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Microscopical Characterization and Physicochemical Standardization of Leaves, Stems and Roots of *Spondias mombin* L. (Anacardiaceae)

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A – research concept and design; B – collection and/or assembly of data; C – data analysis and interpretation; D – writing the article; E – critical revision of the article; F – final approval of article.

Abstract

Background: *Spondias mombin* L. belongs to the family Anacardiaceae. Despite its wide ethnomedicinal applications in the management of diverse diseases, there is a paucity of documented reports on its standardization.

Objectives: The present study evaluated microscopical characters and some physicochemical properties of different parts of the plant for its identification and standardization.

Material and Methods: Epidermal tissue preparation of the leaf of *Spondias mombin* (SM) was obtained using physical method while thin sections (10-12 µm) of the stem bark and root were obtained using a rotary microtome. Physicochemical parameters were determined for the powdered samples of SM using standard methods.

Results: Diagnostic characters from the epidermal tissue of the leaf revealed anomocytic, paracytic stomatal type, non-glandular trichome, smooth to slightly wavy anticlinal walls while sections of the stem bark and root were characterized with abundant sclereids and calcium oxalate crystals. The stomatal number and stomatal index of the abaxial epidermis were 23.70±0.86 and 24.62±0.78 %, respectively. Ethanol had the highest extractive value (17.84±0.50) % in the leaf whereas it was lowest in petroleum ether (1.92±0.08) %. The leaf had the lowest ash value (7.13±0.76) %.

Conclusion: The microscopical characterization and some of the physicochemical parameters reported herein could be useful in the compilation of monograph for the correct identification of *Spondias mombin*, thus contributing to the knowledge of its collection and preservation.

Keywords: Diagnostic characters; Monograph; Physicochemical parameters; *Spondias mombin*

INTRODUCTION

Spondias mombin L. (Anacardiaceae) commonly called hog plum originates from tropical America but widely distributed in Asia and Africa. It is a deciduous tree that grows up to 25 m height and has been naturalized in parts of Africa, India, Bangladesh, Sri Lanka, the Bahamas, Indonesia and other Caribbean Islands (Vasconcelos *et al*., 2016). The fruit, which is one half inch long oval yellow plum, has a tough skin and a thin coating of fruit pulp with an incredibly exotic taste (Ayoka *et al*., 2008).

The leaves, stems and roots of *Spondias mombin* have been reported in the management and treatment of various ailments. Specifically, the decoction of the root is used as purgative (Abo *et al*., 1999); bark decoction is used as an emetic, remedy for diarrhoea, dysentery, haemorrhoids and gonorrhoea (Rodrignes and Hesse, 2000); the leaves are used as a tea to relieve stomach ache, the decoction of immature leaves is a remedy for diarrhoea and dysentery, juice of crushed leaves and powder of dried leaves are used in wound healing and inflammation (Abo *et al*., 1999; Rodrignes and Hesse, 2000); the fruits are used to prepare juice and taken as diuretic and febrifuge (Corthout *et al*., 1991). The morphological parts of *Spondias mombin* showing the leaves, stems and roots are presented in Fig.1.

Some of the documented pharmacological activities of *S. mombin* include anti-inflammatory (Cabral *et al*., 2016); antiulcer (Sabiu *et al*., 2015); anticholinesterase (Elufioye *et al*., 2017);

antiepileptic and antipsychotic (Ayoka *et al*., 2006); antimicrobial (Olugbuyiro *et al*., 2013) and hypoglycemic (Fred-Jaiyesimi *et al*., 2009). Moronkola *et al*. (2003) reported several essential oils from the leaves of *S. mombin* with caryophyllene as the most abundant. Secondary metabolites reported from *S. mombin* include alkaloids, proanthocyanins and saponins (Edeoga and Eriata, 2001), phenolics and tannin (Apori, 1998), ellagitannins (Corthout *et al*., 1991), anthraquinones, flavonoids, sesquiterpenes, indole and quinoline alkaloids. Also, arabinose, mannose and rhamnose have been found to be present in the gums (Leon-De-Pint *et al*., 1995) Therapeutic properties of the plant have been attributed to these reported class of compounds.

Herbal drugs exert a crucial impact on health care programs, particularly in developing nations. According to Shu-yi *et al*. (2013) about 75-80% of the world's population majorly from developing countries relies on herbal medicine as a mainstay of their primary health care. These herbal products in raw form and concoction abound in major cities and towns across Africa. Herbal products demand and acceptability are gaining rapid attention as an alternative to orthodox medicine, hence the need for proper quality assurance of these products in the herbal market (Daswani *et al*., 2006). Lack of documentation and stringent quality control measures amongst others serve as a hindrance in accepting herbal medicine in developed nations (Sreedhar *et al*., 2013). Consequently, documentation and standardization of the crude materials utilized in herbal medicine are vital for the global compliance of this system of medicine.

The World Health Organization (WHO) emphasizes the relevance of qualitative and quantitative methods for identifying medicinal plants (Yadav and Dixit, 2008). Amongst considered methods of standardization which will contribute to the quality of herbal drugs include correct identification of the plant materials, organoleptic, pharmacognostic and quantitative evaluations (ash and extractive values) (Nikam*et al*., 2012). Similarly, Sreedhar *et al*., (2013) reported pharmacognostic standardization, physicochemical investigation and preliminary phytochemical studies as recognizable proof and confirmation of plant materials source. The utilization of herbal drugs by consumers necessitates the creation of monograph where safety, efficacy and quality control of drugs are watchword. Available information from the literature is limited only to the microscopic features of *Spondias mombin* leaf (Vasconcelos *et al*., 2016). *Spondias mombin* is a medicinal plant with many potentials and untapped resources for treating diverse diseases. Despite the numerous reports on bioactive compounds and pharmacological activities of different parts of this important medicinal plant, there is a paucity of information on the leaves, stems and roots anatomical features. Therefore, the study was designed to document diagnostic characters and physicochemical properties from the leaves, stems and roots of *S. mombin* with a view to contributing to the knowledge of this important medicinal plant for its pharmacognostic identification and preservation.

Figure 1(a): Morphological parts of *Spondias mombin* (b) stem bark (c) root

METHODOLOGY

Plant collection and authentication

The fresh plant of *Spondias mombin* was collected in February, 2019 at the pilgrimage gate entrance, Madonna University, Elele, Rivers state, Nigeria. The plant collection lies within geographical location of 5.9314 ºN and 6.8376 ºE in Elele, Rivers State, Nigeria. The plant sample was identified and authenticated at the Forest Herbarium Ibadan (FHI) of the Forestry Research Institute of Nigeria (FRIN), Ibadan, with voucher number FHI 112453 by Mr. A. Adeyemo. Voucher specimen of the sample was also deposited at FHI.

Preparation of plant materials

Fresh leaves of *Spondias mombin* were cleaned and air dried under shade (27-30 ºC). The dried leaves were then pulverized into powder and stored in an airtight container while fresh stem and root barks were cleaned, chopped into pieces and dried at 40 ºC in the oven. These were then pulverized into powder and stored in an airtight container.

Microscopic technique

Epidermal tissue preparation

Scraping technique of Pandya *et al*. (2010) was used for the preparation of epidermal tissues. Briefly, median portion of the fresh leaf (3 cm by 2 cm) was excised. Appropriate surface (adaxial or abaxial surface) was carefully scrapped using a sharp surgical blade to obtain the adaxial and abaxial surfaces. Surface tissues obtained were further cleared using 1.75% w/v NaOCl for 2-3 min and rinsed severally with distilled water. The cleared epidermal tissues were stained with Safranin O for about 2-3 min and then dehydrated in vials containing 60%, 70%, 80% and 100% ethanol successively. A drop of glycerin was added, covered with 0.2 mm coverslips and ringed with nail varnish to prevent dehydration. This was done for about 4-5 slides.

Micrometric

Linear measurement of diagnostic characters

Eyepiece micrometre (ERMA Japan) was calibrated with the aid of stage micrometre (ERMA Japan) on a light microscope (Zenith Ultra-500A). Prepared slides of the adaxial and abaxial epidermises of *Spondias mombin* leaves were placed on the stage. Measurements and numerical data for diagnostic characters such as dimensions of trichomes and stomata size were taken and recorded based on the calibration of the eyepiece micrometre (Stahl, 1969).

Determination of the stomatal number and stomatal index

Stomatal number and stomatal index data were recorded with the aid of a square graticule using standard procedures. A square graticule (ERMA Japan) was inserted into the light microscope's eyepiece, and the prepared slides of the epidermis of *S.mombin* were placed on the stage. The number of stomata and epidermal cells found in the 1mm by 1mm square was counted and recorded (Chaudhary and Imran, 1997) and stomatal index was calculated as follow:

$$SI = \frac{SN}{SN + NE} \times 100$$

SI = Stomatal Index
SN = Stomatal number
NE = Number of epidermal cell

Transverse section of the midrib

Freehand sectioning was used to obtain the transverse section of the midrib. The fresh leaves were cut from the leaf's median portion (1 cm by 1 cm) using an unripe pawpaw tissue as support. Thin sections of the midrib were then sectioned using a sharp surgical blade and were cleared with 1.75% w/v NaOCl in 2-3 min. They were rinsed severally with distilled water. Thin cleared sections were stained in safranin O for about (2-3 min) and then counterstained with methylene blue. Thereafter, they were dehydrated in vials containing graded ethanol series ranging from 60-100%. A drop of glycerin was then added, covered with 0.2 mm coverslips and ringed with nail varnish to prevent dehydration. This was done for about 4-5 slides.

Stem and root preparation

The fresh roots and stem bark of *Spondias mombin* were stored in 70% ethanol until use. Thin sections (10-12 μm) of the stem bark and root were obtained using a Leica RM2255 rotary microtome (Leica Microsystems, Wetzlar, Germany). They were cleared with 3.5% w/v NaOCl for 8-10 h after which they were rinsed severally using distilled water. Thin cleared sections were stained in safranin O for about (3-5 min) and then counterstained with methylene blue. They were dehydrated in vials containing 60%, 70%, 80% and 100% ethanol successively. A drop of glycerin was then added, covered with 0.2 mm coverslips and ringed with nail varnish to prevent dehydration. This was done for about 4-5 slides for the stem bark and roots.

Photomicrograph
Diagnostic characters from the prepared epidermises (adaxial and abaxial surfaces), stem bark and root tissues were observed using a light microscope and photographed with a digital camera mounted on a Zenith Ultra-500A light microscope. Photomicrographs were taken at 25, 50 and 100 µm.

Physicochemical analysis
Powdered samples of the leaf, stem and root barks of *Spondias mombin* were subjected to physicochemical analysis for moisture content, total ash, water-soluble ash and acid-insoluble ash. This was done using standard procedures (British Pharmacopoeia, 1980; Najafi and Deokule, 2010; Ishtiaq*et al*., 2014).

Determination of moisture content
The air-dried pulverized sample of *Spondias mombin* was determined for its moisture content. In brief, 2 g of the powdered sample was weighed into a clean crucible (six replicates). These crucibles were placed in a Gen lab oven at 105 ℃ for 4 h. After 4 h, the crucibles containing the samples were removed and placed in a desiccator to cool after which they were reweighed and recorded. They were returned to the oven severally and then reweighed until a constant weight was obtained and recorded. The difference in weight after drying and the initial weight of the powdered samples represent the moisture content. This procedure was used to obtain moisture content values for the leaves, stem and roots barks of *Spondias mombin* (British Pharmacopoeia, 1980).

Determination of total ash value
The total ash value of the plant was obtained using standard procedures (Masiwal*et al*., 2013).

In brief, 2 g of the air-dried powdered sample was accurately weighed into a clean crucible and placed in a Gen lab furnace at 450 ºC. The samples were left for a few hours until ashed indicating the absence of carbon. The crucibles were then removed with crucible thong, cooled in a desiccator and reweighed (British Pharmacopoeia, 1980). This was done in six replicates, and the percentage of total ash of air-dried sample was calculated as follow:

$$\% AV = \frac{WA}{IW} x \quad 100$$

% AV = Percentage Ash Value
WA = Weight of residual ash
IW = Initial weight of air-dried plant material

Determination of water-soluble ash
The ash obtained from the air-dried powdered sample of *S. mombin* was boiled for 5 min with 25 mL of distilled water. The insoluble matter was filtered on an ashless filter paper, washed with hot distilled water and ignited in a clean crucible at a temperature not exceeding 450 ℃ in a furnace for 15 min. The water-soluble ash was obtained by subtracting the weight of the insoluble residue from the initial weight of the ash. This was done in six replicates, and the percentage of water-soluble ash was calculated with reference to the initial air-dried plant material (British Pharmacopoeia, 1980).

Determination of acid-insoluble ash
The ash obtained from the air-dried powdered sample of *S. mombin* was boiled for 5 min with 25 mL of 10% HCl. The insoluble residue was filtered on an ashless filter paper, washed with hot distilled water and ignited in a clean crucible at a temperature of 600 ℃ in a furnace until free of carbon (British Pharmacopoeia, 1980). This was done in six replicates, and the percentage of acid-insoluble ash was calculated with reference to the initial air-dried plant material as follow:

$$\% AIA = \frac{WRA}{IW} X \quad 100$$

% AIA = Percentage Acid –insoluble ash
WRA = Weight of residual ash
IW = Initial weight of air-dried plant material

Extractive values
Extractive values were calculated according to the procedure described by Arambewela and Arawwawala (2010). Briefly, 5 g of each powdered sample was accurately weighed, and 250 mL of each solvent (absolute ethanol, petroleum ether and distilled water) was added to the powdered sample. Maceration of the air-dried drug was carried out in a closed container for 24 h with constant mechanical shaking for about 6 h. It was then left to stand for 18 h. The extract (20 mL) in replicates of six was then filtered and evaporated by heating. The evaporated samples were placed in an activated desiccator to remove moisture and after that weighed. The percentage extractive values of all solvents with reference to air-dried plant sample were calculated.

RESULTS

Epidermis surface tissue

In the present study, stomata were observed on the adaxial and abaxial epidermises but more prominent on the abaxial epidermis. Specifically, anomocytic and paracytic stomata types were characterised of abaxial and adaxial epidermises, respectively (Fig. 2a and 2b). Hence, the leaf of *Spondias mombin* is amphistomatic- the presence of stomata on both epidermises of the leaf. Five to six compact epidermal cells in a rosette form are arranged round the trichome base, as shown in Fig. 2a. A non-glandular trichome – short unicellular trichome type with a pointed tip and slightly broad base is typified of the adaxial epidermis (Fig. 2a) while it is absent on the abaxial epidermis of the leaf. Also, straight anticlinal walls were observed on the adaxial epidermis while the abaxial epidermis is slightly wavy. Clusters of rectangular cells- coastal cells were also observed on the adaxial epidermis (Fig. 2a).

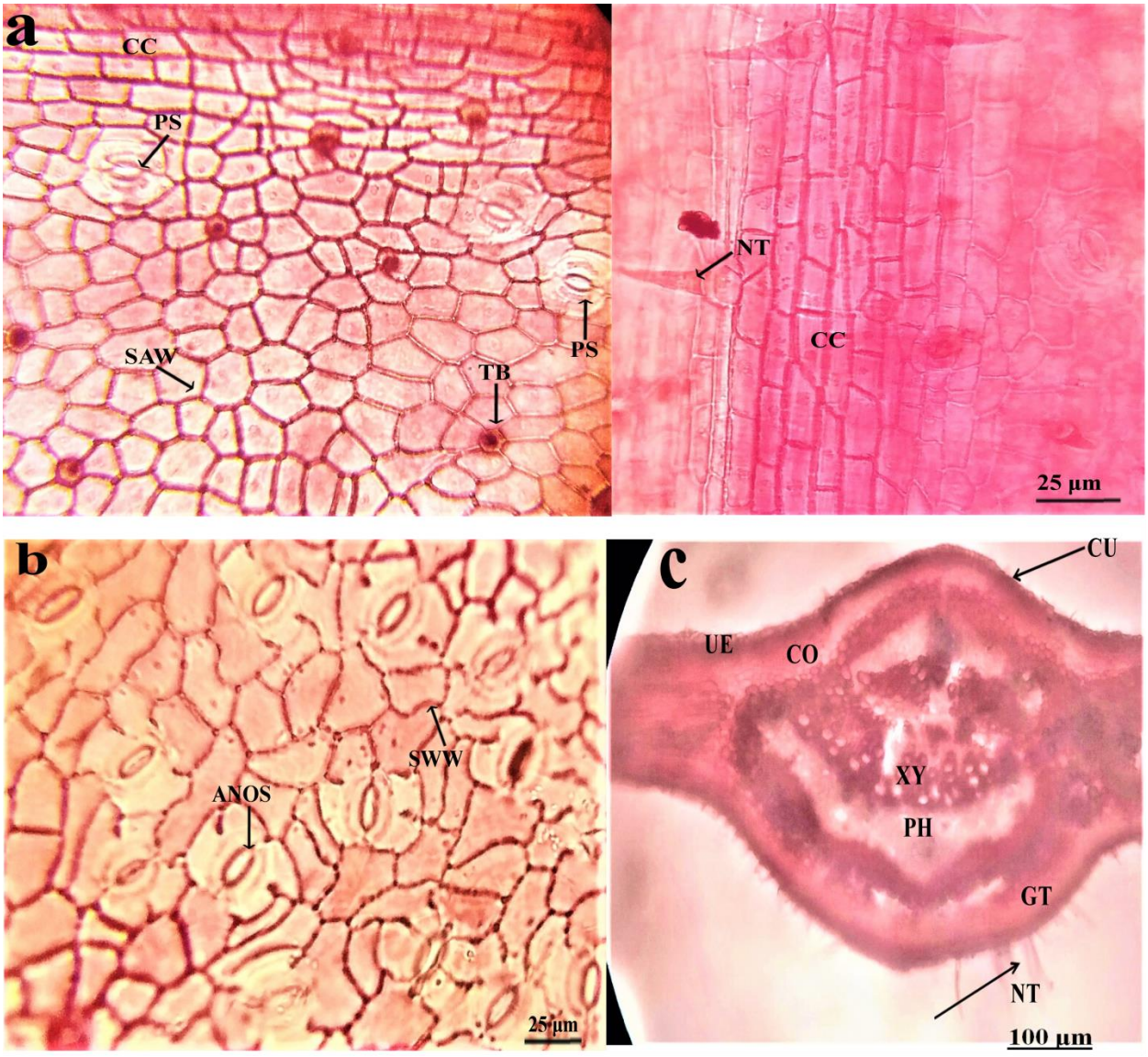

Figure 2: Epidermal surfaces and transverse section of *Spondias mombin* showing diagnostic features (a) Adaxial epidermis (b) Abaxial epidermis (c) Transverse section of midrib

ANOS- Anomocytic stomata, CC-Coastal cells, CO- Collenchyma cells, CU- Cuticle, GT- Ground tissues, NT- Non glandular trichome, PC- Paracytic stomata, PH- Phloem, SWW- Slightly wavy wall, SAW- Straight anticlinal wall, TB-Trichome base, UE- Upper epidermis, XY- Xylem

Micrometric evaluation

Quantitatively, the mean dimension of non-glandular trichome on the adaxial epidermis is 22.00±1.60 long and 6.13±0.30 µm in diameter. The stomata dimension on the adaxial epidermis is 19.00±0.90 by 6.25±0.61 µm while on the abaxial epidermis is 12.56±0.67 by 3.88±0.25 µm (Table 1). The stomatal number on the abaxial range from 15-(23.7)-28 per mm square while the average stomatal index is (24.62±0.78) % per mm square (Table 1).

Table 1: Quantitative measurement of diagnostic characters from the leaf epidermis of *Spondiasmombin*

Adaxial epidermis	Dimension (µm)
Trichome length	22.00 ± 1.60
Trichome width	6.13 ± 0.30
Stomata length	19.00 ± 0.90
Stomata width	6.25 ± 0.61
Abaxial epidermis	
Stomata length	12.56 ± 0.67
Stomata width	3.88 ± 0.25
Stomatal number and stomatal index	per mm square
Average number of stomata	23.70 ± 0.86
Range	15.00 - 23.70 – 28.00
Stomata index	24.62 ± 0.78%
Range	16.70 -24.60- 33.60%

Transverse section of leaf

The transverse section of the midrib (Fig. 2c) is biconvex in shape with a truncated base. The epidermis is a single layer and covered externally by a thin cuticle. The vascular bundle appeared as arc-shaped with the tissues stained with safranin O typifying lignified tissues. The portion of the midrib towards the base composed mainly of ground tissues made up of parenchyma cells. An aggregate of collenchyma cells is found along the upper and lower epidermises of the midrib.

Anatomy of stem bark and root

The anatomical features of the transverse section of the stem bark of *Spondias mombin* revealed compact peridermal layers with brown content (Fig. 3a). As a mature stem, the epidermis is pushed outwardly as a result of cork tissues. The next layer-phellogen is a single-layered made up of thin-walled cells without brown inclusions. Interestingly, the cortex layer is characterized by numerous prismatic calcium oxalate crystals (Fig. 3a). Longitudinal sections further showed starch grains, xylem fibre and thickened sclereids appearing as concentric rings and lignified (Fig. 3b). The transverse section of the root is circular (Fig. 4a) with a well-developed cork layer (phellem) made up of compact rectangular cells (19-20) with suberized walls and brown inclusions (Fig. 4b). Phellogen appeared as a thin layered cell followed by the cortex layers, thickened sclereids, abundant circular calcium oxalate crystals (Fig. 4c), phloem and tissues with interwoven medullary rays, and pith at the center (Fig. 4d).

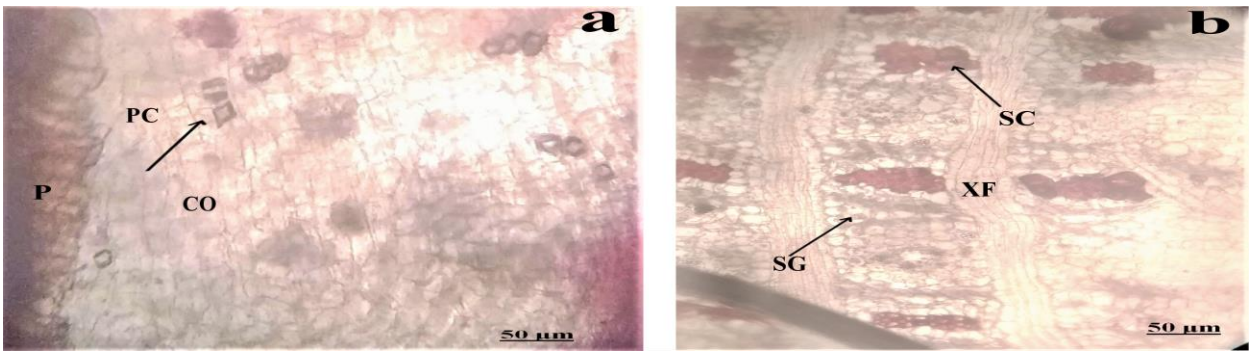

Figure 3: Anatomical features of stem bark of *Spondias mombin* (a) Transverse section (b) Longitudinal section

CO- Cortex, P- Periderm layer, PC- Prismatic crystals, SC-Sclereids, SG- Starch grains, XF- Xylem fibre

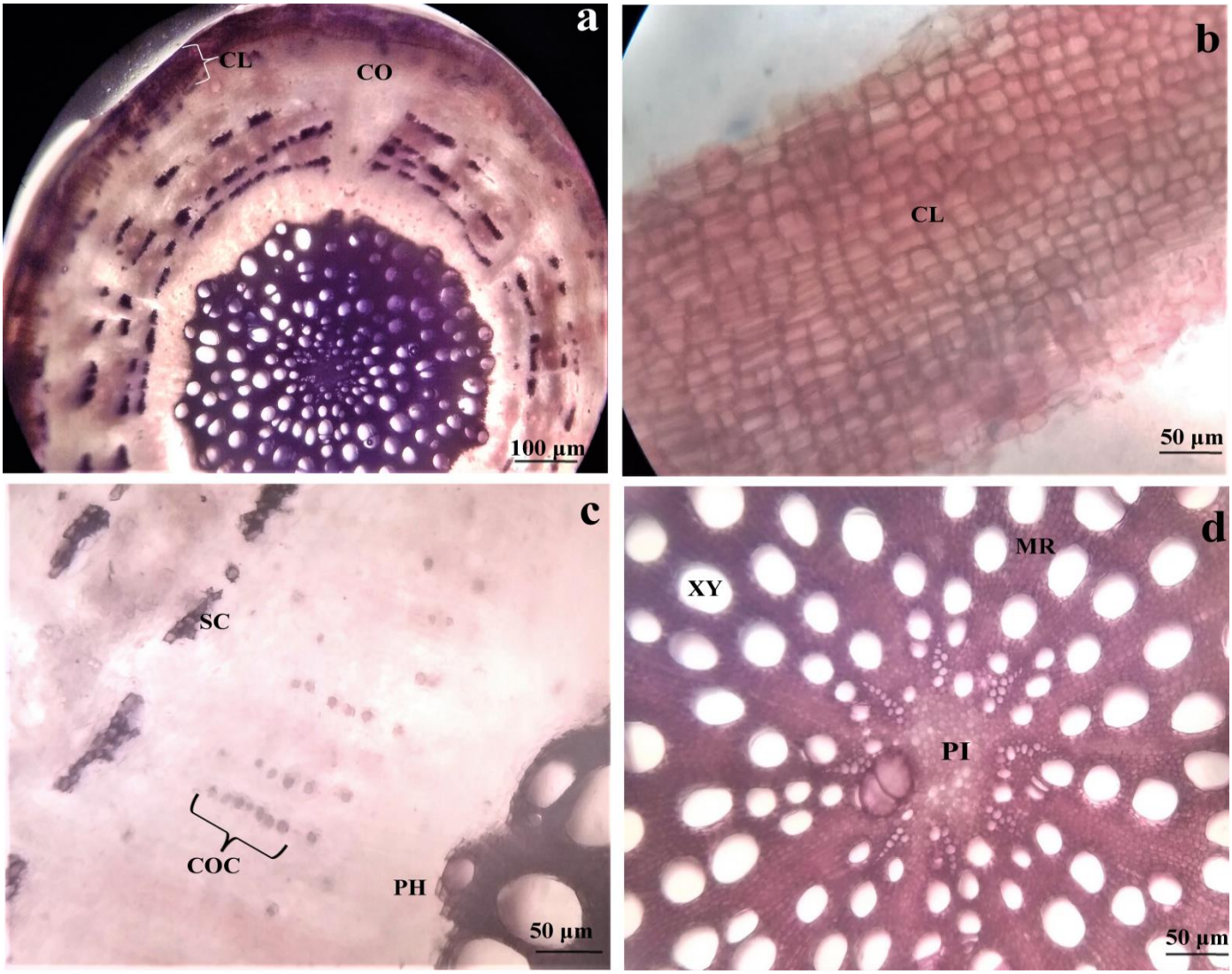

Figure 4: Anatomical features of root of *Spondias mombin* (a) Circular transverse section of root (b) Compact rectangular cork layer of root (c) Root transverse section showing sclereids and calcium oxalate crystals (d) Root transverse section showing pith and medullary ray

Physicochemical parameters

The moisture content, total ash value, water-soluble ash, insoluble acid ash and extractive values using absolute ethanol, petroleum ether and distilled water are presented in (Table 2).

Table 2: Physicochemical properties of leaf, stem and root bark of *Spondias mombin*

Parameters	Leaf powder (%)	Stem bark powder (%)	Root bark powder (%)
Total ash value	7.13 ± 0.76	11.60 ± 0.45	14.40 ± 0.42
Water soluble ash	5.20 ± 0.09	6.20 ± 0.45	4.17 ± 0.39
Acid insoluble ash	3.10 ± 0.33	6.57 ± 0.52	7.90 ± 0.53
Moisture content	9.59 ± 0.23	11.37 ± 0.05	11.37 ± 0.20
Extractive values			
Water	16.57 ± 0.59	4.12 ± 0.19	5.17 ± 0.29
Petroleum ether	1.92 ± 0.08	2.94 ± 0.22	3.04± 0.09
Ethanol	17.84 ± 0.50	9.29 ± 0.12	11.73 ± 0.11

DISCUSSION

The quest and thirst of developing countries in herbal standardized products for treatment and management of various ailments necessitate the compilation of specific standards for quality control of botanicals. The flooding of the herbal market with different crude drugs and patronizing of these products by consumers due to their availability, accessibility and efficacy also make it imperative for proper documentation of crucial medicinal plant even in their comminuted form. Anatomical studies are essential not only in plant taxonomic classification but also have profound applications in Pharmacognosy. Similarly, Sonibare and Adeniran (2014) emphasized the relevance of macroscopic and microscopic evaluation as a vital tool for identifying medicinal herbs and its paramount importance in compiling standard parameters in modern monographs. To this end, collection and documentation of medicinal plants' anatomical features are the backbone to identification and authentication and has become the mainstay of published research worldwide.

Documentation of diagnostic characters from the crude drug and by extension from the epidermises of *Spondias mombin* shed more light for proper identification of this important medicinal plant at the microscopic level. In the present study, the stomata description as anomocytic and unicellular trichome description as short and stout agreed with the pharmacognostic description of *Spondias mombin* from Brazil as reported by Vasconcelos *et al*., (2016). However, in their report, the leaves were hypostomatic (having stomata on the abaxial epidermis only). Their account contradicts our observation in the present investigation where stomata were reported on both sides of the leaves (amphistomatic) of *Spondias mombin*. The observed disparity could be as a result of environmental factors and/or geographical location as opined by Fontana *et al*. (2017), where amphistomy of *Salix miyabeana* has been attributed to climatic conditions and period of collection.

According to Omitola *et al*., (2019), quantitative microscopy such as stomatal number and stomata dimension was successfully used in differentiating two-closely related species of *Alstonia*. They concluded that the pool of the results in their study might represent some of the data required to compile the pharmacopoeial monograph for each of the two *Alstonia* species, which could be earnest in the revision of relevant herbal pharmacopoeias. In the present investigation, the quantitative linear measurement of diagnostics characters such as stomata and trichome dimensions along with the stomatal number and stomatal index may aid further identification of the comminuted leaf of *Spondias mombin* thereby assisting in detecting adulterants in local herbal markets.

The transverse section being biconvex on both upper and lower surfaces and the vascular bundle being arc-shaped could be used as a marker tool. Also, the presence of non-glandular trichome around the transverse section of the biconvex midrib is equally diagnostic. In a pharmacobotanical study of two medicinal species of Fabaceae, the vascular bundle of *Lonchocarpus cyanescens* and *Leptoderris micrantha* were described by Sonibare *et al*., (2014) as arc-shaped. Similarly, Silva and Paiva (2007) also reported vascular bundle as arc deposition in

Spondias tuberous leaves, which agrees with the arc-shaped observed in *Spondias mombin*.

Mohamad *et al*., (2013) documented layered cork cells, phellogen, cortex, medullary rays and pith from the anatomical root of two Malaysian plants- *Salacia macrophylla* Blume, *Prismatomeris glabra* (Korth.). Their anatomical features documentation is similar to those obtained from the root of *Spondias mombin*. The diagnostic character from the stem bark and root of *Spondias mombin* such as the presence of calcium oxalate crystals, which are prismatic and circular, respectively in these parts of the plant may further aid its identification microscopically. Prismatic calcium oxalate crystals in the present study are similar to the crystals observed from the leaves of *Alstonia boonei* and *Alstonia congesis* as reported by Omitola *et al*. (2019). Similarly, the presence of clustered thickened sclereid in both the stem bark and the root is also diagnostic, and it could be used at a microscopic level for the identification of the drug in comminuted form.

Accurate pharmacognostic information is pertinent in identifying medicinal plants for their biodiversity, sustainability, utmost utilization and detection of adulterants from crude drugs. In the present investigation, physicochemical parameters such as extractive values, moisture content, ash value, water-soluble ash and acid insoluble ash were documented for the powdered leaf, stem and root barks of *Spondias mombin*. The extractive value bears a resemblance of weights of chemical constituents from the crude drug. Generally, a high extractive value suggests the better extraction of phytochemicals from the plant material. Folashade *et al*., (2012) opined that extractive values aid in selecting the best solvent that will further assist in having optimum yield. The percentage extractive yields of the leaf, stem and root barks using distilled water were 16.57±0.5, 4.12±0.19 and 5.17±029 %, respectively while that of absolute ethanol were 17.84±0.50, 9.29±0.12 and 11.73±0.11 %, respectively. However, the use of petroleum ether recorded the least yield as 1.92±0.08, 2.94±0.22 and 3.04±0.09 %, respectively. The highest extractive value being absolute ethanol, followed by distilled water, suggests more polar compounds than using petroleum ether.

The amount of moisture content in a crude drug is significant during storage. According to Kunle *et al*., (2012), the lower the moisture content in a natural drug, the less likely microbial contamination is, hence preventing herbal medicines spoilage. Specifically, the British Pharmacopoeia (1980) recommends moisture content not more than 14% for crude drug storage. In our report, the powdered leaf's percentage moisture content, stem and root barks being 9.59±0.23, 11.37±0.05 and 11.37±0.20, respectively are in tandem with the acceptable moisture content of the British Pharmacopoeia standards. This also suggests that the possibility of microbial contamination and degradation will be minimized during storage.

The ash values are determined to ascertain the level of siliceous material after incinerating the powdered plant material and detect extraneous material attached to the plant during collection. Prabhu *et al*., (2009) suggested that the presence of numerous calcium oxalate crystals may be responsible for high amounts of ash in their report of Chemical and pharmacognostical characterization of two Malaysian plants both known as Ajisamat. The powdered stem and root barks of *Spondias mombin* indicated high ash value of 11.60±0.45 and 14.40±0.42%, respectively. The high ash values from the stems and roots may be attributed to the abundant calcium oxalate crystals, unlike in the leaves where it is absent, consequently having low ash value of 7.13±0.76%. The ash value could help detect adulterants from this crude drug with the water-soluble ash and acid-insoluble ash values of the different parts of *Spondias mombin*.

CONCLUSION

Some of the pharmacognostic standards (extractive values, moisture content, ash value, water-soluble ash value, acid-insoluble ash value, and diagnostic characters) presented in this study could be useful in the preparation and compilation of monograph for the identification of the leaf, stem bark and root of *Spondias mombin*, thus contributing to the knowledge of its collection and preservation.

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