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QUALITY ASSESSMENT OF *GUIERA SENEGALENSIS* J.F. GMEL ADANS. EX JUSS (COMBRETACEAE) LEAF

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Abstract

Guiera Senegalensis (Combretaceae) is one of the important medicinal charms but despite its tremendous medicinal value, less information is available on the physicochemical and FTIR characterization of the plant. This study aimed to screen the phytochemical composition of the petroleum ether, ethyl acetate, methanol, and aqueous extracts by keeping in view the pharmacological importance of the leaves of *Guiera Senegalensis* (*GS*). Additionally, the study aimed to identify the functional phytochemical groups of the powdered leaves and extracts by performing Fourier transform infrared

Keywords: Quality Assessment, *Guiera Senegalensis,* Physicochemical, FTIR Characterization, Extract Yield, Metabolites, Functional Groups

spectroscopy (FTIR) as well as the physicochemical characterization. Fourier transform infrared (FTIR) spectroscopic studies conclude that the peak value characteristic indicates the presence of several functional groups of important bioactive compounds in the powdered leaves as well as the extracts. The FTIR analysis of *GS* conforms to the presence of alcohols, phenols, alkanes, ketones, aldehydes, aromatic compounds, and carboxylic acids using the peak values of functional groups in the different solvent systems. The phytochemical screening (PS) revealed the presence of primary (carbohydrates, proteins) and secondary (flavonoids, phenols, cardiac glycosides, triterpenoids, and steroids) metabolites in high and moderate amounts among all the extracts. Physicochemical analysis revealed the estimate of total ash (6.33 ± 0.33 % w/w), water-soluble ash (2.83 ± 0.17 % w/w), and acid-insoluble ash (1.00 ± 0.29 % w/w) in the leaf and the lower content (7.67 ± 0.17 % w/w) of moisture. The value of pH ranged from 4.30 to 4.95. The maximum extractive value was reported in the methanol extracts (28.80 ± 0.80 %) of *GS* leaf. The quality assessment of the plant was done and the data obtained would serve as a benchmark for use in the future.

INTRODUCTION

Medicinal plants are crucial in global healthcare programs, with bioactive constituents used in developing new pharmaceutical agents for various diseases and infections (Chaudhary and Janmeda, 2022). However, pollution in air, water, and soil has led to concerns about the quality and safety of herbal products (Singh *et al.,* 2010). The side effects and drug resistance issues of synthetic agents have prompted further investigation into herbal drugs (Banothu *et al.,* 2017). Natural variation in plants and samples from different locations and growing conditions can also affect their quality (Chew *et al.,* 2004). Despite advancements in analytical methodologies and commitments to pharmaceutical quality control, substandard and counterfeit medicines remain a significant issue worldwide, despite efforts by national and supranational entities

(Biancolillo and Marini, 2018). The pharmaceutical industry values the physicochemical evaluation of herbal plants due to their authenticity and quality in natural drugs (Alam and Saqib, 2015). *Guiera senegalensis* (*Gs*) is an excellent choice for effective therapeutics due to its ease of availability and low propagation costs. *Gs* is a known source of phytochemicals, and bioactive compounds used in treating various ailments. However, there is limited information on the plant's physicochemical and FTIR profile in different solvent systems, despite its significant medicinal value. FT-IR is a widely used method for identifying chemical constituents in medicines, particularly in the pharmacopeias of many countries (Liu *et al.,* 2006). *Guiera senegalensis*, a shrub found in Africa, is known as "Sabara" by Hausa and other tribes (Hassan *et al.,* 2020). In northern Nigeria, the plant is used to treat diarrhea, and fever, and increase milk supply in breastfeeding women (Dirar and Devkota, 2020, Yahaya *et al.,* 2019). The leaves are known as a "cure-all" for various diseases, including diabetes, dysentery, eczema, malaria, cough, asthma, and tuberculosis (Hamadnalla *et al.,* 2020). They have antibacterial, vulnerary, antimalarial, antibacterial, antifungal, anticancer, antioxidant, and anti-inflammatory properties. They are used to treat various diseases and promote healing through external applications (Fiot *et al.,* 2006, Mamman and Isa, 2013, Shafei *et al.,* 2016). Physicochemical studies on plant drugs are more reliable than pharmacognostic studies due to their ability to identify and determine the quality and purity of crude drugs (Fatehalrahman *et al.,* 2018). Physicochemical analysis in plants provides valuable information and aids in evaluating herbal drug quality. Standardizing preparations is crucial for ensuring purity, safety, potency, and efficacy (Singla, 2021). Analyzing pH, moisture content, total ash, and acid-soluble ash is essential for identifying native medicinal plants (Kavitha and colleagues, 2017). The solvent used in extraction determines the extraction of phytochemicals from plants, so different solvent types must be tested (Tiwari *et al.,* 2011, Ugochukwu *et al.,* 2013). Standardized procedures are needed to determine the identity, quality, purity, extractive values, and moisture content of crude drugs from medicinal plants (Prakash *et al.,* 2019). Numerous studies have explored the therapeutic activity of *Gs* leaves, but their physicochemical evaluation and FTIR profile remain limited. This research focuses on phytochemical study,

physicochemical evaluation, and FTIR characterization of phytoconstituents to identify adulteration and authenticate phytoconstituents, crucial in treating disorders. The data obtained can serve as a baseline for future studies. The significance of phytochemicals and other constituents in medicinal plants, widely used by local communities and practitioners for various ailments, necessitates the provision of routine scientific database lines to determine their quantities and changes.

Material and Methods

Chemicals/Reagents

The studies utilized various chemicals and reagents, including ethyl acetate, methanol, distilled water, petroleum ether, hydrochloric acid, iron (iii) chloride, sodium hydroxide, benedict's reagent, glacial acetic acid, sulphuric acid, and nitric acid.

Plant Material Collection

The leaves of *Guiera senegalensis (GS)* were collected fresh and healthy in Wamakko, Sokoto, Nigeria. The plant specimens were authenticated by (MUSA Magagi) and stored in the pharmacognosy herbarium at Usmanu Danfodiyo University. The leaves were cleaned and dried before being ground into fine granules with a pestle and mortar. The powder was kept at room temperature until they were needed.

Preparation of the Plant Extract

Leaf extracts are traditionally prepared by placing powdered material in separate sterile bottles containing petroleum ether, ethyl acetate, methanol, and distilled water (Akinyemi *et al.,* 2006, WAHO, 2020, Mamman and Isa, 2013). The leaf powder is soaked (40 g) in petroleum ether (200 cm^3), while 25 g in ethyl acetate (200 cm^3), methanol (200 cm^3), and distilled water (250 cm^3) and allowed to macerate for 24 hours before being filtered and evaporated. After being completely evaporated, the filtrates are stored in glass bottles. A formula is used to calculate the percentage yields of each leaf extract.

Extract yield (%) = $\frac{\text{mass of dried extract (g)}}{\text{mass of powdered material (g)}}$ x 100 (1)

Qualitative Phytochemical Screening

The phytochemical screening of leaf petroleum ether, ethyl acetate, methanol, and aqueous extracts was conducted using methods described by Mushtaq *et al.,* 2014, Giftillda, *et al.,* 2018, and Mamman and Isa (2013) to identify various compounds such as phenolic, flavonoids, alkaloids, proteins, tannins, saponins, and carbohydrates.

FT-IR Spectroscopy Analysis.

The study analyzed *G. senegalensis* powdered leaf and extracts using Fourier transform infrared spectroscopy (FT IR Cary 630, Agilent Technologies, Shimadzu, Pvt Ltd, Malaysia) on a micro lab. The samples were scanned with a spectral resolution of 4 cm^{-1} and compared to reference literature and online IR wizard spectroscopic tools to determine the functional groups of phytochemicals present in each sample.

Physicochemical Evaluation

The physicochemical evaluation of *G. senegalensis* was conducted using methods from Giftillda *et al.* (2018), WHO (1998), and Uba *et al.* (2016), including testing weight loss, total ash, acid- insoluble ash, water-soluble ash, pH, and extractive values.

Determination of Moisture Content

Powdered plant material (2 g) was weighed into pre-weighed crucibles (in triplicate), dried in an oven at 105℃, and then cooled in a desiccator, with weight loss calculated as moisture content.

Percentage loss on drying = $\frac{\text{Loss of weight of sample}}{\text{weight of sample}}\ x\ 100$ (2)

Determination of Total Ash

The sample (2 g) was weighed, incinerated at 450 ℃, and then cooled in a desiccator. The percentage of total ash was calculated with reference to the weight of the air-dried drug.

$$\text{Total Ash}=\frac{\text{Weight of Ash}}{\text{Wt of the air-dried drug taken}}\ x\ 100 \quad (3)$$

Determination of Acid-insoluble Ash

The total ash was transferred to a beaker using 25 cm^3 of dilute HCl and boiled on a Bunsen burner for 5 minutes. The solution was filtered, washed twice with hot water, burned to ash, cooled, and weighed. The acid-insoluble ash was calculated using the weight of air-dried ash as a reference, after being weighed.

$$\text{Acid-insoluble ash (\% w/w)} =\frac{(\text{weight of acid-insoluble ash})}{\text{weigh of sample}}\ \text{x } 100 \quad (4)$$

Determination of Water-soluble Ash

The total ash was boiled in a beaker with 25 cm^3 of water, filtered, washed twice with hot water, and weighed. The insoluble matter was subtracted from the ash weight to determine the water-soluble ash. The percentage of water-soluble ash was calculated using the air-dried drug, after the residue was washed twice with hot water, burning to ash, and cooled.

$$\text{Water-soluble ash (\% w/w)} =\frac{(\text{Total ash} - \text{Water-insoluble residue in total ash})}{\text{weigh of sample}}\ \text{x } 100 \quad (5)$$

Determination of pH

The pH of freshly prepared suspensions (1% and 10 % w/v) in distilled water was determined using a simple glass electrode pH meter, following the recommendations of Chandel *et al.* (2011) and Mushtaq *et al.* (2014).

Determination of Extractive Values

A powdered *G. senegalensis* leaf (5 g) was macerated for 24 hours with 100 cm^3 solvents (petroleum ether, ethyl acetate, methanol, and water), shaking frequently for 6 hours and then allowed to stand for 18 hours. The mixture was filtered using Whatman filter paper, evaporated (25 cm^3), dried at 105°C, and weighed. The percentage of extractive values was calculated with reference to powdered material taken.

$$\text{Extractive value (\%)} =\frac{\text{Weight of Extract}}{\text{Wt of the Sample taken}}\ x\ 100 \quad (6)$$

Statistical Analysis

The results were analyzed using Minitab 17, with all results presented as Mean ± SEM, in triplicate.

Results and Discussion

Solvent Extraction and Yield

The study calculated and tabulated the w/w yield percentages of four extracts of *G. senegalensis* leaf. Table 1 shows color, nature, consistency, and physical appearance of the extracts. The colors ranged from light brown to dark green, the consistency was oily to sticky, and the nature was solid to semi-solid. The minimum yield was in ethyl acetate (4.10 %), while the maximum was in methanol (24.40 %).

Table 1: Properties of crude extracts in different solvent systems of G. *senegalensis* leaf

Plant part	Solvents	Extraction method	Extract color	Consistency	Nature of extracts	Extract weight (g)	% Yield (w/w)
Leaf	PE	M	Dark green	Oily	Solid	1.09	4.60
	EA	M	Light green	Dry	Solid	1.64	4.10
	ME	M	Dark green	Sticky	Semi-Solid	6.10	24.40
	AQ	M	Coffee Brown	Dry	Solid	3.45	13.80

petroleum ether (PE), ethyl acetate (EA), Methanol (ME) distilled water (AQ), maceration (M)

Preliminary Qualitative Phytochemical Screening

Table 2 presents a qualitative phytochemical screening of various solvent extracts from *G. senegalensis* plant leaf powder. Primary metabolites include carbohydrates in PE, carbohydrates and proteins in EA, ME, and AQ extracts, while secondary metabolites include polyphenolics in ME, flavonoids in EA, ME, and AQ extracts,

saponin in ME, and tannins in ME, EA, and AQ extracts. Other metabolites include triterpenoids/steroids, cardiac glycosides, anthraquinone, and trace alkaloid in ME extract.

Table 2: Preliminary qualitative phytochemical screening of the petroleum ether, ethyl acetate, methanol, and aqueous extracts of *Guiera senegalensis*

S/No	Metabolites	Petroleum ether	Ethyl acetate	Methanol	Water
1	**Carbohydrate Test**				
	a) Molisch's test	Absent (-)	Absent (-)	Present (+)	Present (+)
	b) Fehling test	Present (+)	Present (+)	Present (+)	Present (+)
2	**Tannins**				
	Ferric Chloride test	Absent (-)	Present (+)	Present (+)	Present (+)
3	**Flavonoids**				
	a) Ferric chloride test	Absent (-)	Present (+)	Present (+)	Present (+)
	b) Alkaline reagent test	Absent (-)	Present (+)	Present (+)	Present (+)
4	**Phenolic Compounds**				
	Ferric chloride test	Absent (-)	Present (+)	Present (+)	Present (+ +)
5	**Proteins**				
	Xanthoproteic test	Absent (-)	Present (+)	Present (+ +)	Present (+)
6	**Saponins**				
	Froth Test	Absent (-)	Absent (-)	Present (+)	Present (+ +)

7	**Cardiac Glycosides**				
	a) Keller Kelliani test	Present (+)	Present (+)	Present (+)	Present (+)
	b) Kedde test	Present (+ +)	Present (+)	Present (+)	Present (+)
8	**Alkaloids**				
	a) Mayer's test	Absent (-)	Absent (-)	Absent (-)	Absent (-)
	b) Wagner's test	Absent (-)	Absent (-)	Present (+)	Absent (-)
9	**Triterpenoids**				
	Libermann-Burchard test	Present (+)	Present (+)	Present (+)	Present (+)
10	**Steroid Test**				
	Salkowski's test	Present (+)	Present (+)	Present (+ +)	Present (+)
11	**Anthraquinone Test**				
	Modified Borntrager's test	Absent (-)	Present (+ +)	Present (+)	Present (+)

Abdullahi *et al.* (2019) studied the phytochemical constituents of aqueous extracts from common medicinal plants, including *Securidaca longipedunculata, Guiera senegalensis*, and *Boswellia dalzielii*. They found saponins, carbohydrates, cardiac glycosides, steroids, terpenoids, alkaloids, and flavonoids in all three plant species. *Guiera senegalensis* leaf extract contained tannins, while Mamman and Isa (2013) found alkaloids, anthraquinones, tannins, and phlobotanins in the methanol, ethanol, and water extracts. These phytocomponents are crucial as they act as antimicrobial, antidiarrheal, and antihelminthetic agents. Shafei *et al.* (2016) found alkaloids, flavonoids, terpenoids, tannins, carbohydrates, proteins, steroids, and saponins in *GS* aqueous leaf extract. These findings suggest that the medicinal plant extract may be safe to drink for treating various diseases, as has been done in Western Sudan villages for years. Further research has been conducted using

80% of methanol leaf extract, methanol leaf extract, and ethanol leaf extract (Ahmed *et al.*, 2022; Yahaya *et al.*, 2019; Ifijen *et al.*, 2019).

Fourier Transform Infrared (FTIR) Spectroscopy

The FT-IR spectroscopic profile of *G. senegalensis* powdered leaf and extracts in different solvent systems in the mid-IR region (4000-650 cm^{-1}) showed similar profiles but varying reading absorbance.

FTIR Spectroscopy Powdered Leaf Sample of G. *senegalensis*

FTIR analyses confirmed the presence of phytocompounds in the powdered leaf sample of *G. senegalensis* by identifying the functional groups present (Figure 1) (Table 3). The spectra revealed significant absorption frequency peaks at various wavelengths, indicating the presence of various functional groups. The leaf-powdered material contained the majority of the detected functional groups. The strong peaks at 3298.7 cm^{-1} corresponded to the O-H (stretching) functional group of alcohols and phenols, while medium peaks were detected at 2911.1 cm^{-1} and 2847.7 cm^{-1}, corresponding to alkane C-H (Stretching). The sharp absorption peak at 1720.2 cm^{-1} is attributed to the C=O stretching vibration in carbonyl compounds, which may be distinguished by the presence of terpenoids and flavonoids in high concentrations. The N-H (bending) functional groups of primary amines were represented by medium peaks detected at 1615.8 cm^{-1}. The presence of nitro compounds was indicated by the strong peak at 1545.0 cm^{-1} (N-O). The presence of primary amines and ethers was indicated by the C-O (stretching) and C-O-C (stretching) peaks at 1159.2 and 1026.9 cm^{-1}.

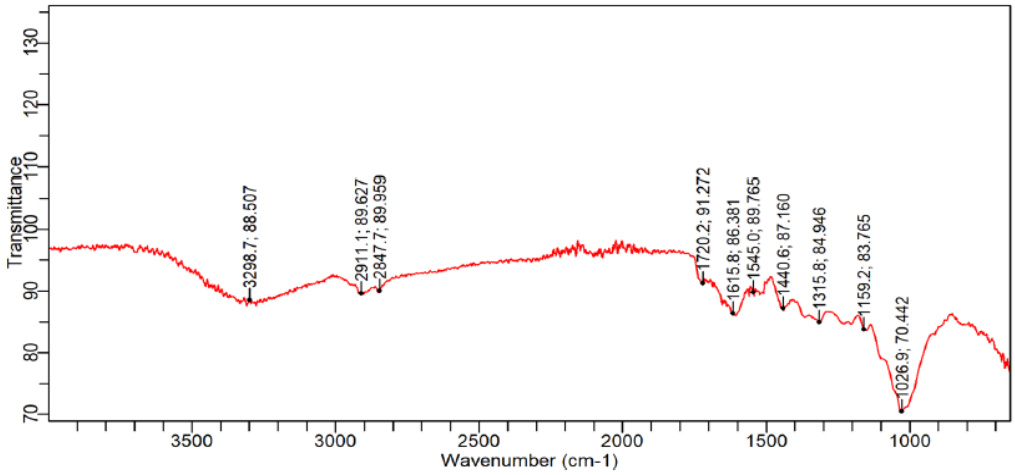

Figure 1: FTIR spectra of the powdered leaf of *G. senegalensis*

Table 3: FTIR spectral peak values and functional groups of dried leaf powder of G. *senegalensis*

Sample	Peak Absorption Frequency (cm^{-1})	Intensity	Functional Group	Compound Class	Type of Vibration
Powder Leaf	3298.7	Strong, Broad	O-H	Alcohol, phenol	Stretching
	2911.1	Medium	C–H	Alkanes	Stretching
	2847.7	Medium	H–C=O: C–H	Aldehydes	Stretching
	1720.2	Strong	C=O stretch	carbonyls (general)	Stretching
	1615.8	Medium	N–H bend	1° amines	Bending
	1545.0	Strong	N–O asymmetric	nitro compounds	Stretching
	1440.6	Medium	C–H	Alkanes	Bending
	1315.8	Strong, Medium	C–O or O-H	alcohols, carboxylic acids, esters, ethers. and phenol	Stretching, Bending
	1159.2	Medium	C–N	aliphatic amines	Stretching
	1026.9	Strong	C–O-C	Ethers	Stretching

FTIR Spectroscopy Petroleum ether (PE) Extract of G. *senegalensis*

The FT-IR spectra of PE extract show characteristic peaks at 3400 cm^{-1}, corresponding to O-H absorption, symmetric and asymmetric stretching vibrations of methyl and methylene, at 2957.6, 2851.4, 1448.1, and 1373.5 cm^{-1} and O-H stretch absorption at 2918.5 and 1308.3 cm^{-1}. Absorption at 1731.3 cm^{-1} and 1662.4 cm^{-1} is attributed to the C=O group, N-H bend vibration of primary amines,

and C-OH stretching vibration. C-N stretch of aliphatic amines, =C-H bend of alkenes, and C-Cl stretch of halogen compounds are assigned.

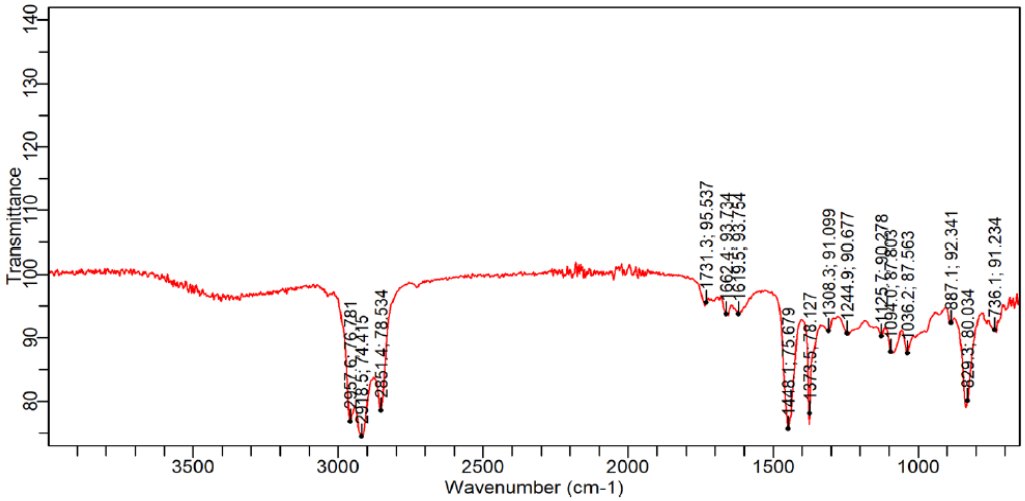

Table 4: FTIR spectral peak values and functional groups of G. *senegalensis* PE leaf extract

Extract	Peak Absorption Frequency (cm^{-1})	Intensity	Functional Group	Compound Class	Type of Vibration
PE Extract					
	2957.6	Medium	C–H stretch	Alkanes	Stretching
	2918.5	Medium	O–H stretch	carboxylic acids	Stretching
	2851.4	Medium	C–H stretch	Alkanes	Stretching
	1731.3	Strong	C=O (general)	Carbonyls	Stretching
	1662.4	Strong	C=O stretch	esters, saturated aliphatic	Stretching
	1619.5	Medium	N–H bend	1° amines	Bending
	1448.1	Medium	C–H bend	Alkanes	Bending
	1373.5	Medium	C–H rock	Alkanes	Rocking

	1308.3	Strong	O-H	carboxylic acids	Bending
	1244.9	Strong	C–O stretch	alcohols, carboxylic acids, esters, ethers	Stretching
	1125.7	Strong	C–O stretch	carboxylic acids, esters, ethers	Stretching
	1094.0	Strong	C–O	carboxylic acids, esters, ethers	Stretching
	1036.2	Medium	C–N stretch	aliphatic amines	Stretching
	887.1	Strong	=C–H bend	Alkenes	Bending
	829.3	Medium	=C–H bend	Alkenes	Bending
	736.1	Strong	C–H "oop" C–Cl stretch	Aromatics, alkyl halides	Stretching

FTIR Spectroscopy Ethyl acetate (EA) Extract of G. *senegalensis*

The FTIR spectra showed characteristic peaks at 3380.7 cm^{-1}, corresponding to O-H absorption, 2926.0 cm^{-1}, 2851.4, 1451.8 cm^{-1}, and 1373.5 cm^{-1}, to methyl (CH_3) and methylene (CH_2) stretching and bending vibration, 1738.8 cm^{-1}, 1709.0 cm^{-1}, to alkene (–C=C–) skeletal stretching vibration, 1612.1 cm^{-1} to N–H bend, 1505.8 cm^{-1}, nitro compounds stretching, 1312.0 cm^{-1}, 1162.9 cm^{-1}, 1244.9 cm^{-1}, 1094.0 cm^{-1}, 1039.9 cm^{-1}, aliphatic amines and primary amines stretching, 836.8 cm^{-1}, =C–H (bending), and 725.0 cm^{-1}, to C–Cl stretching vibration.

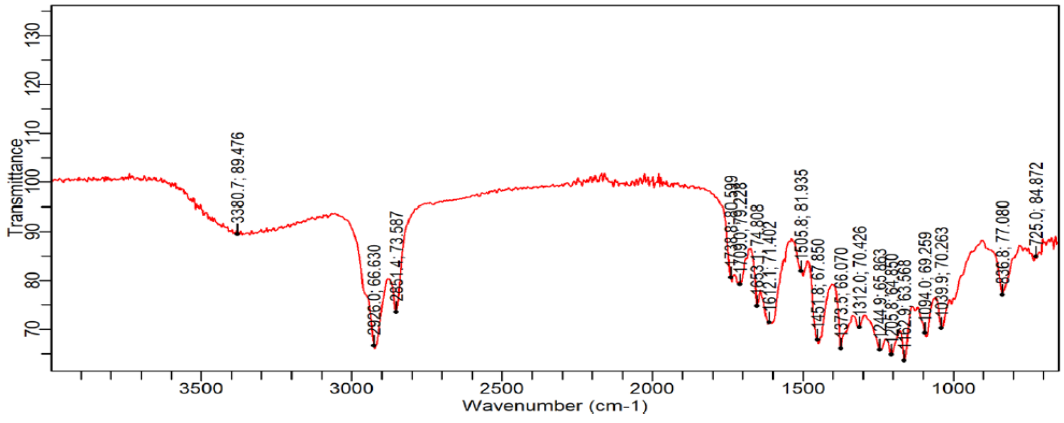

Figure 3: FTIR spectra of Ethyl acetate (EA) Extract of G. *senegalensis*

Table 5: FTIR spectral peak values and functional groups of G. *senegalensis* EA leaf extract

Extract	Peak Absorption Frequency (cm^{-1})	Intensity	Functional Group	Compound Class	Type of Vibration
EA Extract	3380.7	Strong, Broad	O–H stretch	H–bonded alcohols, phenols	Stretching
	2926.0	Medium	C–H stretch	Alkanes	Stretching
	2851.4	Strong	C–H stretch	Alkanes	Stretching
	1738.8	Strong	C=O stretch	carbonyls (general)	Stretching
	1709.0	Strong	C=O stretch	aldehydes, saturated aliphatic	Stretching
	1653.1	Medium	–C=C– stretch	Alkenes	Stretching
	1612.1	Medium	N–H bend	1° amines	Bending
	1505.8	Strong	N–O asymmetric stretch	nitro compounds	Stretching
	1451.8	Medium	C–H bend	Alkanes	Bending
	1373.5	Medium	C–H bend	Alkanes	Bending
	1312.0	Strong	C–O stretch	alcohols, carboxylic acids, esters, ethers	Stretching
	1244.9	Medium	C–N stretch	aliphatic amines	Stretching
	1205.8	Medium	C–N	aliphatic amines	Stretching
	1162.9	Strong	C–O stretch	esters, ethers	Stretching
	1094.0	Medium	C–N stretch	aliphatic amines	Stretching
	1039.9	Medium	C–N stretch	primary amine	Stretching
	836.8	Strong	=C–H bend	Alkenes	Bending
	725.0	Medium	C–Cl stretch	alkyl halides	Stretching

FTIR Spectroscopy Methanol (ME) Extract of G. *senegalensis*

The FT-IR spectra of methanol extract showed characteristic peaks at 3306.1 cm^{-1}, corresponding to the O-H absorption of alcohols and phenols, and at 2940.9 cm^{-1},

corresponding to the stretching vibrations of methyl and methylene of alkanes. The absorption at 2832.8 cm^{-1} is attributed to the (H–C=O: C–H) group of aldehydes, while the C=O stretching vibration of aldehydes and saturated aliphatic is at 1705.3 cm^{-1}. Primary amines have absorption at 1606.5 cm^{-1} for N–H bending, while alkanes have C–H (bending) at 1451.8 and 1343.7 cm^{-1}.

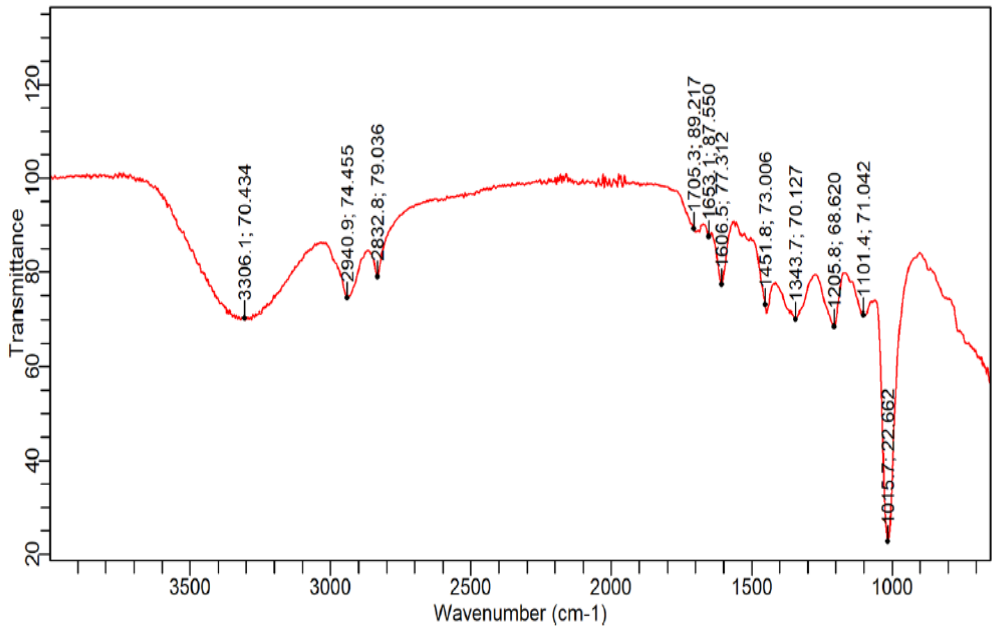

Figure 4: FTIR spectra of Methanol (ME) Extract of G. *senegalensis*

Table 6: FTIR spectral peak values and functional groups of G. *senegalensis* ME leaf extract

Extract	Peak Absorption Frequency (cm^{-1})	Intensity	Functional Group	Compound Class	Type of Vibration
I Extract	3306.1	Strong, Broad	O–H stretch, H–bonded	alcohols, phenols	Stretching
	2940.9	Medium	C–H stretch	Alkanes	Stretching
	2832.8	Medium	H–C=O: C–H	Aldehydes	Stretching

	1705.3	Strong	C=O stretch	aldehydes, saturated aliphatic	Stretching
	1653.1	Medium	–C=C– stretch	Alkenes	Stretching
	1606.5	Medium	N–H bend	1° amines	Bending
	1451.8	Medium	C–H bend	Alkanes	Bending
	1343.7	Medium	C–H bend	Alkanes	Bending
	1205.8	Medium	C–N	aliphatic amines	Stretching
	1101.4	Medium	C–N stretch	aliphatic amines	Stretching
	1015.7	Medium	C–N stretch	primary amine	Stretching

FTIR Spectroscopy Aqueous (AQ) Extract of G. *senegalensis*

The aqueous leaf extract spectra showed strong peaks at 3295.0 cm^{-1}, corresponding to the O-H functional group of alcohols and phenols. Medium peaks at 2886.6 and 1351.2 cm^{-1} indicated the C-H stretch and C-H bend functional groups of alkanes. The presence of aldehydes was indicated by the 2832.8 cm^{-1} medium peak, which had a –C=O: C–H (stretching) functional group. Other medium peaks at 1627.0 cm^{-1} indicated the N–H (bending) group of primary amines.

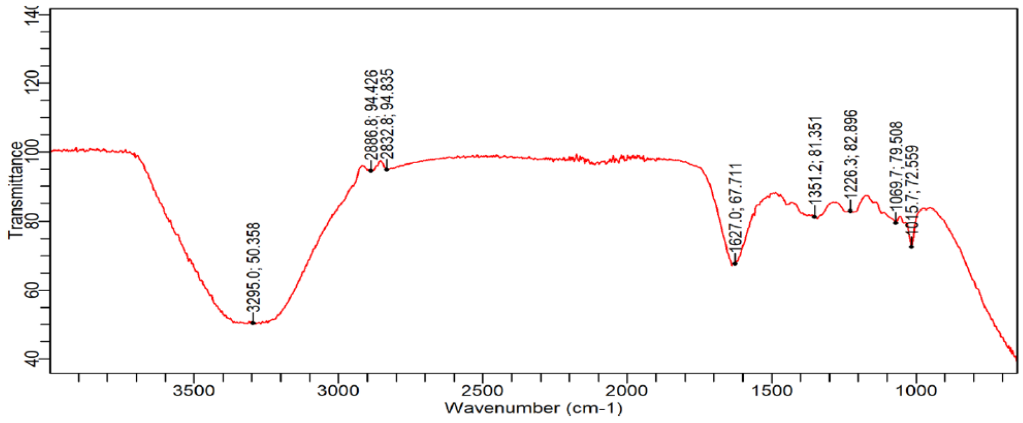

Figure 5: FTIR spectra of Methanol (ME) Extract of G. *senegalensis*

Table 7: FTIR spectral peak values and functional groups of G. *senegalensis* AQ leaf extract

Extract	Peak Absorption Frequency (cm^{-1})	Intensity	Functional Group	Compound Class	Type of Vibration
AQ Extract	3295.0	Strong, Broad	O–H stretch, H–bonded	alcohols, phenols	Stretching
	2886.6	Strong	C–H stretch	Alkanes	Stretching
	2832.8	Medium	H–C=O: C–H	Aldehydes	Stretching
	1627.0	Medium	N–H bend	1° amines	Bending
	1351.2	Medium	C–H bend	Alkanes	Bending
	1226.3	Medium	C–N	aliphatic amines	Stretching
	1069.7	Medium	C–N stretch	aliphatic amines	Stretching
	1015.7	Medium	C–N stretch	primary amine	Stretching

m=medium, w=weak, s=strong, b=broad

Previous research has shown that different extracts of *Monotheca buxifolia* leaves can be used to treat various serious diseases and isolate bioactive compounds from the plant. Ahmad *et al.* (2019) conducted a comparative study using different solvents to screen phytochemicals from *Monotheca buxifolia* leaves. FTIR spectroscopic studies revealed characteristic peak values indicating the functional groups of important bioactive compounds. Narendhran and Sivaraj (2015) used FT-IR spectroscopy to investigate the phytochemical profile of *lantana aculeata L.* leaf extracts in methanol, chloroform, ethanol, and aqueous form. FT-IR analyses revealed various characterization absorption peak values in the extracts with various functional groups. The presence of phytoconstituents in the leaf extracts was attributed to their antibacterial activity. Devi and Battu (2019) used qualitative phytochemical analysis and Fourier-transform infrared spectroscopy (FTIR) to

screen for phytochemicals in *Grewia tilifolia* leaf extracts in eight different solvents. Saranya and Sekar (2016) and Deshmukh (2020) obtained similar results. The current study provides evidence that different extracts of *G. senegalensis* leaf are useful in treating serious diseases and identifying bioactive compounds for drug development.

Physicochemical Analysis

The safety of medicinal herbs is significantly influenced by their identity, quality, and purity, as highlighted by Nayeem *et al.,* (2020).

Estimation of Moisture Content

The moisture content of Guiera senegalensis leaf at 105°C is 7.67±0.17 (Table 8, Figure 6), with a water content ranging between 8% and 14% as reported by (Junior *et al.,* 2011). Excessive moisture in plant drugs can cause hydrolysis, bacterial and fungal growth, and biochemical reactions. Pharmacopoeial monographs impose mandatory limits on water content, especially in drugs with hygroscopic properties or those prone to product deterioration (Junior *et al.,* 2011, Mukherjee, 2019). Plant powder with less moisture is expected to be safe for longer periods. To discourage bacteria, yeast, or fungi growth during storage, the drug's moisture content should be kept to a minimum. Low moisture content indicates an appropriate standard, quality, and stability of plant material, which can be considered in future research or applications (Prakash *et al.,* 2019). Inefficient drying processes can degrade the drug's phytoconstituents, while high water content can interfere with drug quality (Longanatghan *et al.,* 2018). The current study supports previous research on the same plant, which reported a drying loss of 3.56 ± 0.09 % (Uba *et al.,* 2016). Low moisture content is preferred for improved drug stability (Chandel *et al.,* 2011).

Estimation of Ash values and pH

Ash values are crucial in detecting low-quality products, earthy matter, and exhausted drugs. The ash content of a plant provides information about its inorganic content, and the percentage variation from one sample to the next

indicates a change in quality. Adulteration, contamination, and substitution increase ash values, with acid-insoluble ash indicating sand/soil contamination and water-soluble ash indicating exhausted material (Kesatebrhan, 2013). High ash values indicate contamination, substitution, adulteration, or negligence in the preparation of drugs for marketing (Chandel *et al.,* 2011). The study calculated ash values in three ways: total ash, water-soluble ash, and acid-insoluble ash. The total ash content of *Guiera senegalensis* was 6.33 ± 0.33% w/w (Table 8/Figure 6), while water-soluble ash is the portion of total ash content soluble in water Chandel *et al.,* 2011). The acid-insoluble ash value of *Gs* was 1.00 ± 0.29% w/w and the water-soluble ash value was 2.83 ± 0.17% w/w (Table 8). This means that *Guiera senegalensis* fell within the 0.8 and 2.5% maximum limit set by West African herbal pharmacopeia and Ayurvedic Pharmacopoeia of India for acid-insoluble ash in powdered medicinal plants. The results indicate that all traces of extraneous or organic matter were removed, demonstrating high purity in the powdered plant material. The ash values are relatively low, indicating little contamination. These values are consistent with previous research on this plant and comparable to similar studies on other plants. Total ash value of the leaves of *Gs* was reported as 11.7 ± 0.25%, and acid-insoluble ash as 6.2 ± 0.21% (Uba *et al.,* 2016), and total ash value (1.92%), water-soluble ash value (0.88%) and acid-insoluble ash value (1.23%) for stem of *Gs* (Olotu *et al.,* 2016).

Table 8: Physicochemical characteristics of *Guiera Senegalensis* leaf and standard(s)

S. No	Parameters	Percentage mean (n=3) ± SEM	Standard for *Guiera* leaves % (WAHP)	Standard % (API)
1	Moisture Content (%)	7.67 ± 0.17	NLMT 6.5	-
2	Ash Content			
A	Total Ash (% w/w)	6.33 ± 0.33	NMT 5.7	NMT 10
B	Water soluble Ash (% w/w)	2.83 ± 0.17	-	-
C	Acid Insoluble Ash (% w/w)	1.00 ± 0.29	NMT 0.8	NMT 2.5
3	pH			

A	pH (1%)	4.95 ± 0.01	-	-
B	pH (10%)	4.30 ± 0.03	-	-
4	Extractive values (% w/w)			
A	Water soluble extractives (AQSE)	23.33 ± 1.16	NLT 6	NLT 20
B	Methanol soluble extractives (MESE)	28.80 ± 0.80	NLT 2	NLT 10
C	Ethyl acetate soluble extractives (EASE)	5.07 ± 0.71	-	-
D	Petroleum ether soluble extractives (PESE)	6.67 ± 0.71	-	-

Hint: Not lose more than **(**NLMT**),** Not more than **(**NMT**),** Not less than (NLT), West-African Herbal Pharmacopoeia (WAHP), Ayurvedic Pharmacopoeia of India (API)

The pH of *Gs* in a 1% solution was 4.95 ± 0.01, while in a 10% solution it was 4.30 ± 0.03. A neutral or alkaline pH is associated with high microbial contamination in herbal preparations (Abba *et al.,* 2009). The pH range of fruits, vegetables, grasses, flowers, trees, shrubs, and annuals is 4.0-7.5, while food has a pH range of 2.0-9.0 (Prakash *et al.,* 2019). Acid/base properties influence drug biopharmaceutical properties, and the charge state of compounds under varying pH conditions significantly impacts absorption, distribution, metabolism, extraction, and toxicity (ADMET). The acid/base character of a drug influences its potency, selectivity, pharmacokinetic, and biopharmaceutical properties (Manallack *et al.,* 2013).

Estimation of extractive values

The extractive values of *Guiera senegalensis (Gs)* were found to be 28.80 ± 0.80, 23.33 ±1.16, 6.67 ±0.71, and 5.07 ± 0.71% w/w, in methanol, water, petroleum ether, and ethyl acetate respectively. This study agrees with the work of Nayeem *et al.,* (2020) in that the methanolic extractive value of the drug, *Plantago Lanceolata*, was found to be 12.7% (%w/w) and was highest, indicating the presence of polar components, while the ethyl acetate extract had the lowest extractive value, 1.2%.

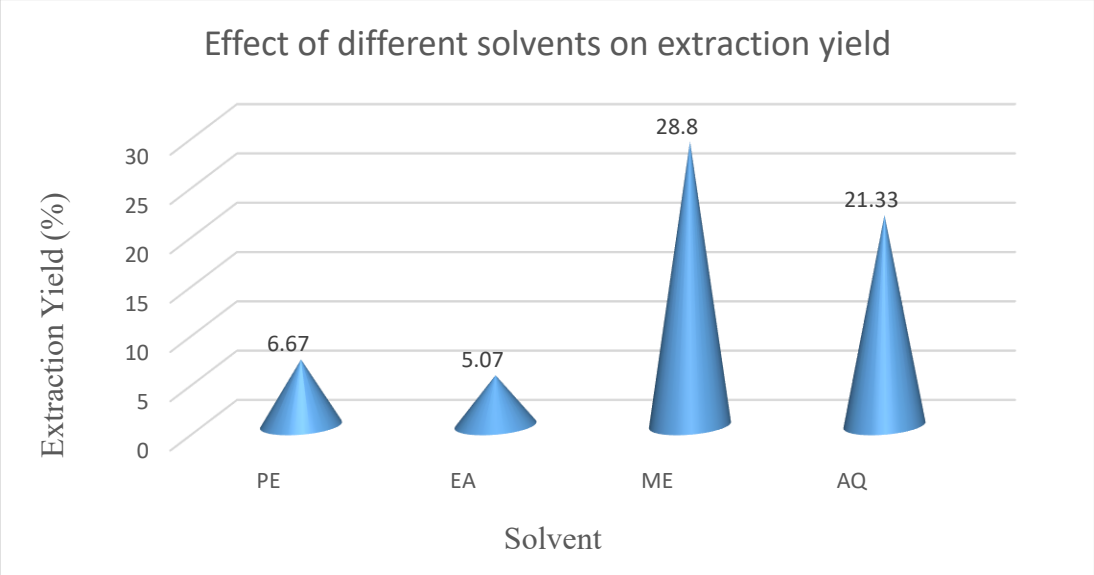

Figure 7: Extractive yield of plant in different solvent systems.

The extractive value of a drug in a specific solvent is a measure of its purity, and polar compounds outnumber nonpolar compounds (Jahan *et al.,* 2008). In *halophyte Cyperus* conglomerates, extractive values ranged from 0.54 % in petroleum ether to 10.94% in methanol, with a water extractive value of 7.93% (Pande *et al.,* 2018). Water-soluble extractive values, alcohol-soluble extractive values, and chloroform-soluble extractive values were reported as 37.6%, 8.8%, and 3.2%, (Agashe *et al.,* 2015) respectively. *Trianthema portulacastrum* extractive values ranged from 0.52 to 8.64%, with a water-soluble extractive value of 17.7% (Pande *et al.,* 2018a). *Moringa oleifera* leaves had an alcohol-soluble extractive value of 13.20% and a water-soluble extractive value of 8.63% (Goswami and Singhai, 2015). The percentage of alcohol extractive value in the powdered stem of *Guiera senegalensis* was 0.94% w/w, and the water extractive value was 0.53 % w/w (Olotu *et al.,* 2016). Higher extractive values are typically preferred for further investigation (Nayeem *et al.,* 2020). The water-soluble extractive value of crude drugs is very important in their evaluation. Less extractive value indicates the use of exhausted material, adulteration, or improper processing during drying, storage, or formulation (Chandel *et al.,* 2011). The presence of fats, lipids, and some steroids in the drug is indicated by the petroleum ether soluble extractive value.

Furthermore, the water-soluble extractive and alcohol-soluble extractive were in agreement with the WAHP and API minimum limits for acid-insoluble ash in powdered medicinal plants of 6 and 20%, respectively.

Conclusion

Herbal medicine has been used for thousands of years, particularly in disadvantaged communities, due to their affordability, accessibility, and cultural acceptance. This study aimed to standardize herbal preparations for antibacterial activity and other illnesses using phytochemical activity, FTIR analysis, and physicochemical parameters. The medicinal properties of *G. senegalensis* leaf extracts were discovered through phytochemical screening, with most phytochemicals found in methanol and aqueous extracts. The powdered material contained functional groups related to these phytocompounds. FTIR analysis revealed that the total ash value, acid-insoluble, and water-soluble ash in the leaf were within the pharmacopeia limits. The extractive value of the plant in various solvent systems was evaluated to determine the most effective solvent for extraction and understand the chemical constituents. The methanol extract outperformed aqueous, petroleum ether, and ethyl acetate solvents, supporting the use of *G. senegalensis* in traditional medicine and highlighting its potential medicinal use and biological activities. Pharmacognostic evaluation of the plant material is crucial for detecting drug adulteration or improper handling and serves as a baseline for future studies.

Recommendations

1. The extractive value of a polyherbal formulation of *Guiera senegalensis* with other plants should be assessed in order to find the most effective solvent for the extraction process and to gain an understanding of the nature of the chemical constituents present and expressed in combination. The formulation can then be used to characterize the pharmacological/biomedical activity against antimicrobial models in vitro.

2. *Guiera senegalensis* should be synthesized to obtain nanoparticles and compare their activity to that of plant extracts. Plant-mediated nanoparticles can be used as effective therapeutic agents not only against human pathogens, but also for the treatment of free radical-caused diseases and waste water purification in the near future.

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