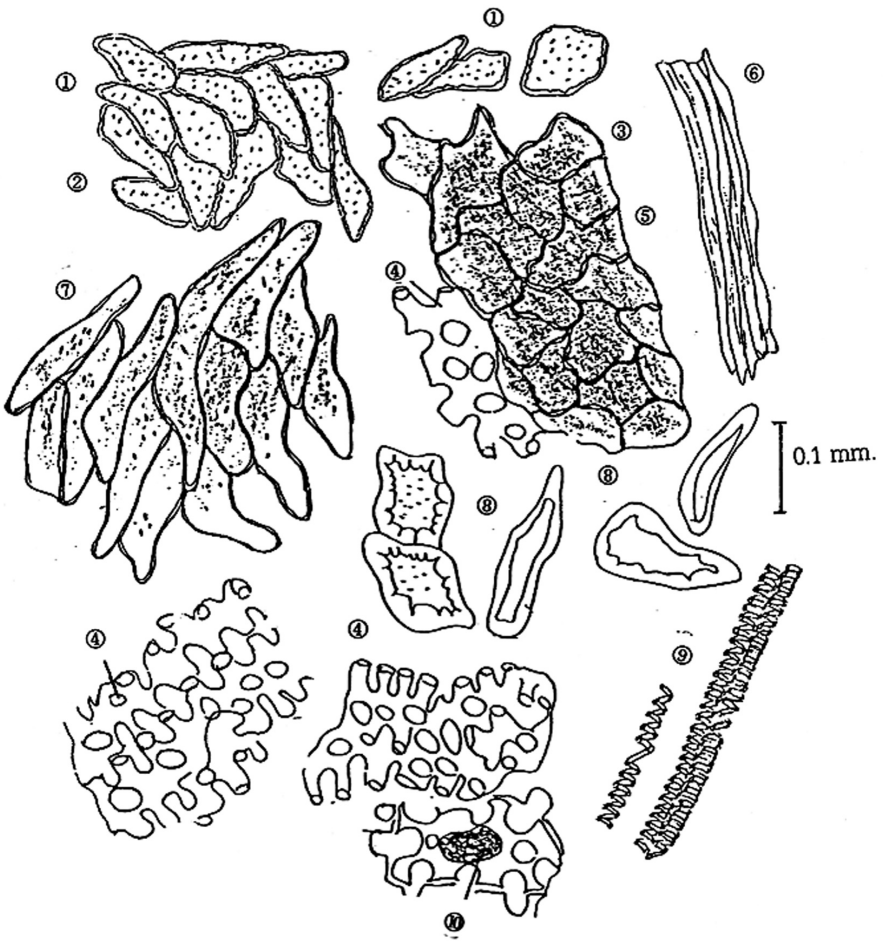
① yellowish brown middle epidermis
② brownish inner epidermis
③ outer epidermis of spermoderm
④ stone cells of hypodermis
⑤ sclereids of hypodermis
⑥ spiral vessel
⑦ reticulate vessel
⑧ spermoderm
⑨ perisperm
⑩ crystals of piperine

Figure 19. Description of Tissue from powdered : Siam Cardamom
Amomum krervanh Pierre, Family Zingiberaceae.



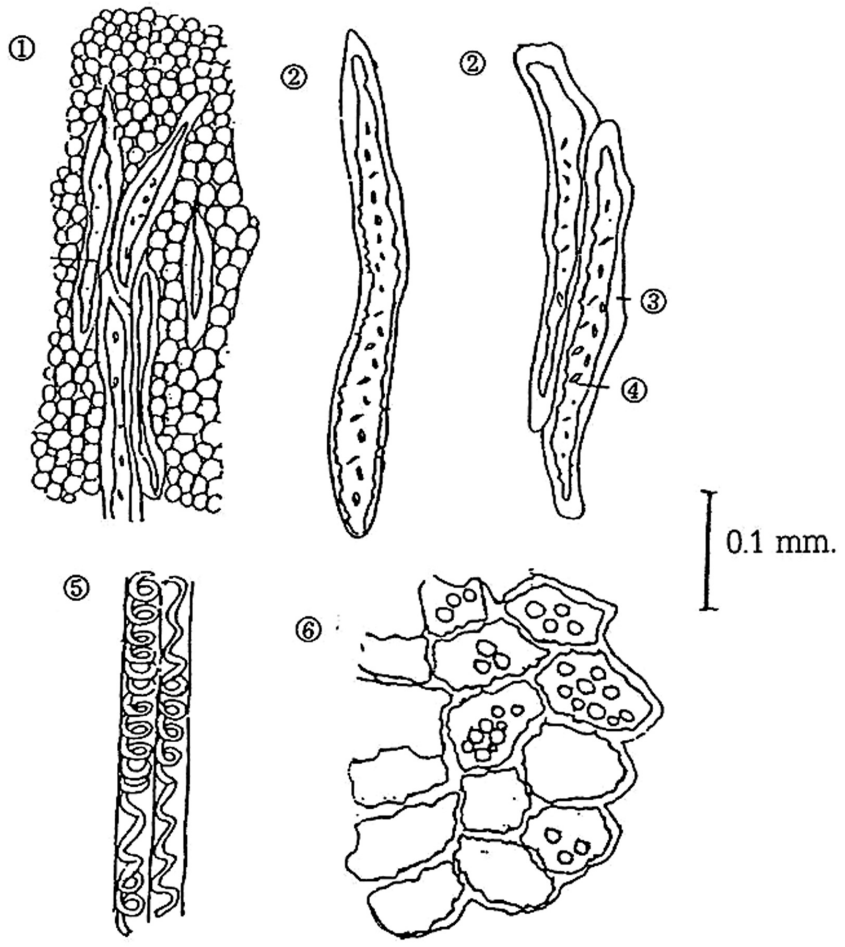
① sclerenchymatous layer of the testa in surface view
② sclerenchymatous layer of the testa from an immature seed in surface view
③ parenchyma of the testa in surface view
④ oil cells
⑤ epidermis of the testa
⑥ epidermis of the testa
⑦ sclerenchymatous layer of the testa in sectional view
⑧ epidermis of the testa in sectional view
⑨ arillus
⑩ starch granules
⑪ prism of calcium oxalate
⑫ perisperm cells
⑬ parenchymatous endosperm

Figure 20. Description of Tissue from powdered : Areca
Areca catechu Linn., Family Palmae.



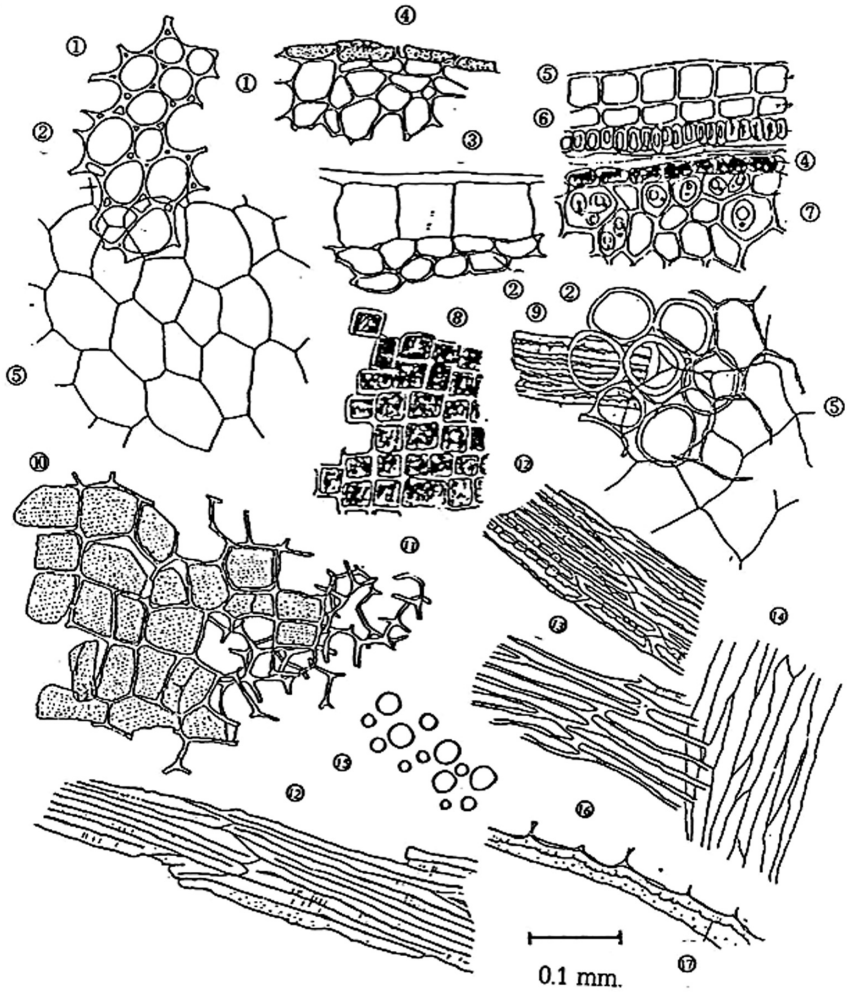
① elongated and lignified cells of mesocarp
② pits
③ testa in transverse sectional view
④ endosperm in surface view
⑤ pigment
⑥ fiber cell of hypodermis
⑦ elongated cells of testa
⑧ sclerenchyma cell of testa
⑨ spiral vessels
⑩ tannin masses

Figure 21. Description of Tissue from powdered : Coffee
Coffea arabica Linn., Family Rubiaceae.



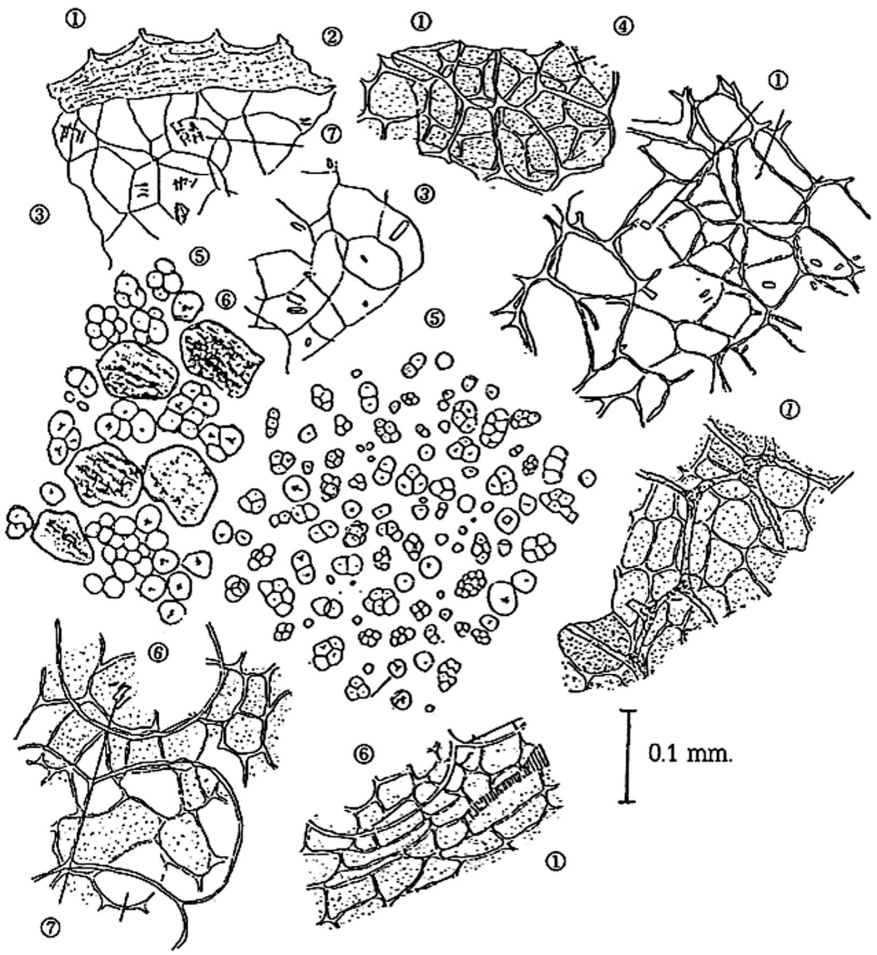
① parenchyma cells
② lignified sclerenchyma cells
③ lignin
④ pores
⑤ spiral vessel
⑥ outer perisperm

Figure 22. Description of Tissue from powdered : Linseed
Linum usitatissimum Linn., Family Linaceae.



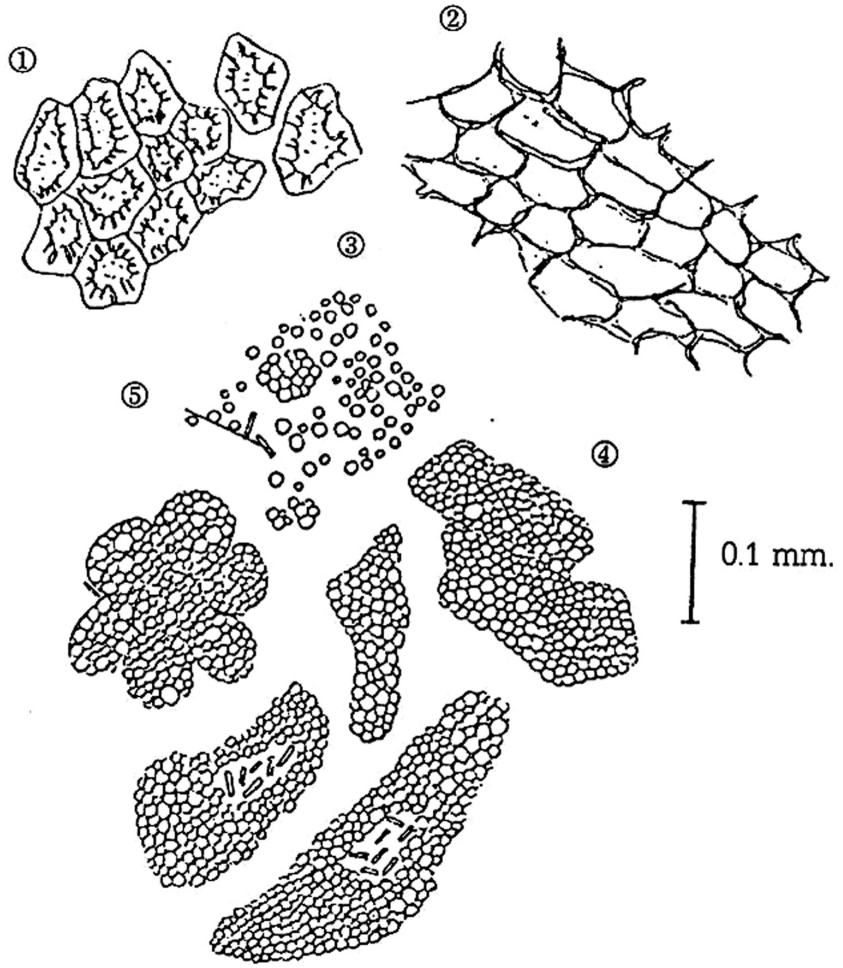
① testa in section view
② parenchyma
③ epidermis
④ pigment
⑤ epidermis
⑥ hypodermis
⑦ endosperm
⑧ testa in surface view
⑨ sclerenchyma
⑩ pigment cells
⑪ endosperm cells
⑫ thick wall sclerenchymatous layer in surface view
⑬ thin wall sclerenchymatous layer
⑭ hyaline layer in surface view
⑮ oil globules
⑯ parenchymatous layer
⑰ sclerenchymatous layer

Figure 23. Description of Tissue from powdered : Nutmeg B.P.C.
Myristica fragrans Houtt., Family Myristicaceae.



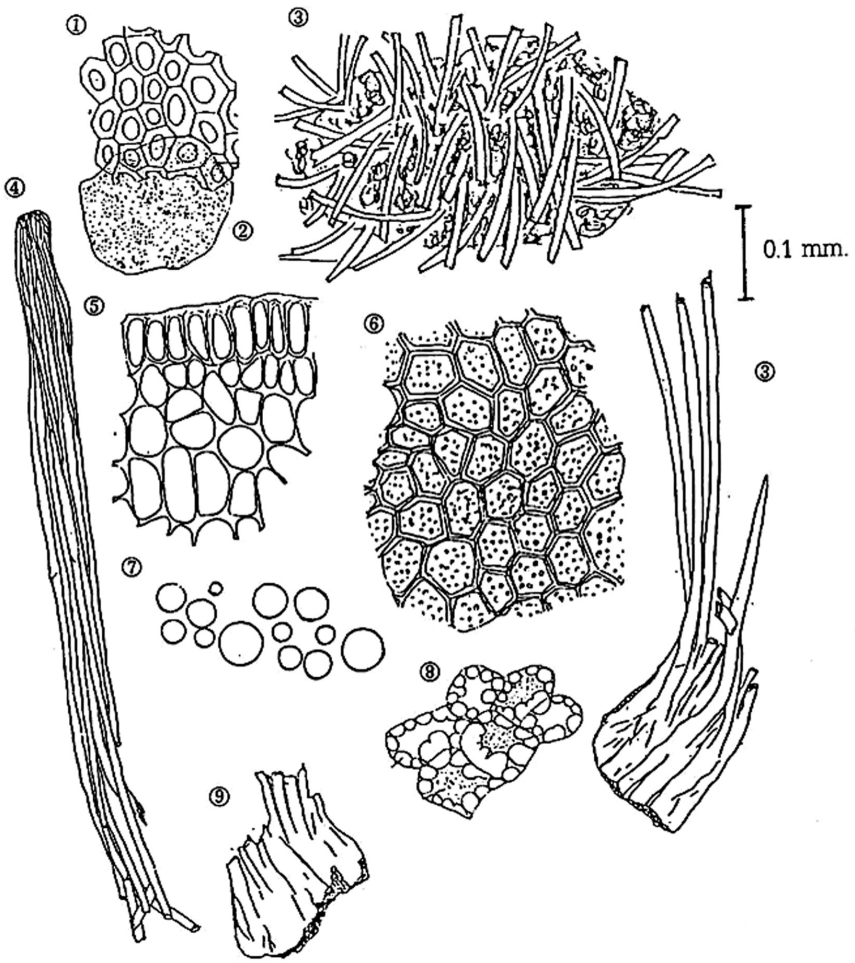
① perisperm
② outer part of endosperm
③ endosperm
④ pigment
⑤ starch grains
⑥ reddish brown content
⑦ calcium oxalate crystals

Figure 24. Description of Tissue from powdered : White pepper
Piper nigum Linn., Family Piperaceae.



① stone cells from hypodermal layer of pericarp
② yellowish brown spermoderm
③ perisperm tissue
④ minute starch grains
⑤ acicular piperine crystals

Figure 25. Description of Tissue from powdered : Nux Vomica B.P.
Strychnos nux-vomica Linn., Family Loganiaceae.



① testa
② pigment
③ lignified trichomes
④ rounded apex of trichome
⑤ endosperm in outer region
⑥ endosperm in surface view
⑦ oil globules
⑧ sclerenchymatous tissue
⑨ part of trichome rods

DISCUSSION AND CONCLUSION

The results show that different cells are distinct for each species of powdered medicinal plant. These characteristics are morphology, size and stain color of cells and tissues. Other factors which affect medicinal plants are age of plants, age of each cell and staining process, viz., duration of staining and constituents of both cell interiors and cell walls. These factors are sometimes obstacles for correct identification of medicinal plants. These factors were in this study. The experience and skills are vital to identify and distinguish the cells of medicinal plant powders. Replications were made to confirm the results. Diagnostic characters and properties of each cell type and component were used to identify each medicinal plant. The conclusions were made from authentic parts.

The results confirmed the hypothesis that powdered tissues of medicinal plant parts are different in type, shape, size and stain for cells and components. Some species of medicinal plants are planted in medicinal plant garden, Faculty of Pharmacy, Chiang Mai University. The results are used as teaching materials for Pharmacognosy, Medical Plant for Primary Health Care, Basic Knowledge of Traditional Thai Medicine and other related subjects.

The results present a protocol to identify diagnostic unique characters and reveal adulteration and contamination in medicinal plants for primary health care. The study showed that medicinal plants can be promoted as a natural-resource use, to reduce the demands of chemically-synthesized drugs from foreign countries and to help stabilize Thailand's economy.

ACKNOWLEDGEMENTS

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