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Pharmacognostical studies and phytochemical evaluation of four Meliaceae plants widely use in ethnomedicine across West Africa

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Abstract
Meliaceae plants are widely used in traditional medicine across West Africa, including well-documented analgesic and anti-inflammatory effects. This study describes assessments for the standardization of powders from the leaves and bark of these plant materials. Pharmacognostical studies carried out by macroscopic and microscopic evaluations revealed the presence of stomata, fibers, hairs and calcium oxalate crystals in plant material powders. The physicochemical assays indicated moisture contents less than 5%, and total ash contents less than 10% for all powders except to *P. kotschyi* bark (20.09%). *P. kotschyi* leaves showed the highest amount of phenolic (89.14±0.9 mgEAG/g) and terpenoids compounds (229.51±8.76 mgETriam/g). The barks of *P. kotschyi* (27242 mg/kg) and *K. senegalensis* (12558 mg/kg) showed the highest calcium contents. These results constitute factual elements that could contribute to the elaboration of monographs for the quality control of Meliaceae powders of interest.

Keywords: Standardization, pharmacognostical studies, phytochemical evaluation, Meliaceae plants

Introduction
Pain-related pathologies are a real health problem worldwide, with a prevalence of 0.4% - 1% in 2015 [1] for pain of the osteoarticular system. Studies between 2006-2011 showed that 2.8% of medical consultations in Burkina Faso were associated with joint pain [2]. Management of these pathologies requires both modern and traditional medicine, which is used by over 80% of African populations, according to the WHO [3]. Ethnobotanical and ethnopharmacological surveys have identified several plants used in traditional medicine to treat joint pathologies associated with pain and an inflammatory component. In Burkina Faso, more than 2 067 medicinal species are used, some of which are used to treat rheumatic pain [2]. These include *Ekebergia senegalensis*, *Khaya senegalensis*, *Pseudocedrela kotschyi* and *Trichilia emetica*, four (04) Meliaceae with anti-inflammatory and anti-arthralgia properties, which have a consensus of preferential use in the traditional treatment of rheumatoid arthritis [4].
Indeed, numerous publications indicate that *E. senegalensis* leaves are used to treat migraines, fever and rheumatism [5]. *K. senegalensis* bark is used as an active medicinal substance in the production of an anti-inflammatory ointment by the Institute for Research in Health Sciences (IRSS) in Burkina Faso [6] and Senegal [7]. Seed oil is used in the traditional treatment of gout [8], neuralgia and joint pain [9]. The bark, roots and leaves of *P. kotschyi* have antipyretic, analgesic, anti-inflammatory and rheumatic properties [10, 11]. The roots and bark of *T. emetica* have anti-pain, anti-platelet aggregation and anti-inflammatory properties through inhibition of prostaglandin synthesis [4]. From a phytochemical point of view, the Meliaceae family has an abundant and highly diversified chemical profile, characterized by the presence of phenolic and terpene compounds [5]. The leaves of *E. senegalensis* [12] and *P. kotschyi* contain flavonoids [9, 11], saponosides and steroids. The trunk bark and leaves of *T. emetica* contain polyphenols, flavonoids, tannins, saponosides and terpenoids [12, 14]. Furthermore, data from the scientific literature indicate a correlation between anti-inflammatory and analgesic activities [17] and the presence of phenolic and terpenic compounds in plant drugs. Thus, phenolic compounds with a structural analogy to NSAIDs are likely to induce an effect on the production of chemical mediators of inflammation such as prostaglandins and thromboxanes [18], while terpenic compounds with steroid-like chemical structures act on the cellular components of inflammation [19].

Given the therapeutic potential of these plants in the development of phytomedicines with analgesic and anti-inflammatory effects, it is essential to draw up monographs presenting the botanical and physicochemical specifications of medical raw materials derived from these Meliaceae in order to guarantee their quality, safety and innocuousness. Despite there are very few data's in the scientific literature that can be used as references to draw up control monographs for the powders of these plants of many interest. However, the adulteration, falsification and contamination of the herbal material may lead to health risks. Effective identification and robust methods for the standardization of the quality of raw material are prerequisite steps, especially for herbal drugs. Thus, pharmacognostical, physico-chemical and phytochemical assays were performed on powders of plant materials from *E. senegalensis*, *K. senegalensis*, *P. kotschyi* and *T. emetica* and reported in the present study.

Materials and Methods

Sampling and process of plants material

The plant material consisted of leaves and barks of *E. senegalensis; K. senegalensis; P. kotschyi* and *T. emetica*, collected at Moami (Fig. 1) (11° 7' 0" North, 4° 31' 0" West) in December 2020. Sampling were conducted by Alain Bambara, Scientist at University Joseph KI-ZERBO. Identification and authentication of specimen to collect were done by comparison with morphological features described in Table 1. Several independent specimens of each species were collected, dried at room temperature (35-40 °C) and then pulverized into a fine powder for assessment.

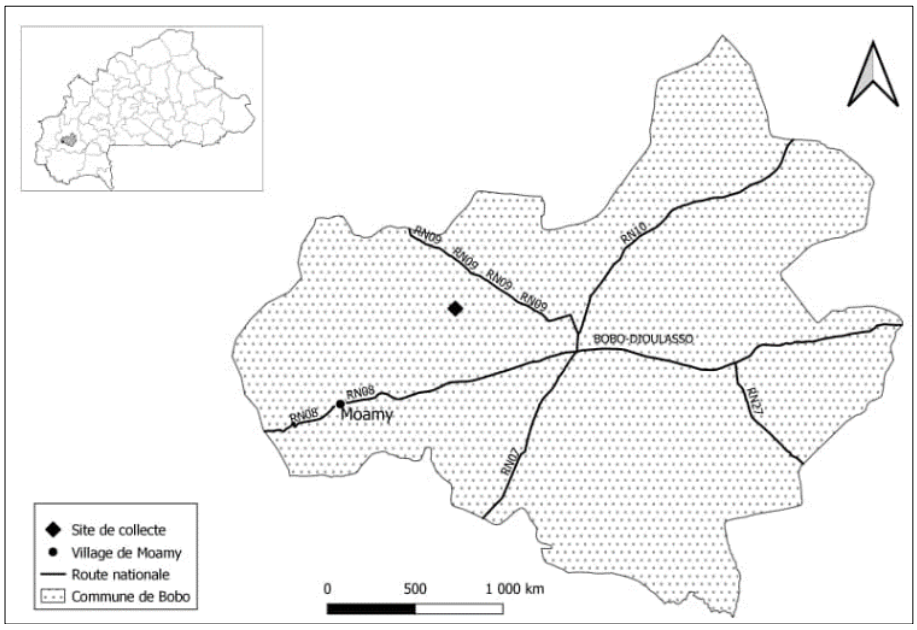


Fig 1: Location of sampling site (GPS Coordinates: 30P346892.205 UTM, 1239101.385 ALT 383, 30

Table 1: Description of the plants in the study

Botanical name	***E. senegalensis***	***K. senegalensis***	***P. kotschyi***	***T. emetica***
Synonyms	Cape Ash	Acajou of Senegal	*Cedrela kotschyi*	Mafura
Vernacular Names	Essenhout tree	Kaicedrat	Dry zone Cedar	Roka
Description	Straight trunk that can reach 35 m in height. The grey to grey-brown or almost black bark is marked by circular leaf scars, and the branches are dotted with white lenticels. Leaves are compound, evergreen or semi-deciduous, green, 10 to 36 cm long and 8 to 18 cm wide. The flowers, in the form of a clustered inflorescence, consist of 12 to 70 small, lightly scented flowers of very variable color (white, greenish yellow, pink) [20]. Fruits look small apples with a very thin skin containing 2-4 oval-shaped, white seeds [21].	It can reach 35 m in height. Its bole is branchless and can exceed 10 m in height. Its bark is very thick and scaly, ranging in color from brownish to dark gray. The trunk can exceed 1 m in diameter, with a huge crown [22]. Leaves are pinnate, with 3 to 6 pairs of leaflets. Flowers are small, around 5 mm in size, white and inconspicuous, in panicles 15 to 20 cm long, inserted at the tip of the twigs with the young leaves. The fruits are globose woody capsules 5 to 10 cm in diameter, which burst into 4 valves when ripe [23].	It is a small, straight-stemmed tree 5 to 10 m tall. Its leaves are composed of *parupeneus parietalia*, alternate, rather clustered at the top of the twigs [24]. Rachis 30 to 50 cm long, bearing 4 to 5 pairs of alternate or supposed leaflets. Leaflets are oblong, lanceolate, 7 to 10 cm long and 2 to 3 cm wide, asymmetrical at the base, with broadly undulating margins. Flowers are white, fragrant, small, 6 to 7 mm wide and arranged in panicles. The fruit is a woody, oblong capsule, 10 to 12 cm long, opening at the top of 5 winged seed valves, 4 to 5 cm long; its bark is gray and cracked [25].	It is a 5 to 7 m tall, straight-stemmed woody tree with deeply fissured and striated gray bark. Young stems are long pubescent. Leaves are alternate, imparipinnate, broadly cordate at the base, long mucronate at the apex, up to 20 cm wide, papery, entire or sometimes slightly lobed, hairy on both sides, palmate venation with 7 veins starting from the base of the blade; petiole up to 12 cm long. The rachis reaches 15 cm with 4 to 7 pairs of oblong, elliptical leaflets. Flowers are greenish, small, in panicles with 10 mm sepals. Fruits are ellipsoid, 1 cm long, bright red when ripe [26].

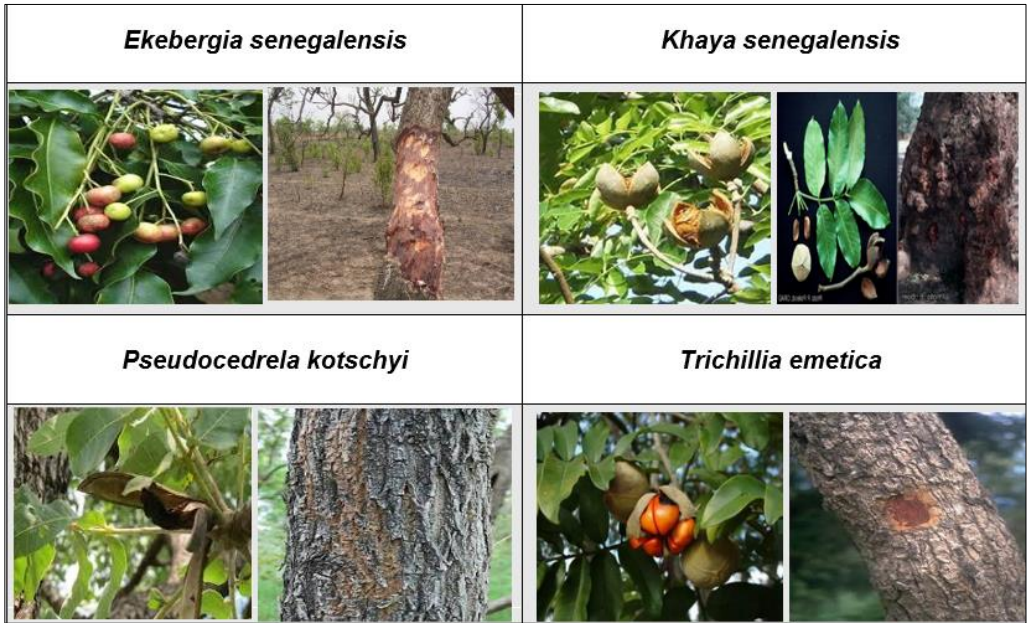


Fig 2: Morphology of species of study (Illustration of the species in the study were obtained from the GOOGLE Images search engine consulted on 28/07/2023)

Pharmacognostical evaluation of plant material

Organoleptic analysis of plant material

Organoleptic characters as the degree of uniformity of the particles, the presence of foreign particles, color, taste, texture and odor were recorded for the fine powder from plant material samples as described by Kouitcheu *et al*. [27].

Microscopic analysis of plant material

Leaf and bark powders were examined under optical microscope using 10% potassium hydroxide at different magnifications. The shape and size of cellular features as hairs, trichomes, calcium oxalate crystals, vessels, fibers and stomata were taken with a camera attached with a microscope and (X100) [28].

Physicochemical characterization of plant material

Determination of moisture content

Moisture content was estimated by gravimetric measurement of loss on drying according to Daouda *et al*. 2022. In brief, approximately 1.0 g of powder was placed in an oven at 105°C for 08 h, then weighed (n =3) [29]. The moisture content was obtained according to the following formula.

$$\text{Humidity (\%)} = \frac{\text{Mass of initial test sample} - \text{Residual Mass}}{\text{Mass of initial test sample}} \text{ X } 100$$

Determination of extraction yield

Then (10) g of grounded samples was macerated in 200 mL of 80% ethanol for 24 h under constant stirring at 250 rpm at room temperature using an orbital shaker. The mixture was then filtered through cotton balls and evaporated to dryness by rotary evaporator at 50°C. The extraction yield is obtained according to the following formula.

$$\text{Extraction yield (\%)} = \frac{\text{Dry extract mass}}{\text{Mass of initial test sample}} \text{ X } 100$$

Determination of ash total ash

According to Mamadou *et al*. 2018, this test reveals the minerals in plant powders after complete calcination of 5 g of powder in an oven at 600 °C for 5 hours, then weighed after cooling [30]. The residual total ash content (% CTr) is then calculated according to the following formula.

$$\text{\% CTr} = \frac{\text{Average bottom ash mass}}{\text{Mass of test sample}} \text{ X } 100$$

Determination of Acid-insoluble ash

As described by Mamadou *et al.* 2018, the total ash previously obtained is boiled for 20 min in an Erlenmeyer flask containing 20 mL of 10% hydrochloric acid. After cooling, the solution is filtered through ash-free filter paper, dried in an oven and then calcined for 5 hours in an oven at 600°C, before being weighed after cooling [30]. The percentage of ash insoluble in hydrochloric acid (% CIC) is then calculated according to the following formula.

$$\text{\% CIC} = \frac{\text{Mass of ash insolubles in hydrochloric acid}}{\text{Mass of test sample}} \text{ X } 100$$

Determination of calcium content

The calcium was determined by atomic absorption spectrometry (AAS) as previously described by Fidele *et al*. and the results are expressed in mg/kg of plant powder [24].

Detection and quantification of phytochemical content

Determination of total Phenolic compounds

Following the method of Yaya *et al*. 2014, 1 mL of $FeCl_3$ was added to 1 mL of extract. The presence of phenolic compounds is indicated by the appearance of a greenish-brown or blackish-blue coloration [25]. The detected compounds were then quantified as described by Nacoulma *et al*. (2012). Extracts were dissolved in distilled water at 0.1 mg/mL and 25 µL was mixed with 125 µL of 0.2 N FCR reagent in microplate wells, and incubated for 5 min. Then, 100 µL of sodium carbonate solution (75 mg/mL) was added and the mixture was incubated for 2 hours. Absorbance of samples were measured with a spectrophotometer (Epoch 251465, Biotek Instruments, U.S.A.) at 760 nm and the Total Phenolic Content (TPC) was expressed using gallic acid standard curve ($y = 0.007x + 0.031$; $R^2 = 0.99$) in term of

milligrams of Gallic Acid Equivalent per gram of dry extract (mgEAG/g) on the mean of three determinations [32].

Determination of total terpenoids

Following the method of Misbah *et al.* (2O13), 1 g of plant drug powder is macerated in 20 mL ether for 24 hours. 10mL of the filtrate is evaporated to dryness and taken up in 2 mL of a 1:1 (v/v) acetic anhydride/chloroform mixture. Next, 1 mL of concentrated sulfuric acid is slowly added to 1mL of extract. The development of a brownish-red or violet ring at the contact interface of the 2 solutions indicates the presence of sterols and triterpenes. Subsequent staining of the supernatant suggests the presence of sterols (green) or triterpenes (red) [31].

Terpenoid content was then assessed according to the method described by Chang *et al.* (2012). 100 µL extract (10 mg/mL in methanol) is added to 150 µL vanillin-glacial acetic acid (5%) and 500 µL perchloric acid solution. The whole is incubated at 60 °C for 45 minutes, then cooled to room temperature. Next, 2.25 mL glacial acetic acid is added, and the reading taken at 548 nm. Total terpenoid levels were determined using a triamcinolone standard curve ($y = 0.53x + 0.09$; $R^2 = 0.99$). Results are expressed as milligram triamcinolone equivalent per gram dry extract (mg EAU/g) with n=3 [33].

Statistical analysis of data

Results are expressed as the mean ± standard deviation (n=3) and are subject to non-parametric comparison of means at the threshold $\alpha = 0.05$ of independent samples.

Results and Discussion

Pharmacognostical evaluation of plant materiel

Macroscopic evaluation of the plant drugs

The visual observation of leaf and bark (organs and powders) from *E. senegalensis; K. senegalensis; P. kotschyi and T. emetica* are illustrated in Fig.3.

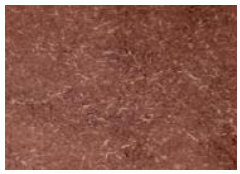
	Leaves		Barks	
Plant species	**Dried organs**	**Powder**	**Dried organs**	**Powder**
Ekebergia senegalensis				
Khaya senegalensis				
Pseudocedrela kotschyi				
Trichilia emetica				

Fig 3: Leaves and barks (organs and powders) of the 4 plant species in the study.

The table 2 summarized the result of macroscopic evaluation of plant material. All plant material samples were found to be fine, homogeneous appearance and without foreign body and spoilage elements such as molds. That is in line with the requirements of the Ph. Eur. 10th E. guidelines for the preparation of a plant drug monograph. These results provided useful information for controlling the quality and purity of powders prepared by drying and pulverizing plant material.

Organoleptic evaluation showed that powder from leaves was light green for *K. senegalensis* and brownish for the others while all bark powders are reddish. All plant material samples

tasted bitter excepted *T. emetica* leaves pounder *that tasted* bland. The texture of plant material was amorphous with more fibrous aspect for leave pounders of *E. senegalensis and T. emetica, and* Bark pounder of *P. kotschyi.*

Very few studies have focused on the macroscopic description of these four Meliaceae plants widely use in ethnomedicine across West Africa. Ibrahim *et al*. in comparative studies on *Khaya*. A. Juss (Meliaceae) in Nigeria found reddish brown for the color of the bark powder of *K. senegalensis* [34]. The taste of the powder was also bitter [35]. Found astringent taste for the stem bark of *K. senegalensis*. Intensely bitter taste was described by Atinga *et al*. [36].

For the other Meliaceae, information is almost non-existent in the scientific literature. However, the aspect of the powders (color, odor, taste and texture) is the first elements of evaluation of plant powders. When these data are well standardized and plant-specific, they lead to rapid identification or discrimination at lower cost. This study suggests clues for the standardization of macroscopic evaluation of some Meliaceae plant that might present specific criteria. Studies including more samples collected from different areas could confirm the specificity of some plant powders for authentication or discrimination as discussed by Adepoju Ogunkunle *et al*. [37].

Table 2: Macroscopic evaluation of leaves and barks pounders

		E. senegalensis	***K. senegalensis***	***P. kotschyi***	***T. emetica***
Leaves	Uniformity of the particles	Fine and homogeneous appearance			
	Presence of foreign particles	Absence of foreign body			
	Color	Brownish	Light green	Brownish	Brownish
	Taste	Bitter	Bitter	Bitter	bland
	Texture	Amorphous	Amorphous	Amorphous	Amorphous
	Fibrous aspect	+++	+	+	+++
Bark	Uniformity of the particles	Fine and homogeneous appearance			
	Presence of foreign particles	Absence of foreign body			
	Color	Reddish	Reddish	Reddish	Reddish
	Taste	Bitter	Bitter	Bitter	Bitter
	Texture	Amorphous	Amorphous	Amorphous	Amorphous
	Fibrous aspect	+	+	+++	++

Legend: +++ = very fibrous; ++ = fibrous; + = less fibrous

Microscopic characteristics of the plant drugs

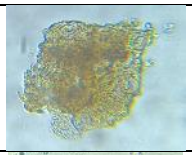
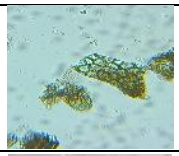
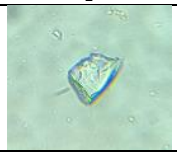
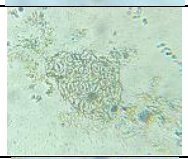
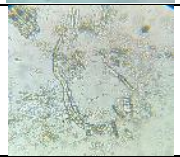
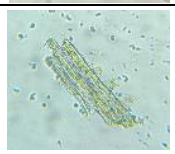
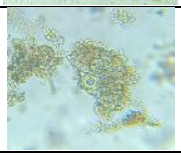
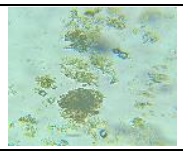
Light microscopic observations of leaf and bark powders from *E. senegalensis*; *K. senegalensis*; *P. kotschyi* and *T. emetica* were showed in Figure 4.

For leaves powders, the presence of stomata of various types fibers, rod-shaped cells isolated or in clusters; and single- or multi-cell tectorial hairs of variable sizes were found. In *K. senegalensis*, trichomes, cells with a light background and pointed tips, and striped vessels have been observed. The presence of calcium oxalate crystals stood out as a particularity of *E. senegalensis (*giant but rare crystals) compared with *P. kotschyi* (small, prismatic crystals, very abundant) and the others, which do not.

Microscopic evaluation of the barks revealed the presence of prismatic calcium oxalate crystals in all four (4) species compared with leaf powders. There was diversity in the number and morphology of crystals. Bark powders were abundant in crystals, with the exception of *T. emetica*. Hairs were abundant, giant, single- or multi-cellular in *E. senegalensis* and *P. kotschyi*, rarer in *K. senegalensis* and almost absent in *T. emetica*. All these species had fibers of different shapes and sizes. In *K. senegalensis*, the fibers were thin and isolated, while in the other species, they were thick, isolated or in clusters (Figure 4).

As for macroscopic description, very few studies deal on the microscopic evaluation of these four Meliaceae plants. The presence of calcium oxalate and calcium carbonate was only described by Atinga *et al*. in *P. kotschyi* Powdered stem bark (*Meliaceae*), [36]. The microscopic elements described in the present work and highlighting some specificities constitute an important keys that could be used in monographs for correct identification and detection of adulteration for these four Meliaceae plants.

Lastly, the abundance of calcium oxalate crystals observed in Meliaceae bark powders could contribute to the reinforcement of osteo-articular stability and muscle tone. However, uncontrolled ingestion of extracts from these species could pose a high risk of calcium lithiasis or stones in organs such as the liver and kidneys, leading to functional impairment [34].

	Leaves	**Stomates**	**Pile**	**Fibers**	**Tissue**	**Ca_2Ox**
A	*Ekebergia senegalensis*					
	Khaya senegalensis					-
	Pseudocedrela kotschyi					

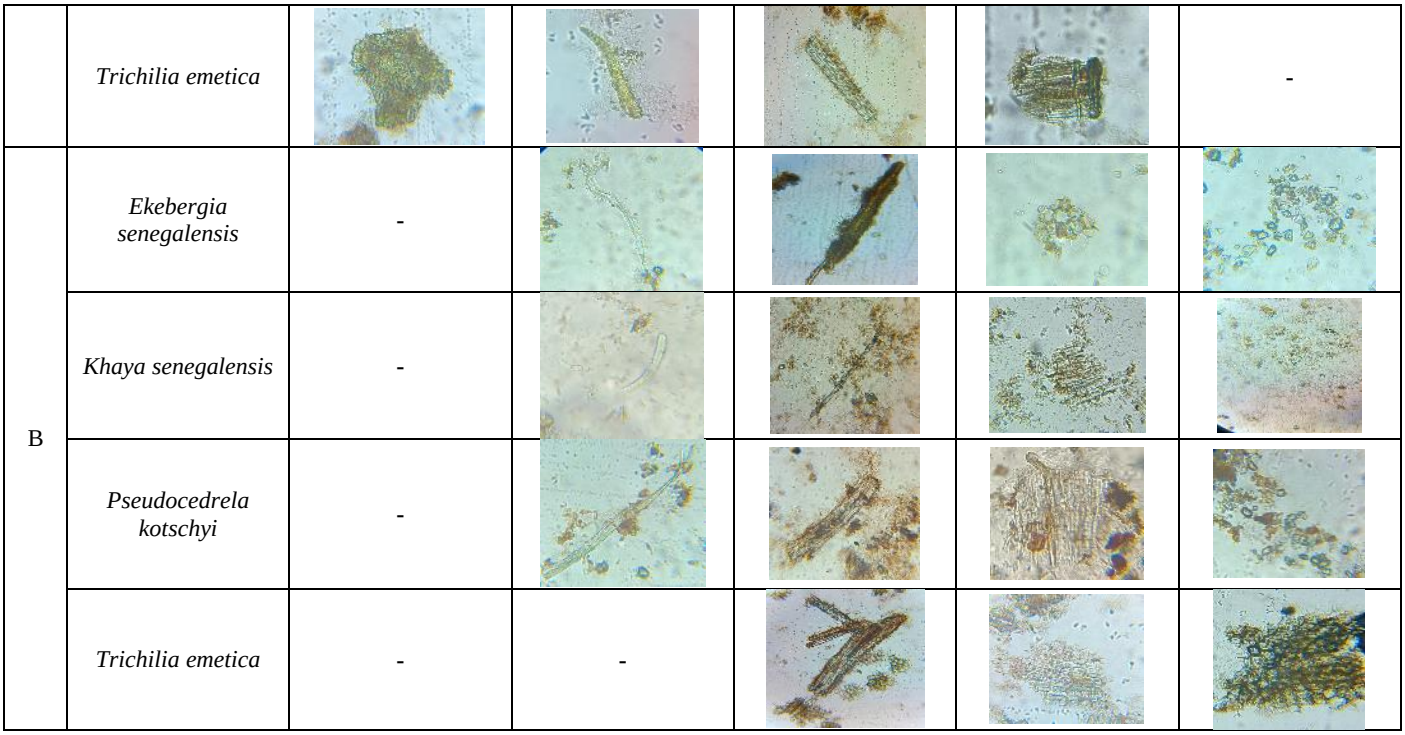


Fig 4: Microscopic details of leaves (A) and bark (B) powders from the 4 Meliaceae studied

Physicochemical characterization of plant material

The gravimetric measurement of loss on drying showed that moisture contents were all below 5% for the bark and leaf powders of the 04 species (Table 3). The residual moisture content of the leaves was higher than that of the bark. These results were in line with the requirements of the European Pharmacopoeia 10 Edition, which defines a powder moisture threshold of less than 10% [3]. The low relative humidity levels observed could protect the plant material from oxidation-reduction phenomena and enable better preservation of the drugs by limiting the development of microorganisms such as fungi and moulds.

On extraction yields, all plants material show more extractives for leaves than in bark. *P. kotschyi* showed the highest rates for the leaves (39.0±0.4%) while its bark show the lowest rate (10.1±0.4).

Determination of total ash showed higher values in bark than in leaves. *P. kotschyi* bark showed the highest total ash percentages (20.09±0.00%) while the other samples exhibited total ash lower that 10%. As for ashes insoluble in 10% hydrochloric acid, all values were below 1%, which testifies to the low presence of siliceous elements and dust in plant drugs. These results are consistent with microscopic observations, which revealed the presence of calcium oxalate crystals more in the barks than in the leaves. In addition, the determination of total calcium content by SAA revealed that barks of *P. kotschyi* (27242 mg/kg dry powder) and *K. senegalensis* (12558 mg/kg dry powder) have higher calcium contents (table 3).

Table 3: Physico-chemical characterization of plant powders

Organs	Species	Water content (%)	Ash content (%)		Extraction efficiency (%)
			Total	Insoluble	
Leaves	*Ekebergia senegalensis*	2,76±0,46	4,37±0,00	0,13±0,00	33,9±0,3
	Khaya senegalensis	0,62±0.13	6,75±0,00	0,31±0,00	27,7±0,5
	Pseudocedrela kotschyi	0,74±0,31	5,89±0,00	0,65±0,00	39,0±0,4
	Trichilia emetica	1,14±0.16	5,01±0,00	0,21±0,00	31,4±0,0
Barks	*Ekebergia senegalensis*	0,62±0,13	7,63±0,00	0,28±0,00	27,5±0,6
	Khaya senegalensis	0,49±0.27	8,43±0,00	0,48±0,00	23,3±0,3
	Pseudocedrela kotschyi	1,37±0,30	20,09±0,00	0,85±0,00	10,1±0,4
	Trichilia emetica	0,38±0.27	7,76±0,00	0,38±0,00	20,1±0.9

Results are expressed as mean ± standard deviation (n=3)

For these four Meliaceae plants, there is a lack of data's on physicochemical properties. Atinga *et al*. reported a total ash value of 11.25±0.83, an acid Insoluble ash of 3.20±0.833 and an alcohol soluble extractive of 15.83±0.88 on stem bark of *P. kotschyi* [36]. So, data's from the present study provide essential physico-chemical control criteria that could be used to draw up monographs ensuring the quality of these Meliaceae widely used in traditional medicine across West Africa.

Detection and quantification of phytochemical content

The detection of phenolic and terpenoid compounds by colorimetric test were positive for all samples,

The quantification of phenolic and terpenoid compounds (Table 4) showed that *P. kotschyi* leaves (89.14±0.9 mgEAG/g) contained the highest levels of total phenolics and total terpenoids (229.51±8.76 mgEAG/g). Its bark also showed the highest contain of total calcium (27242 mg/kg of dry powder) which represents twice to thrice more than the other samples.

When focusing on the quantification of phenolic compounds, *E. senegalensis* (34,1 mg EAG/g±1,7) and *P. kotschyi* (34,3 mg EAG/g±4,2) show the highest amounts of phenolic compounds in extracts from leaves while *K. senegalensis* (64,6 mg EAG/g±1,0) and *T. emetica* (58,2 mg EAG/g±1,8) show the highest amounts in those from barks.

On the other hand for the quantification of terpenoid compounds, *E. senegalensis* (185.5 mgE Triamcinolone / g±2, 2) and *K. senegalensis* (208.2 mgE Triamcinolone/g±1,6) show most amounts in bark extracts when *P. kotschyi* (229,5 mgE Triamcinolone/g±8,8) and *T. emetica* (138.6 mgE Triamcinolone/g±21.1) show most amounts in leave extracts

The presence of tannins in some parenchyma cells that reacting with 5% Ferric Chloride was reported by Atinga *et al*. in stem bark of *Pseudocedrela kotschyi* [36]. Polyphenols contents of extracts (aqueous acetone extract and fractions), including flavonoid from *Trichilia emetica* were reported by Konaté *et al*. [39]. Also, a lot of studies focusing on the chemical screening of the Meliaceae of our study, especially for *K. senegalensis* dealed on the detection or metabolic profiling of phenolic and terpenoid compounds. The phenolic and terpenic compounds assessment in our study provides data's on the quantities of metabolites of interest that can act on the chemical and cellular components of inflammation respectively. These results are consistent with data in the scientific literature, and support the pain-relieving and anti-inflammatory properties already described for these species.

Table 4: Phytochemical compound contents of plant powders

Organs	Species	Total phenolic content (mgE gallic acid / g of dry powder)	Total terpenoides content (mgE Triamcinolone/g of dry powder)
Leaves	*Ekebergia senegalensis*	34,1±1,7	13,9±1,6
	Khaya senegalensis	34,3±4,2	25,2±0,3
	Pseudocedrela kotschyi	89,1±0,9	229,5±8,8
	Trichilia emetica	48,3±3,2	138,6±21,1
Barks	*Ekebergia senegalensis*	22,9±1,5	185,5±2,2
	Khaya senegalensis	64,6±1,0	208,2±1,6
	Pseudocedrela kotschyi	21,4±10,0	57,8±1,3
	Trichilia emetica	58,2±1,8	105,0±1,3

Conclusion

The present study described keys for the control standardization of plant material from *E. senegalensis, K. senegalensis P. kotschyi and T. emetica* leaves and bark, four Meliaceae widely use in ethnomedicine across West Africa. Otic microscopy of bark powders revealed the presence of prismatic calcium oxalate crystals in all 4 species, and their abundance in Meliaceae bark could contribute to strengthening osteo-articular stability and muscle tone. However, consumption of Meliaceae bark extracts could ultimately pose a public health problem in the event of uncontrolled ingestions, due to the risk of calcium lithiasis or stones in the liver and kidneys. Physicochemical assessment provided initial elements for setting reference values to standardize the quality of powders from these Meliaceae plants. Evaluation of phytochemical content revealed interesting amount of phenolic and terpenic compound especially for *P. kotschyi* leaves, which supports anti-inflammatory potential of these powders. Further studies on the nature of the molecules that can be found in these extracts and their potential on inflammatory models are required the best valorization of these four Meliaceae plants.

Auteur's Contributions

Harvesting and identification of the plant parts used were carried out by AB. N-S-BR, AY, APN participated in the extraction and determination of polyphenols, terpenoids and moisture content. CAP took part in the determination of total ash and ash insoluble in hydrochloric acid. the results obtained were analyzed statistically by N-S-BR and APN. finally, YKC, APN and N-S-BR supervised the work and wrote the article.

Conflict of interest

We declare that there is no conflict of interest relating to this work.

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