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COMPARATIVE PHARMACOGNOSTICAL EVALUATION OF MALE AND BISEXUAL FLOWER OF *KADALI* (*MUSA PARADISIACA* L.)

SHIVANI SHARMA[1*], PRIYA DARSHANI[2], HARISHA CR[3], VD. BHUPESH PATEL[4]

*[*1]Ph.D Scholar Department of Pharmacognosy, Institute of Teaching and Research in Ayurveda, Jamnagar, Gujarat, India*

[2]Ph.D Scholar Department of Pharmacognosy, Institute of Teaching and Research in Ayurveda, Jamnagar, Gujarat, India

[3]HOD of Pharmacognosy Department, Institute of Teaching and Research in Ayurveda, Jamnagar, Gujarat, India

[4]Porfessor of Dravyaguna Department, Institute of Teaching and Research in Ayurveda, Jamnagar, Gujarat, India

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***Corresponding Author**

Shivani Sharma Department of Pharmacognosy, Institute of Teaching and Research in Ayurveda Jamnagar, Gujarat, India 361008

ORCID: 0009-0009-2324-1839

Abstract

Background: The Sanskrit word *Kadali* means a plant with profuse water. It is known as *Kela* in Hindi. The botanical name of *Kadali* is *Musa paradisica* Linn. belongs to family Musaceae. In *Vedas Kadali* was not mentioned but in *Nighantus* the plant is classified in different *Gana* or *Varga*. Banana is an herbaceous flowering plant in the genus *Musa* belonging to family Musaceae. The flowers of *kadali* used in the treatment of breast cancer, hypertension, anemia dysentery, bronchial asthma, dysmenorrhoea, wound healing, menorrhagia, type 2 diabetes, bowel diseases, antibacterial etc.

Objective: Present study was undertaken to study the comparative pharmacognostical study of *Kadali Pushpa* of male and bisexual flowers.

Material & Method: Collection of *Kadali Pushpa* are done & observed carefully for its identical morphological, macroscopically, microscopically parameters.

Result: Macro – microscopic features of different parts of a bisexual *Kadali* and male *Kadali* flower with wide perianth, spathe, gynoceium, androecium. T.S. of spathe show purplish colouring matter with epidermal cells. T.S. of perianth shows single layered inner and outer epidermis. Epidermis covered with thin cuticle Powder microscopy of *Kadali* male and bisexual flower shows different characters like pollen grain, acicular crystal, prismatic crystal, simple and compound starch grain, fibers, oil globules etc. In micrometric evaluation both male and bisexual flowers of *Kadali* show similar and dissimilar characters.

Conclusion: Individual floral microscopical characters show that presence and absence of gynoceium. The powder microscopy of both the flowers samples are shows all most similar characters.

INTRODUCTION

From olden days fruits and vegetables are important component of a healthy diet. There are lots of fruits and vegetables available which are high in nutrition and also having great medicinal use. Bananas are the excellent source of nutrition and also have great medicinal value. Banana is the most significant of all the tropical and subtropical fruit [1]. Banana is an herbaceous flowering plant in the genus *Musa* belonging to family Musaceae. The genus contains different species of monocot (pseudo) plant significant for food, medicinal purpose, local religious purpose, ornamental plant, fiber industries, nutraceuticals etc [2]. Ayurveda, Siddha, and other traditional medical systems have made considerable use of many plant parts, including fruits, leaves, pseudostem, rhizome, and flowers. In addition to being eaten as a vegetable, the blooms of *Musa paradisiaca*, commonly known as banana blossom, are said to have therapeutic qualities like anti-diabetic, antioxidant, anti-ulcer, anti-inflammatory and wound-healing effects. Scientific standardization of banana blossoms is crucial for their accurate identification, quality control, and safe use in herbal formulations due to their growing medicinal and nutraceutical relevance.

Banana is originated in India and South Asia [3]. It is currently farmed over the entire subtropical and tropical regions of Africa, not just in Nigeria. Plantains are an important part of the diet of many indigenous peoples that make their home in the subtropics [4]. Cultivation is limited to Florida, The Canary Islands, Egypt, Southern Japan, and South Brazil [5]. As per classical literature available in *Ayurveda* it is evident that the drug *Kadali* is having much importance being extensively used for its varied benefits. Almost all the *Acharyas* of *Ayurveda* has referred this drug for its multiple benefits in therapeutics. In Vedas *Kadali* was not mentioned but during *Nighantu* periods

and in *Sushruta samhita* it is mentioned. It is also mentioned in Hindu religious book *Ramayana* [6].

The goal of the current study was to do a thorough comparative pharmacognostical analysis of the male and bisexual flowers of *Musa paradisiaca* Linn. Detailed macroscopic descriptions, transverse section analyses of the spathe, perianth, anther, and ovary, histochemical reactions and powder microscopy determination are all included in the inquiry. In order to accurately identify and authenticate male and bisexual flowers for use in pharmaceutical and nutraceutical applications, this effort aims to develop diagnostic features and standard quality control measures.

MATERIAL AND METHODS

Collection & Authentification of Raw Drug

At the beginning of this work raw sample of *Kadali Pushpa* (*Musa paradisaca* L.,) was collected from the Natural Habitat of Jamnagar Gujarat during month of April 2024. Pharmacognostical identification and authentification was done in pharmacognosy laboratory ITRA, Jamnagar Gujarat. Fresh sample was used for various pharmacognostical & phytochmeical study. The specimen is kept in Pharmacognosy lab ITRA Jamnagar Gujarat with (Specimen no. Ph. M/6712/ 2023-24). Plant authtification is done in Botanical survery of India, Jodhpur (BSI) and also Herbarium is deposit in BSI. **(Fig. 2)**

Pharmacognostical Analysis

Macroscopic:

The collected sample was identified and authentified by studying their characters were studied systematically as per the methods described in the textbooks of pharmacognosy. The specimen was observed as such with naked eyes [7].

Organoleptic:

Organoleptic characters i.e color, texture, odour, taste etc. by using sensory organs [8].

Microscopic:

Transverse sections of perianth, spathe and androceium and gynoecium with ovary were taken and made permanent with suitable stains [9]. Quantification and photomicrographs were taken of the permanent preparations. The cell contents were measured using stage and ocular micrometer [10]. Later sections of the plant material observed first in distilled water under the microscope for the presence of primary and secondary metabolites, like starch grains which were confirmed by staining them with iodine. The sections cleared with chloral hydrate to observe the various ergastic cell contents like, crystals of calcium oxalate, calcium carbonate, and silica if present any. The natures of these crystals were also confirmed by performing some tests like, solubility of them in acids (HCl). The sections then stained with Phloroglucinol and HCl [11].

Histochemical Evaluation

The histochemical studies for the cell content were done by staining the hand cut sections of spathe, perianth, androceium, and gynoceium with different reagents [12].

Micrometric Evaluation

Micrometric evaluation of observed cellular characters also had done [13]. All determinations were performed in triplicate and the results are presented as mean ± standard deviation (SD).

Powder Microscopy

The dried powder of flower was obsereved with first studied under water then followed by staining in different reagents [14].

Observation & Result

Bisexual flower (*Musa paradisiaca* L.)

Macroscopic Study

A terminal spike covered with red bracts arranged in three spiral lines around the floral axis, each bract covers many unisexual flowers. Sessile, monoecious, unisexual, zygomorphic, epigynous, male flowers occur above the female in the bracteates inflorescence, bisexual flowers are also found within the middle bracts. Bracts are large, concave, purplish red in colour. Group of flowers arranged spirally on flowering pedancle and covered by bract. About 11-13 flowers are produced per cluster. Macroscopic measurement of individual flowers is about ± 8-9 cm in length. Perianth and tepals are six, arranged in tubuler shape, five forked tepals united (anterior) and sixth taple is free boat shaped (posterior). Taples are thick, smooth, pale yellow in color. Stamens six, five stamens are fertile (posterior) and the sixth stamen is sterile (staminode) or sometimes absent, stamens free, anthers bithecus and basifixed.

Gynoecium tricarpillary, syncarpous, ovary inferior, trilocular, axile placentation, many ovules in each locule, ovules do not developed into seed and that's why fruits are seedless, style simple, filiform, stigma three lobed. **(Table no. 1.1)**

Microscopic study of bisexual flower (*Musa paradisiaca* L.)

Transverse section of Spathe

Diagrammatic T.S. of spathe measures about 16cm in (4X) and shows outer and inner epidermis with colouring matters. The outer epidermis is two to three layered and covered with thick cuticle.Ground tissue with parenchyma cells consists fibro vascular bundles, starch grains, acicular crystals, silica deposition is found in parenchyma cells. Central cavity due to disintegration of ground tissue. **(Photo plate 1 fig. C, D, E)**

Transverse section of perianth

Section shows single layered inner and outer epidermis. Epidermis covered with thin cuticle. Ground tissue consist only parenchymatous cells, often embedded with acicular crystals, oil globules and starch grains. **(Photo plate 1 fig. G, H)**

Transverse section of Anther (Androecium)

Diagrammatic T.S. of anther measures about 6.7 µm X 2.8 µm in diameter, anthers are tetrasporangiate and locules are separated by the septum. The connective region has single layered epidermis and ground tissue made up of parenchyma cells along with some vascular bundles, starch grains very common in the section. Pollen grains distributed all over the section as the chamber get ruptured. **(Photo plate 1 fig.K)**

Transverse section of ovary (Gynoecium)

Diagrammatic T.S. of gynoecium measures about 7.8 µm in diameters. Slightly three lobed. Detailed T.S. shows single layer epidermis made of squarish shaped epidermal cells. Ground tissue made of parenchyma cells embedded by starch grains. As the fruit tricarpillary the 3 distinguished ovaries distributed in

ground tissue along with the vascular strands. **(Photo plate 1 fig. J, L, M)**

Powder Microscopy Bisexual flower (*Musa paradisiaca* L.)

Organoleptic characters

The organoleptic & sensory Characters were used in identification of plant material and also serve as an important standardization parameter. Studies showed that the *Kadali pushpa* is blackish brown in colour, astringent in odour & astringent in taste and fibrous in touch. **(Table no. 1.2)**

Powder microscopic characters of bisexual flower (*Musa paradisiaca* L.)

Diagnostic characters of bisexual flower are pollen grain, oil globules, and spiral vessel of perianth, simple fiber, fragment of annular vessles, Brown content, colouring matter, parenchyma cells, and lignified fiber, mucilage content cells, epidermal cells of perianth, acicular crystal. **(Table no. 1.3) (Photo plate no.2)**

Micrometric study

Result of Micrometric evaluation of bisexual flower are shown in **(Table no. 1.4)**

MALE FLOWER

Macroscopical characters of Male flower ((*Musa paradisiaca* L.)

A terminal spike covered with red bracts arranged in three spiral lines around the floral axis, each bract covers many unisexual flowers. Sessile, monoecious, zygomorphic, epigynous, male flowers occur below the female in the bracteates inflorescence, Bracts are large, concave, dark red in colour. Group of flowers arranged radially on flowering stalk and covered by bract. About 10-12 flowers are produced per cluster. Macroscopic measurement of is about 6-8 cm in length.

Six perianth tepals, arranged in tubuler shape, five forked tepals united (anterior) and sixth taple is free boat shaped (posterior). Taples are thick, smooth, pale yellow in color. Six stamens, five stamens are fertile (posterior) and the sixth stamen is sterile (staminode) or sometimes absent, stamens free, anthers bithecu and basifixed. measurement of flower parts also depicted in **(Table no.1.5) (Plate no. 1, fig. B)**

MICROSCOPIC STUDY OF MALE FLOWER (*MUSA PARADISIACA* L.)

Transverse section of Spathe

Diagrammatic T.S. of spathe measures about 12cm in length (4X) and shows outer and inner epidermis with colouring matters. The outer epidermis is two to three layered and covered with cuticle layer. Epidermis was followed by palisade parenchyma with chlorophyll content and spongy paranchymatous layer were found. Fibro vascular bundles, starch grains, acicular crystals, silica deposition is found in parenchyma cells. Cavity due to disintegration of ground tissue found after spongy parenchyma region. **(Photo plate 3 fig. C, D)**

Transverse section of perianth

Section shows single layered inner and outer epidermis. Epidermis covered with thin cuticle. Ground tissue consist only parenchymatous cells, often embedded with acicular crystals, oil globules and starch grains. **(Photo plate 3 fig. I, J)**

Transverse section of Anther (Androecium)

Diagrammatic T.S. of anther measures about 6.7 µm X 2.8 µm in diameter, anthers are tetrasporangiate and locules are seprated by the septum. The connective region has single layered epidermis and ground tissue made up of parenchyma cells along with some vascular bundles, starch grains very common in the section. Pollen grains distributed all over the section as the chamber get disturbed. **(Photo plate 3 fig. E, H)**

MALE FLOWER

Organoleptic characters of Male flower (*Musa paradisiaca* L.)

The organoleptic & sensory character was used in identification of plant material and also serves as an important standardization parameter. Studies showed that the *Kadali pushpa* is brown in colour, aromatic in odour, taste is sweetish followed by astringent and course in touch. **(Table no.1.6)**

Powder microscopic characters of Male flower (*Musa paradisiaca* L.):

Diagnostic characters of male flower are pollen grain with anther, oil globules, and spiral vessel of perianth, fragment of annular vessels, Brown content, colouring matter, parenchyma cells, acicular crystal and lignified fiber, Annular vessel of spathe, beaded parenchyma cells of spathe. **(Table no. 1.7) (Photo plate 3)**

Micrometric study

Result of Micrometric evaluation of male flower are shown in **(Table no. 1.8)**

COLLECTION & AUTHENTICATIONOF FLOWER SAMPLES *MUSA PARADISIACA*

Fig. 1 Natural Plant habitat

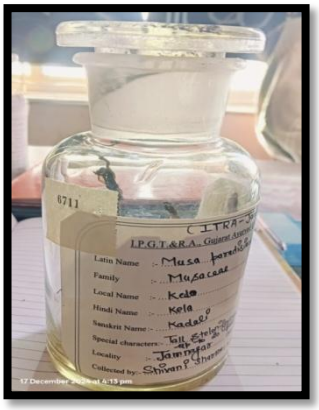

Fig.2 Dried Flower Specimen

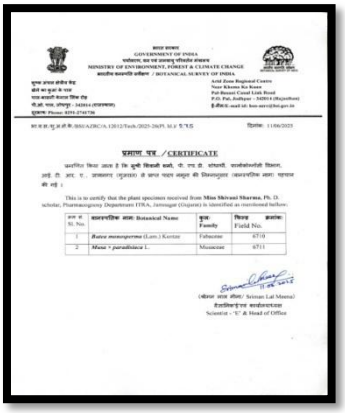

Fig. 3 Authentication Certificate

Plate 1 T.S. of Bisexual flower (*Musa paradisiaca* L.)

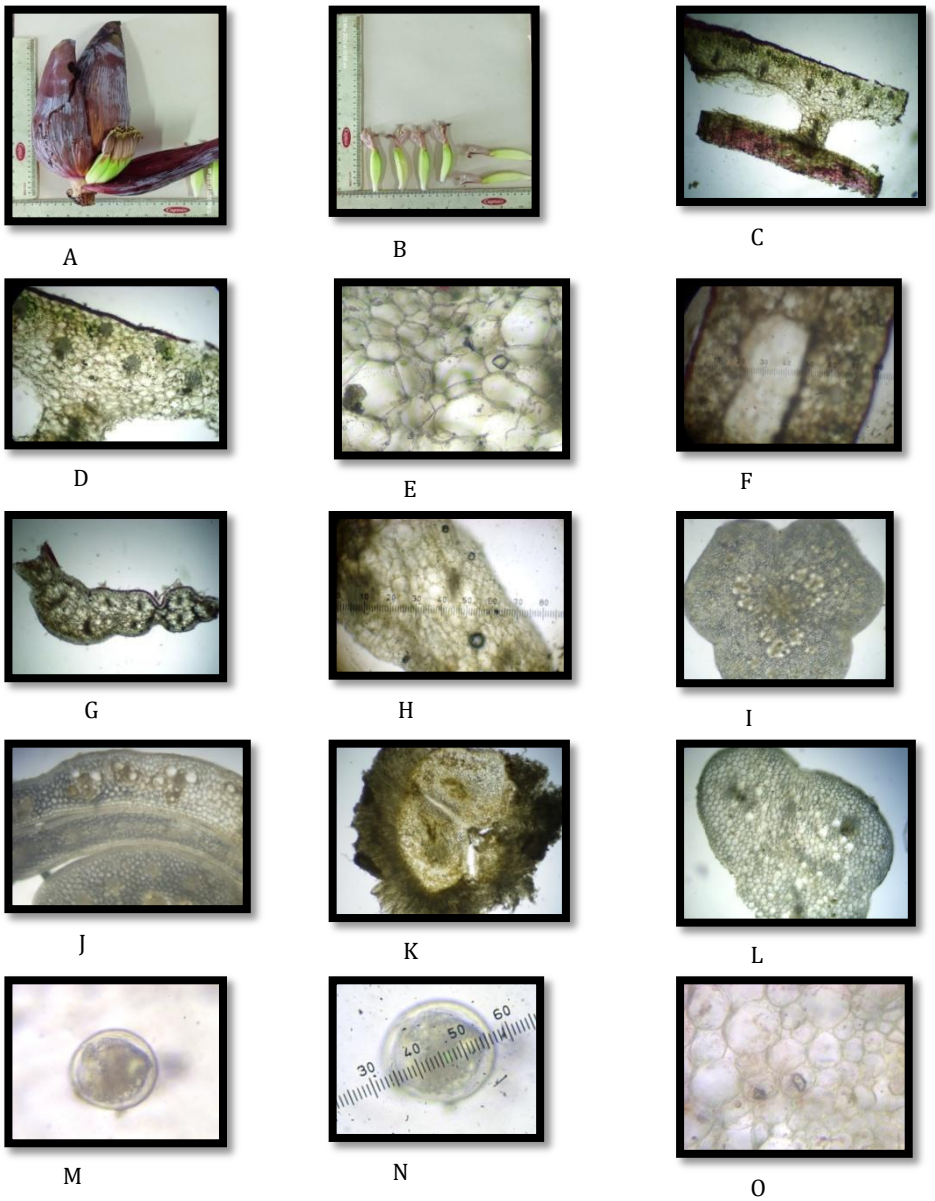

Plate no. 1 Fig (A) Inflorescence with flower (B) Macromeasurement of flowe; (C) T.S. of Spathe; (D) T.S. of spathe with cuticle with epidermis, ground tissue and air chamber; (E) Parenchyma cells with prismatic crystal; (F) Measurement of spathe (G) T.S. of perianth; (H) Micromesaurement of perinath ; (I) T.S. through ovary with three carpels; (J) Outer and inner epidermis with ground tissue; (K) Outer epidermis ground tissue following cortical region central loacted ovaries; (L) T.S. of tricarpillary gynoecium with epidermis and ground tissue; (M) Pollen grain; (N) Micromeasurement of pollen grain; (O) Ground tissue with prismatic crystal

Plate 2 Powder microscopy of Bisexual flower (*Musa paradisiaca* L.)

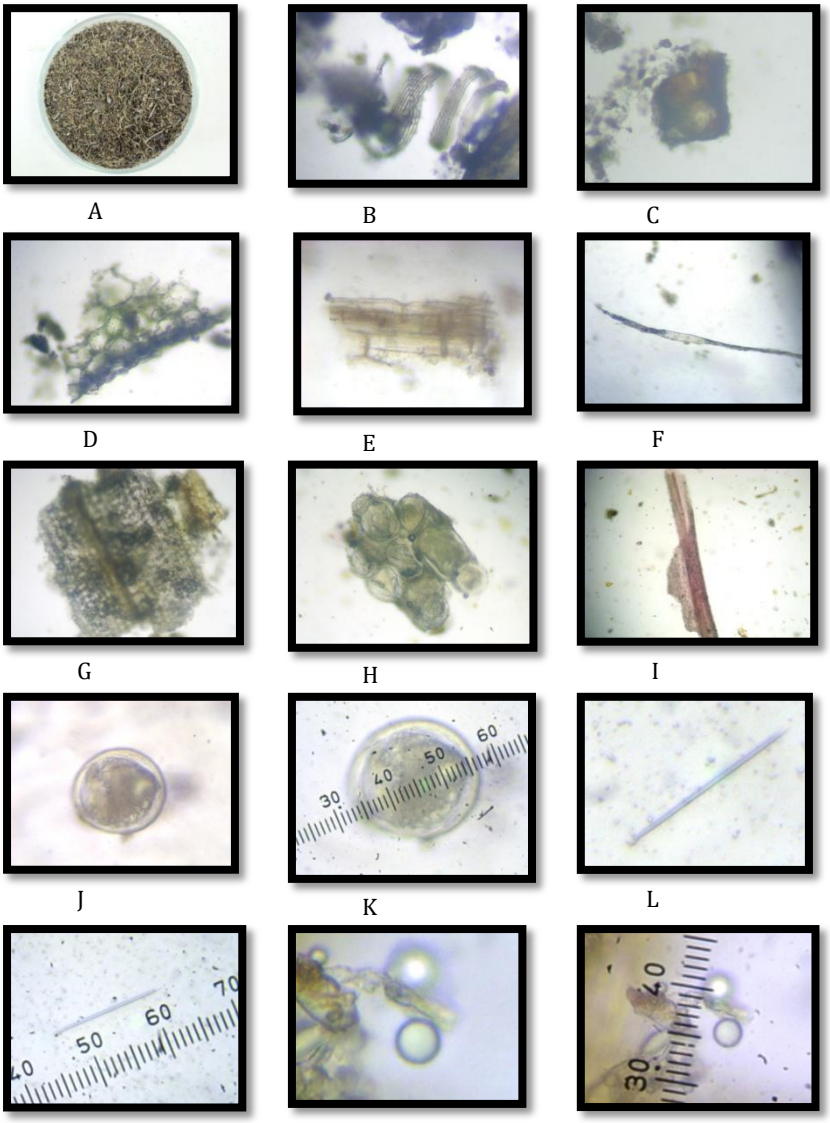

Plate 2. Fig. (A) Natural sample**;** (B) Spiral vessel**;** (C) Colouring matter**;** (D) Parenchyma cells of perianth; (E) Epidermal cells of spathe; (F) fiber; (G) Annular vessels; (H) Parenchyma cells of spathe; (I) Lignified fiber; (J) Pollen grain; (K) Measurement of pollen grain; (L) Acicular crystal; (M) Measurement of acicular crystal; (N) Oil globules; (O) Measurement of oil globules

Plate 3 T.S. of male flower (*Musa paradisiaca* L)

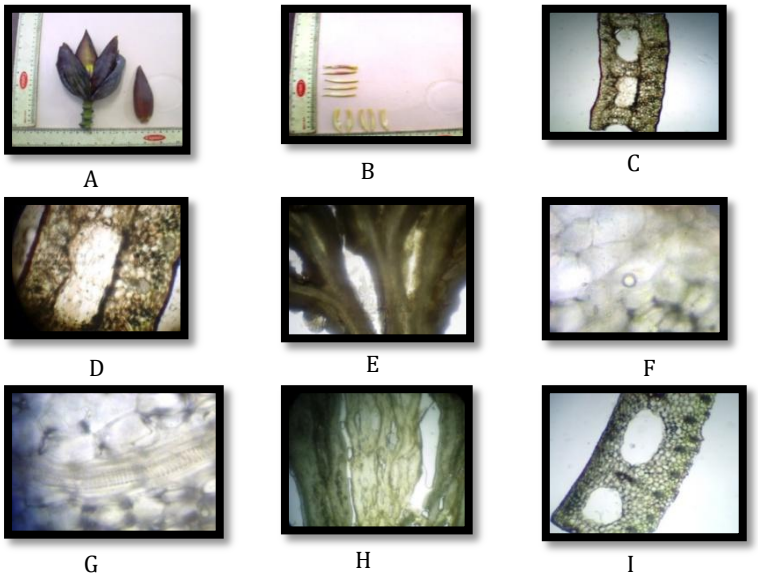

Plate 3 (A) Inflorescence with flowers & perianth; (B) Macromeasurement of flower; (C) Digramatic T.S. of perianth; (D) Measurement of perianth**;** (E) Squashed androecium with anthers; (F) Ground tissue with oil globules; (G)Vascular strands passing through ground tissue; (H) Basel part of the androecium with parenchyma cells; (I) Diagrammatic section of Spathe

Plate 4 Powder microscopy of male flower (*Musa paradisiaca* L.)

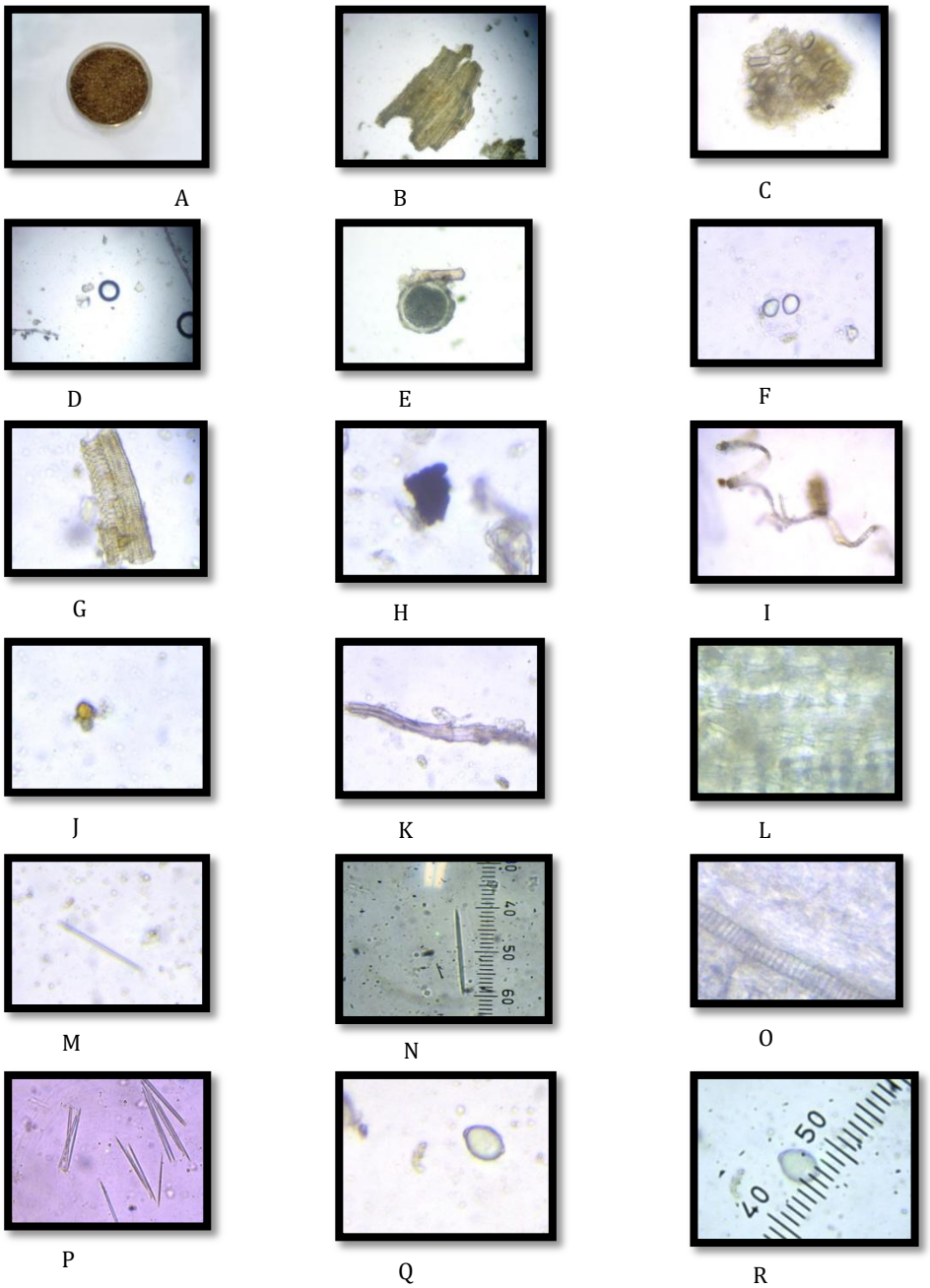

Plate 4 (A) Natural powder; (B) Epidermal cells of spathe; (C) Parenchyma cells of perianth; (D) Oil globules; (E) Pollen grain with anther; (F) Starch grain; (G) Annular vessels; (H) Dark coloring matter; (I) Sprial vessel; (J) Coloring matter; (K) Lignified fiber; (L) Beaded parenchyma cells of spathe; (M) Acicular crystal**;** (N) Measurment of acicular crystal; (o) Annular vessel of spathe; (P) Group of acicular crystal; (Q) Starch grain; (R) Measurement of starch grain

Table no 1.1: Macromeasurement of different parts of Bisexual flower *(Musa paradisiaca* L.) (Photo plate 1 fig.1)

Sr. No.	Part of flower	Measurements
1.	Flower	8 cm length
2.	Spathe	16 cm X 1.7 cm
3.	Perianth	2 cm X1.6 cm
4.	Androecium	4.3cm length
5.	Gynoecium	6.2 cm length

Table 1.2 Organoleptic Characters of Bisexual flower (*Musa paradisiaca* L.)

Characters	Description
Colour	Blackish brown
Odour	Astringent
Taste	Astringent
Touch	Fibrous course

Table 1.3 Histochemical Test of Bisexual flower (*Musa paradisiaca* L.)

Reagents	Observation	Characteristics	Result
Phloroglucinol + Conc. HCL	Pink Colour	Lignin cells	+ve
Iodine	Blue Colour	Starch grain	+ve
$Fecl_3$ Solution	Dark blue colour	Tannin content	+ve
Phloroglucinol + Conc. HCL	Dissovled	Ca Ox crystal	+ve

Table 1.4: Micrometric measurement of Bisexual flower powder characters (*Musa paradisiaca* L.)

Powder Character	Length (in µm)		Breadth (in µm)	
	Range	Mean ±SD	Range	Mean ±SD
Starch grain	14.28±21.42 µm²	12.71±17.85 µm²	10.71±7.85 µm²	10.09±4.12 µm²
Prismatic crystal	32.13±40.41	39.01±7.14	17.84±28.56	22.61±5.45
Acicular crystal	2.12±4.15	3.14±4.02	-	-
Oil globule	**7.**14±14.28 µm²	11.09± 4.12 µm²	-	-

Table 1.5: Macromeasurement of different parts of male flower (*Musa paradisiaca* L.) (Photo plate 3 fig. 1)

Sr. No.	Part of flower	Measurements
1.	Flower	6 cm length
2.	Spathe	12 cm X 1.7 cm
3.	Perianth	2 cm X1.6 cm
4.	Androecium	3.3 cm length

Table 1.6 Organoleptic Characters of Male flower (*Musa paradisiaca* L.)

Characters	Description
Colour	Brown
Odour	Aromatic
Taste	Sweetish followed by astringent
Touch	Course

Table 1.7 Histochemical Test of Male flower (*Musa paradisiaca* L.)

Reagents	Observation	Characteristics	Result
Phloroglucinol + Conc. HCL	Pink Colour	Lignin cells	+ve
Iodine	Blue Colour	Starch grain	+ve
$Fecl_3$ Solution	Dark blue colour	Tannin content	+ve
Phloroglucinol + Conc. HCL	Dissovled	Ca Ox crystal	+ve

Table 1.8: Micrometric measurement of Male flower powder characters (*Musa paradisiaca* L.)

Powder Character	Length (in µm)		Breadth (in µm)	
	Range	Mean ±SD	Range	Mean ±SD
Starch grain	10.28±08.42 µm²	7.71±08.85 µm²	5.21±.85 µm²	5.09±4.12 µm²
Prismatic crystal	28.13±32.41	32.01±7.14	16.84±20.56	20.61±10.45
Acicular crystal	2.12±4.15	3.14±4.02	-	-
Oil globule	**7.**14±14.28 µm²	11.09± 4.12 µm²	-	-

DISCUSSION

The male and bisexual flowers of *Musa paradisiaca* L., were found to have numerous similarities and differences. The lower and middle bracts of the inflorescence contain the bisexual flowers, while the upper bracts contain the male flowers.

The bisexual flower's spathe's transverse slice (T.S.) revealed epidermal cells that contained coloring material. The perianth's T.S. showed a thin cuticle covering a single layer of inner and outer epidermis. The locules were divided by a noticeable septum, the anthers were tetrasporangiate, and the T.S. of the anther was roughly uniform in diameter. The gynoecium's T.S. displayed a single-layered epidermis made of squarish epidermal cells and was slightly three-lobed.

The male flower, on the other hand, carried pollen grains inside the anther and lacked the bisexual reproductive organ (gynoecium), although having many anatomical similarities in the spathe and perianth. Prismatic crystals, acicular crystals, simple and compound starch grains, parenchyma cells, oil globules, and annular and spiral vessels were all visible under a powder microscope in both male and bisexual flowers. Additionally, only the male flower powder included pollen granules.

Micrometric analysis of male and bisexual flowers revealed some clear differences as well as many identical cellular diameters. Pollen grains were also seen in the bisexual bloom, which is indicative of its reproductive system. The physical and structural distinctions between the male and bisexual flowers of *Musa paradisiaca* L., give rise to these distinctive characteristics, because it is sterile, the male bloom of *Musa paradisiaca* L., does not bear fruit. Additionally, pharmacognostical distinction was supported by the comparable and distinctive reactions that both male and bisexual flowers showed in histochemical assays.

CONCLUSION

By comparing the macroscopic, microscopic, powder, and physicochemical features of male and bisexual flowers of *Musa paradisiaca* L., the current study develops thorough pharmacognostical standards for their identification and differentiation. The exterior morphology, internal tissue organization, and reproductive structures of both kinds of flowers were found to differ significantly, despite the fact that they are members of the same species and share several structural characteristics.

The arrangement of vascular bundles, the development of androecium and gynoecium, the presence and distribution of pollen grains, and the morphological characteristics of the ovary and anther-all of which are dependable diagnostic markers-were all clearly different under the microscope. These results were further corroborated by powder microscopy, which revealed distinctive fragments that varied in size and quantity between male and bisexual flowers, including epidermal cells, fibers, capillaries, pollen grains, calcium oxalate and acicular crystals.

Thus, the study offers quality control measures and distinguishing characteristics for male and bisexual *Musa paradisiaca* flowers that have been scientifically validated.

These results will help prevent adulteration or substitution in herbal and nutraceutical formulations and will be helpful for accurate identification, authentication, and standardization of the crude medication.

The developed pharmacognostical profile might also be used as a guide for future phytochemical and pharmacological studies employing banana blossoms as well as for the writing of monographs.

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AUTHORSHIP CONTRIBUTIONS STATEMENT

Shivani Sharma: Writing original draft, performed experimental part of both pharmacognostical, Experimental designing & statistical, Priya Darshani: Analysis part, Dr. Harisha C.R.: Supervision & Review, Vd. B.R. Patel: Supervision & Review.

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DATA AVAILABILITY

There is no available data or extra material for the review.

CONFLICTS OF INTEREST

The author declares no conflicts of interest.

ETHICAL CONSIDERATIONS

Not Applicable

INFORMED CONSENT

Not Applicable

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