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Investigating the bioactive compounds and characterization of *Guiera senegalensis* aqueous extract

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Abstract

The growing demand for plant-based medications raises concerns about overharvesting and biodiversity loss. Integrating traditional medicine with modern techniques is becoming popular, especially in areas with limited access to conventional medicine. The West African native plant *Guiera senegalensis*, known for its numerous medicinal uses, is widely employed in traditional medicine. The demand for affordable treatments using bioactive chemicals is increasing. Therefore, this study aimed to characterize the bioactive compounds present in the aqueous extract of *Guiera senegalensis* leaves.

Aqueous extracts from *Guiera senegalensis* leaves were prepared and analyzed using Fourier Transform Infrared Spectroscopy (FTIR) and Gas Chromatography-Mass

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Spectrometry (GC-MS). The GC-MS analysis revealed the presence of carboxylic acids and their derivatives, along with other compounds such as n-propyl 11-octadecenoate, aspidospermidin-17-ol, and 1-acetyl-19,21-epoxy-15,16-dimethoxy. These findings support the therapeutic potential of *Guiera senegalensis*.

FTIR analysis showed significant peaks, including a strong intensity at 3205 cm^{-1} attributed to carboxylic acids, 2926 cm^{-1} for C-H stretching (alkanes), and 1200 cm^{-1} corresponding to esters, carboxylic acids, or ethers. Additional peaks were observed at 1442 cm^{-1} (aromatic C=C double bond), 1602 cm^{-1} (N-H bend of primary amine), 1457 cm^{-1} (aromatic ring stretch), 1375 cm^{-1} (alkane bend vibration), and 1162 cm^{-1} (C-N stretch of amines).

The study identifies essential bioactive compounds such as D-limonene, butanoic acid, and phenolic acids, which have significant pharmacological and biological applications. These compounds are utilized in various industries, including fragrance, cosmetics, and household cleaners. The presence of fatty acids in the extract, which aid in improving heart conditions by lowering cholesterol and reducing inflammation, further underscores the therapeutic potential of *Guiera senegalensis*. This research provides a scientific basis for the traditional use of *Guiera senegalensis* and highlights its potential for developing cost-effective treatments.

Introduction

Plants continue to be invaluable sources of traditional medicine, offering a rich resource for discovering new medicines and providing accessible healthcare options for many populations worldwide. For centuries, they have been fundamental in health and wellness across diverse cultures and regions, used to treat numerous ailments. However, many of the active compounds responsible for these medicinal properties can also lead to side effects and health risks if not properly understood. Therefore, it is crucial to investigate the active compounds present in plants and their concentrations to ensure safe usage.

Due to their unparalleled chemical diversity, natural products like plant extracts, whether in pure form or as standardized extracts, offer countless opportunities for discovering new drugs. According to the World Health Organization (WHO), over 80% of the world's population relies on traditional medicine for primary healthcare. In Asia, the use of herbal remedies reflects a long history of environmental interactions with humans. Many compounds found in plants used in traditional medicine have potential applications in treating both chronic and infectious diseases (Duraipandiyan *et al.* [11]).

Guiera senegalensis has demonstrated effectiveness against fever, respiratory congestion, and cough (Adedapo [2]). It is traditionally prescribed to treat lung and bronchial illnesses, aid in breathing, and manage conditions such as hypertension, hypotension, and venereal diseases. The plant is also known for its anti-malarial properties. Elemental analysis reveals that *G. senegalensis* leaves contain significant amounts of essential minerals, supporting their longstanding medicinal use (Mohammed [14]).

The roots and leaves of *G. senegalensis* contain various bioactive compounds, including the bitter principle elastine, flavonoids, alkaloids, quercetin, catechins, saponins, tannins, amino acids, ascorbic acid, and anthraquinones, which exhibit biological activities such as potential anticancer properties (Jigam [13]). These compounds are believed to act through mechanisms such as hormone modulation, antioxidant effects, enzyme activation, inhibition of DNA replication, and antibacterial properties (Cushnie *et al*. [9]).

According to estimates by the World Health Organization (WHO), only a fraction of the plant species used worldwide for medicinal purposes, including *G. senegalensis*, have undergone comprehensive biological evaluation (Ansari and Inamdar [5]). In northern Nigeria, the leaves of *G. senegalensis* are traditionally used to treat ailments like diarrhea, piles, and stomachaches, highlighting its widespread use in local medicine (Dambatta and Aliyu [10]).

The discovery of new physiologically active compounds from various sources, including plants, is the central focus of this theme series on secondary metabolite (also known as natural product) production and function (Bourgaud [8]). Plants have been found to produce a diverse array of bioactive molecules, making them a rich source of various types of medicines. Medicinal plants are valued for their profound therapeutic properties, attributed to the presence of numerous biologically active phytochemical compounds.

Plants contain a variety of bioactive compounds that contribute to their medicinal effects, and many modern pharmaceuticals are derived from or inspired by plant compounds. Plants continue to serve as a basis for the development of new drugs because they house a broad range of bioactive substances such as lipids, phytochemicals, flavors, fragrances, and pigments. Plant extracts are widely used in the food, pharmaceutical, and cosmetics industries (Alamgir and Alamgir [4]). Plants produce many chemical

compounds for biological functions, including defense against insects, fungi, and herbivorous animals (Bolouri *et al*. [7]). These chemical compounds mediate their effects on the human body through processes identical to those already well understood for conventional drugs, enabling herbal medicines to have beneficial pharmacology but also the potential to cause harmful side effects.

Herbs are experiencing a resurgence, with a herbal renaissance happening globally. Herbal products today symbolize safety in contrast to synthetic products, which are often regarded as unsafe for humans and the environment. Over three-quarters of the world's population depends mainly on plants and plant extracts for health care (Ahmad *et al*. [3]). Collectively, plants produce a remarkably diverse array of over 500,000 natural products known as secondary metabolites (Bills and Gloer [6]), which contribute to their medicinal properties. The medicinal value of these secondary metabolites is due to the presence of chemical substances that produce specific physiological actions on biological systems. These substances include alkaloids, steroids, phenols, flavonoids, saponins, lipids, fatty oils, glucosides, glycosides, resins, and minerals such as calcium and phosphorus, which are essential for cell growth, replacement, and body building (Alamgir and Alamgir [4]).

In Sub-Saharan Africa, especially in Nigeria, medicinal plants have shown great promise in the treatment of infectious diseases. Among the medicinal plants distributed worldwide, *Guiera senegalensis* J. F. Gmel. (Combretaceae) is often used to treat microbial infections, acute gastroenteritis, dysentery, and as an anti-malaria agent (Etkins and Ross [12]). It also has astringent properties that are beneficial in the treatment of wounds and ulcers. Aqueous (cold and hot) and methanolic extracts of *Guiera senegalensis* were prepared and their efficacy studied in vitro against *Staphylococcus aureus*, *Salmonella typhi*, *Escherichia coli*, and *Streptococcus pyogenes*, showing that they effectively kill these bacteria and prevent their growth or ability to cause diseases.

Material

Methanol, chloroform (CCl_4), sodium hydroxide (NaOH), concentrated tetraoxosulphate (VI) acid (H_2SO_4), lead acetate $Pb(C_2H_3O_2)_2$, iron(III) chloride ($FeCl_3$), acetic anhydride, distilled water, hydrogen chloride (HCl), and glacial acetic acid ($C_2H_4O_2$) were obtained from Sigma-Aldrich.

Methodology

Sample Collection

Guiera senegalensis leaf samples were collected from Dan Dalama town, Dawakin Tofa Local Government, Kano State. The plant was identified and authenticated in the Biological Laboratory of Ahmadu Bello University (ABU), Zaria, Kaduna State.

Samples Preparation

The leaf sample was air-dried at room temperature under shade for two weeks in the Chemistry laboratory at Federal University, Lokoja, Kogi State. After drying, the sample was pulverized using a wooden laboratory mortar and pestle. The pulverized sample was sieved through a 2 mm sieve and then stored in a tightly sealed glass bottle in a cool, dry place until ready for extraction.

Extraction

200 g of powdered sample was soaked in 700 mL of water in a jar and extracted for 10 days with continuous agitation. After extraction, the mixture was filtered using a funnel and filter paper to obtain the aqueous extract. The methanol crude extract was then dried and weighed.

Fractionation

The crude methanol extract was dissolved in a mixture of water and chloroform. In a 250 mL separating funnel, 40 mL of chloroform and 20 mL of water were added to the methanol crude extract. The mixture was vigorously shaken and then allowed to settle to form two distinct layers: an upper aqueous layer and a lower chloroform layer. The chloroform layer was carefully separated first, followed by the aqueous layer. Both the aqueous and chloroform fractions were then dried and weighed. The dried fractions were stored in a vial until further analysis.

Preparation of Reagent

10% lead acetate solution, 2% solution of Iron (III) chloride ($FeCl_3$), 10 mL of chloroform, Acetic anhydride, Distilled water, 1% hydrogen chloride, 0.1% ferric

chloride solution, Glacial acetic acid (Shittu *et al*. [15]), Fehling's solution, Mayer's Reagent (potassium mercuric iodide), Wagner's Reagent (iodine in potassium iodide).

Fourier Transform Infrared (FT-IR) Spectroscopic Analyses

The aqueous extract of *Guiera senegalensis* was analyzed for the presence of functional groups using a FT-IR spectrophotometer. The functional groups present in the sample were recorded with a Happ-Genzel spectrophotometer over the range of 4000-650 cm^{-1} at the Multi-user Research Laboratory, Ahmadu Bello University (ABU), Zaria.

Gas Chromatography- Mass Spectroscopy Analyses

The aqueous extract of *Sarcocephalus latifolia* was analyzed to determine the compounds present using a GC Clarius 500 Perkin Elmer Analyzer at the Multi-User Research Laboratory, Ahmadu Bello University (ABU), Zaria. The retention times were measured for 45 minutes.

Results

Table 1. Phytochemical results.

Phytochemicals	**Inference**
Flavonoids	+
Terpenoids	+
Cardiac glycosides	–
Tannins	+
Steroids A	–
Steroids B	–
Alkaloid (Mayer test)	+
Alkaloids (Wagner test)	–
Phenols	–

key: + *denotes presence*

– denotes absence

The study reveals the presence of flavonoid, terpenoid, tannin, and alkaloid compounds in *Guiera senegalensis* leaf extract. Flavonoids and terpenoids are essential for maintaining health due to their diverse biological activities. They reduce chronic disease risk, improve cardiovascular health, enhance cognitive function, and promote metabolic health. Terpenoids have antimicrobial, anti-inflammatory, anticancer, antioxidant, and neuroprotective properties. Alkaloids are crucial in medicine and human health due to their analgesic and antimicrobial properties.

Table 2. GC-MS result of aqueous extract of *Guiera senegalensis.*

	R/T	Area	Name of Compound	Peak	Molecular formula	Activity	M/W g/mol^{-1}
1	6.2312	2.4169	D-Limonene	16046	$C_{10}H_{16}$	Antimicrobial, Antioxidants, Anti-cancer	136.238
2	6.8966	0.1999	Butanoic acid, 4-methoxy-, methyl ester	14641	$C_4H_8O_2$	Manufacture of esters	88.11
3	38.7984	0.2674	2-Methyl-Z,Z-3,13-octadecadienol	140253	$C_{19}H_{36}O$	Antimicrobial	280.5
4	19.404	76.8057	Butylated Hydroxytoluene	83554	$C_{15}H_{24}$	Antioxidants	220.356
5	27.8935	0.7963	Propyl ester	130825	$C_5H_{10}O_2$	Antioxidants	116.1583
6	31.8502	1.5849	Hexadecanoic acid, propyl ester	157915	$C_{16}H_{32}O_2$	Antioxidants, antimicrobial and anti-inflammatory	256.43
7	32.0355	0.5319	9-Octadecenoic acid (Z)-, methyl ester	155751	$C_{18}H_{34}O_2$	Antibacterial	282.4614
8	34.9902	1.7563	n-Propyl 11-octadecenoate	182559	$C_{21}H_{40}O_2$	Anti-fungal	324.5
9	35.4755	0.3282	Octacosyl trifluoroacetate	267158	$C_{30}H_{37}F_3O_2$	Antioxidants, antimicrobial	366.5

10	37.8394	6.003	Squalene	243219	$C_{30}H_{50}$	Antioxidants, anti-tumor	410.73
11	38.1479	0.3443	Hexadecane, 1-(ethenloxy)-	128822	$C_{18}H_{36}O$	Detection of Cationic surfactants in polymers	268.5
12	38.6157	0.2862	cis-11-Hexadecenal	100562	$C_{16}H_{30}O$	Pheromone	238.41
13	39.7886	1.2429	Bis(2-ethylhexyl)phthalate	233372	$C_{24}H_{38}O_4$	Antimicrobial	390.6
14	39.2772	0.038	Aspidospermidin-17-ol	244774	$C_{19}H_{26}N_2$	Antibacterial	282.431
15	39.3282	0.0262	1-Docosene	167462	$C_{22}H_{44}$	Antimicrobial	308.59

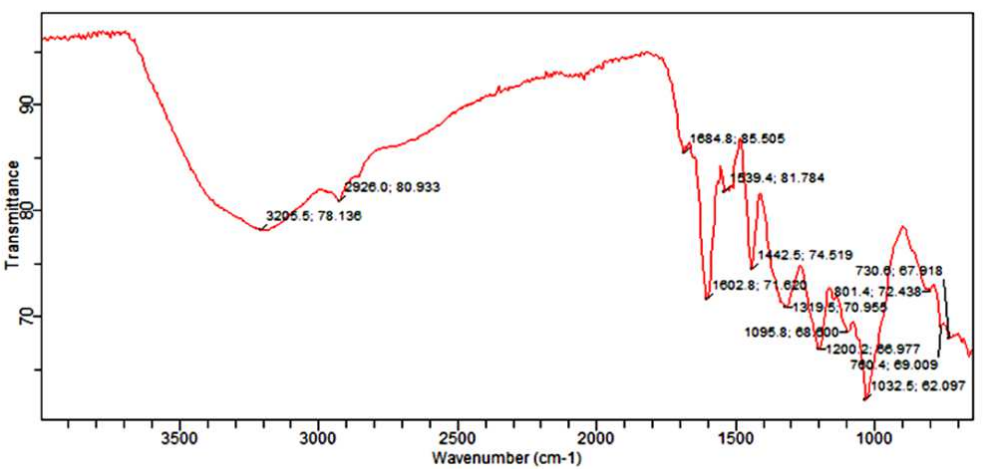

Figure 1. FTIR spectrum of *Guiera senegalensis* leave.

Table 3. Fourier transform infrared spectroscopy result of aqueous extract of *Guiera senegalensis interpretation.*

S/N	Wave number (cm^{-1})	Bond	Intensity	Functional Group
1	3205	-OH stretch	Strong	Alcohols and phenols
2	2926	C-H stretch	Strong	Alkane
3	1319	CH_3 bend	Strong	Alkane
4	1200	-C-O	Strong	Carboxylic acid, Ether, ester, Alcohol
5	1442	C=C	Medium	Aromatic
6	1602	N-H bend	Strong	Primary amine
7	1684	C=O	Medium	Ketone
8	1539	C=C-C	Medium	Aromatic ring stretch
9	1032	C-N	Strong	Amine

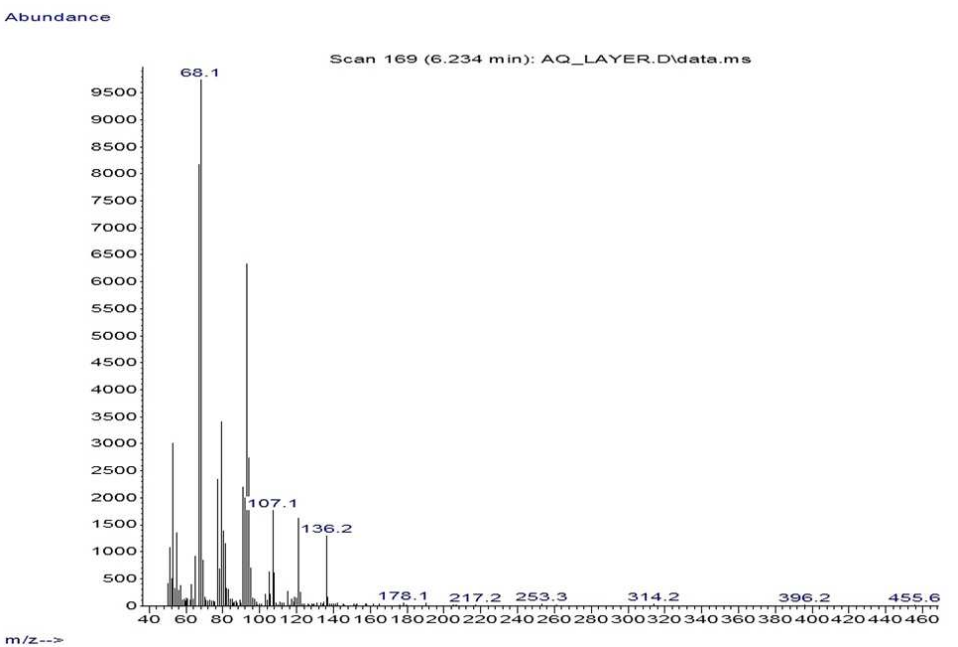

Figure 2. GC-MS Spectrum of Aqueous Extract of *Guiera senegalensis*.

Discussion

Phytochemical screening of the aqueous layer of *Guiera senegalensis* leaf extract, as presented in Table 1, revealed the presence of flavonoids, terpenes, tannins, and alkaloids, with the absence of cardiac glycosides, steroids, phenols, and saponins. Secondary metabolites observed in the leaf extract of *Guiera senegalensis* included alkaloids, which have an analgesic effect and have been clinically used (Cushnie *et al*. [9]).

The FT-IR analysis of the aqueous extract of *Guiera senegalensis* in Table 3 showed bonding vibrations at 3205 cm^{-1}, which is a strong intensity attributed to carboxylic acid. A strong signal observed at 2926 cm^{-1} can be attributed to the C-H stretch (alkane). A carbon-oxygen (C-N) band was observed at 1200 cm^{-1}, which could be characteristic of esters, carboxylic acids, or ethers. An aromatic functional carbon-carbon double bond was observed at 1442 cm^{-1}. Strong intensity was observed at 1602 cm^{-1}, attributed to the N-H band of primary amines. An aromatic ring stretch at 1457 cm^{-1} was also observed with medium intensity. An alkane band was observed at 1375 cm^{-1}, and a strong signal was observed at 1162 cm^{-1}, attributed to C-N (amine). A C=C medium signal was observed at 1442 cm^{-1}, characteristic of aromatic compounds, similar to the report by Adam *et al*. [1].

A total of 15 compounds were identified in the plant extract. Carboxylic acid and its derivatives were present in significant amounts. Other compounds detected included D-Limonene, Butanoic acid, 4-methoxy-, Butylated Hydroxytoluene, Hexadecanoic acid, propyl ester, 9-Octadecanoic acid, Dodecanoic acid, propyl ester, Methyl 8-oxohexadecanoate, n-Propyl 11-octadecenoate, and Aspidospermidin-17-ol.

Conclusion

From the study, it was observed that the plant contains several vital bioactive compounds, including D-Limonene, Butanoic acid, 4-methoxy-, Butylated Hydroxytoluene, Hexadecanoic acid, propyl ester, 9-Octadecanoic acid, Dodecanoic acid, propyl ester, Dodecyl propyl ether, n-Propyl 11-octadecenoate, Aspidospermidin-17-ol, and squalene, which are of great pharmacological and biological importance. Additionally, Linoleic acid ethyl ester and phytol are used in the fragrance industry and in cosmetics, shampoos, toilet soaps, household cleaners, and detergents. Oleic acid, which is a fatty acid, helps improve heart conditions by lowering cholesterol and reducing inflammation.

References

[1] Adam, A. B., Mohammed, A. D., & Kaugama, A. A. (2022). Extraction and modification of cellulose from Calotropis procera plant. *International Conference on Chemical and Biological Sciences*.

[2] Adedapo, A. A., Sofidiya, M. O., & Afolayan, A. J. (2009). Anti-inflammatory and analgesic activities of the aqueous extracts of Margaritaria discoidea (Euphorbiaceae) stem bark in experimental animal models. *International Journal of Tropical Biology, 57*(4), 1193-1200. https://doi.org/10.15517/rbt.v57i4.5456

[3] Ahmad, K. B., Kabiru, H. D., Adam, A. B., Ebun, E. P., & Abdullahi, B. I. (2023). Phytochemical constituents, antimicrobial and antioxidant activity of methanol crude extract of Daniellia oliveri stem bark. *2nd International Congress on Natural and Medicinal Science*, Turkey, 2, 12-16.

[4] Alamgir, A. N. M., & Alamgir, A. N. M. (2018). Phytoconstituents—Active and inert constituents, metabolic pathways, chemistry and application of phytoconstituents, primary metabolic products, and bioactive compounds of primary metabolic origin. In *Therapeutic Use of Medicinal Plants and their Extracts: Volume 2: Phytochemistry and Bioactive Compounds* (pp. 25-164). https://doi.org/10.1007/978-3-319-92387-1_2

[5] Ansari, J. A., & Inamdar, N. N. (2010). The promise of traditional medicines. *International Journal of Pharmacognosy, 6*, 808-812. https://doi.org/10.3923/ijp.2010.808.812

[6] Bills, G. F., & Gloer, J. B. (2016). Biologically active secondary metabolites from the fungi. *Microbiology Spectrum, 4*(6), 10-1128. https://doi.org/10.1128/microbiolspec.FUNK-0009-2016

[7] Bolouri, P., Salami, R., Kouhi, S., Kordi, M., Asgari Lajayer, B., Hadian, J., & Astatkie, T. (2022). Applications of essential oils and plant extracts in different industries. *Molecules, 27*(24), 8999. https://doi.org/10.3390/molecules27248999

[8] Bourgaud, F., Gravot, A., Milesi, S., & Gontier, E. (2001). Production of plant secondary metabolites: a historical perspective. *Plant Science, 161*(5), 839-851. https://doi.org/10.1016/S0168-9452(01)00490-3

[9] Cushnie, T. T., Cushnie, B., & Lamb, A. J. (2014). Alkaloids: An overview of their antibacterial, antibiotic-enhancing and antivirulence activities. *International Journal of Antimicrobial Agents, 44*(5), 377-386. https://doi.org/10.1016/j.ijantimicag.2014.06.001

[10] Dambatta, S. H., & Aliyu, B. S. (2011). A survey of major ethno-medicinal plants of

Kano North, Nigeria, their knowledge and uses by traditional healers. *Bayero Journal of Pure and Applied Sciences, 4*(2), 28-34. https://doi.org/10.4314/bajopas.v4i2.6

[11] Duraipandiyan, V., Ayyanar, M., & Ignacimuthu, S. (2006). Antimicrobial activity of some ethnomedicinal plants used by Paliyar tribe from Tamil Nadu, India. *BMC Complementary and Alternative Medicine, 6*(35), 35-41. https://doi.org/10.1186/1472-6882-6-35

[12] Etkin, N. L., & Ross, P. J. (1982). Food as medicine and medicine as food: An adaptive framework for the interpretation of plant utilization among the Hausa of northern Nigeria. *Social Science & Medicine, 16*(17), 1559-1573. https://doi.org/10.1016/0277-9536(82)90167-8

[13] Jigam, A. A., Akanya, H. O., Dauda, B. E., & Ogbadoyi, E. O. (2011). Antiplasmodial, analgesic and anti-inflammatory effects of crude *Guiera senegalensis* Gmel (Combretaceae) leaf extracts in mice infected with *Plasmodium berghei*. *Journal of Pharmacognosy and Phytotherapy, 3*(10), 150-154. https://doi.org/10.5897/JPP11.033

[14] Mohammed, S. Y. (2013). Quantitative phytochemical and elemental analysis of *Guiera senegalensis* leaf extract. *Journal of Pharmacognosy and Phytotherapy, 5*(12), 204-207.

[15] Shittu, A. M., Ansar, B. A., Ushie, O. A., Ahmad, K. B., Abdullahi, J. A., & Nasir, A. M. (2022). Phytochemical screening of lettuce, spring onion and spinach cultivated at Farin Gada Farm Land. *Tropical Journal of Engineering, Science and Technology, 2*(1), 45-48.