

ISSN: 2790-9522 (Print) | 2790-9530 (Online)

Website: <https://journals.jozacpublishers.com/ajbcps/index> <https://doi.org/10.5281/zenodo.16928451>

Potential therapeutic agents from *Pterocarpus Osun* bioactive extracts: Isolation and characterization

Adewale Elijah Fadeyi^{1,2*}, Oluremi Isola Adeniran¹^{1,2}Department of Chemistry, University of Abuja, Nigeria.²Chemistry Advanced Research Centre, Sheda Science and Technology Complex, Abuja, Nigeria.*Correspondence: ae.fadeyi@shestco.gov.ng

Received: May 05, 2025 | Accepted: July 09, 2025 | Published: August 22, 2025

Abstract

In traditional African medicine, *Pterocarpus Osun* has found application in the treatment of several illnesses, such as cough, diarrhoea, eczema, and malaria. Examining the chemical components of the plant that give it its biological and therapeutic properties was the aim of this study. *Pterocarpus Osun* leaf and stem bark were extracted using ethyl acetate, methanol, and n-hexane. Extracts obtained were chromatographed on silica gel using column chromatography, yielding pure isolates. These isolates were identified and characterized using nuclear magnetic resonance, liquid chromatography/mass spectrometry, and Fourier transform infrared techniques. Six known pharmacologically and biologically active compounds: squalene, 9,12-Octadienoic acid methyl ester, maslinic acid, sitosterol, and stigmasterol are reported here as isolates from the leaf and stem bark of *Pterocarpus Osun*, probably for the first time, as there is little or no known information about these compounds ever being obtained from the plant.

Keywords: Column chromatography, Therapeutic, *Pterocarpus Osun*, Squalene, Spectroscopy

1. Introduction

Therapeutic plants are those that are utilized for medicinal purposes and have qualities that make them acceptable as medications and therapeutic agents. The production of modified derivatives with increased activity and decreased toxicity can be facilitated using biologically active chemicals derived from medicinal plants (Kinki, 2021).

2. Literature review

Around 80% of people worldwide, as reported by the World Health Organization (WHO), rely on herbal remedies for their primary healthcare (Maroyi, 2017). Plant-based treatments have high popularity today, especially in developing nations with inadequate access to basic healthcare. Rural as well as urban populations are embracing herbal medicines because they are more cost-efficient, safe, and effective (Ullah & Muhammad, 2018). Isolation of bioactive medicinal compounds from herbs as therapeutic agents has greatly benefited from information gathered from indigenous peoples

or practitioners of traditional medicine (Katewa et al., 2004). Medicinal plants are highly sought after for meeting basic healthcare needs in both industrialized and developing nations due to their extensive biological and therapeutic properties, higher safety margins, and lower costs (Venthodika et al., 2021). The WHO has advocated for nations to utilize herbal medicine over the years, capitalizing on secondary metabolites that offer efficient and secure treatments for diseases of both microbial and non-microbial origins (Nasrin, 2013). The abundance of several bioactive components, including minerals, phytochemicals, and other substances with pharmacological effects on humans and other animals, makes herbal medications effective in combating diseases (Oluchi et al., 2019). The production of modified compounds with improved activity and decreased toxicity can be facilitated by using biologically active molecules and lead structures derived from plants. Since the early 19th century, several bioactive phytoconstituents have been discovered and characterized. Many of these chemicals are mainstays of modern medicine or are used as building blocks for the creation of new drugs (Uddin & Zidorn, 2020).

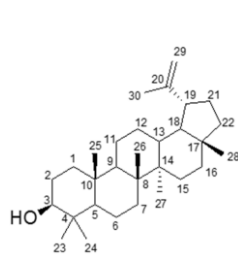
Most chemical drugs utilized in the pharmaceutical industry (70%) are derived from plants, animals, microorganisms, and marine environments, or are by-products of these sources. They are either naturally occurring products or biomimetic compounds based on natural products with heterocyclic ring systems of various kinds. According to Newman and Cragg (2016), 50% of anti-infective medications and 55% of cancer-fighting drugs originate from natural sources. Three notable advances in drug development in the natural product field include digitoxin discovery from *Digitalis purpurea*, used in the treatment of congestive cardiac failure; quinine from cinchona bark, used as a medication in the treatment of malaria; and pilocarpine from *Pilocarpus jaborandi* (which is used to treat cases of chronic open-angle glaucoma). An oral version of pilocarpine was authorized by the FDA in 1994 for the treatment of xerostomia, an adverse effect of radiation therapy for brain tumors. It can also be utilized to stimulate sweat glands to monitor salt and chloride concentrations (Dias et al., 2012). Various plant parts, including root, leaves, and bark, have been used traditionally in the treatment of a variety of ailments. The genus *Pterocarpus* exhibits a range of ethnopharmacological properties (Tchamadeu et al., 2011). In the review by Arbain et al. (2021), it was reported that the *Pterocarpus* species (about 46 known species, with only eleven of these comprehensively studied) currently lack comprehensive ethnopharmacology, phytochemistry, biological activity, and clinical data despite having tremendous therapeutic qualities. Hence, in this study, therapeutic compounds from the stem bark and the leaves of *Pterocarpus Osun* (PO) were isolated and characterized.

Table 1: Yield of extracts

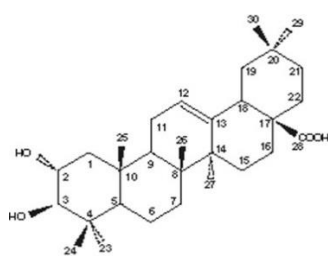
Extract	Weight (g)	%Yield
HL	22.610	2.261
EL	20.813	2.081
ML	47.163	4.716
Total yield for leaf	90.586	9.058
HB	7.8625	0.655
EB	15.525	1.293
MB	47.088	3.924
Total yield for stem bark	70.476	5.872

Key: **ML**- methanol leaf extract, **MB**- methanol stem bark extract, **EL**- ethyl acetate leaf extract, **EB**- ethyl acetate stem bark extract, **HL** - hexane leaf extract, **HB**- hexane stem bark extract.

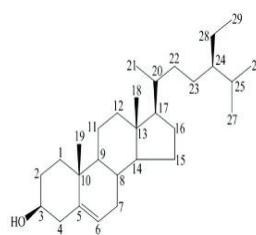
Functional group	C1 cm ⁻¹	C2 cm ⁻¹	C3 cm ⁻¹	C4 cm ⁻¹	C9 cm ⁻¹
OH stretch	3340	-	3310	3310	3325
C-H Sp ³	2920,	2952,	2914,	2914,	2915,
	2850	2847	2847	2847	2848
C=O carbonyl	1710	1735,	1732,	1730,	1731,
		1709	1716	1716	1716
CH ₂ , CH ₃	1462,	1462,	1472,	1462,	1363,
	1378	1379	1374	1362	1276
CO str	1239,	1239,	1212,	1212,	1047
	1032	1172	1046	1173	
C-C, C-H rock	882,	883,	728	943,	729
	719	719		729	



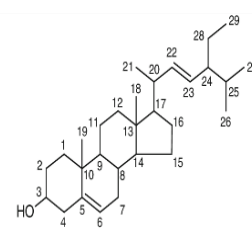
Lupeol



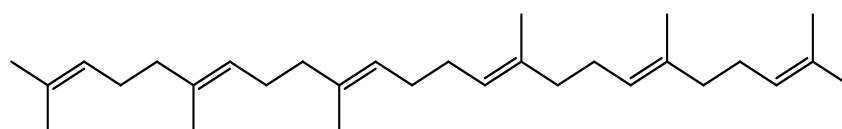
Maslinic acid



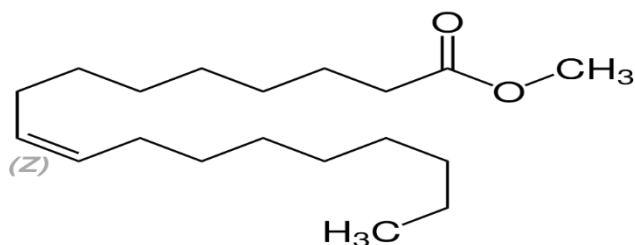
β-sitosterol



Stigmasterol



Squalene



Methyl (9Z)-octadec-9-enoate

Figure 1: Isolates from *Pterocarpus Osun*

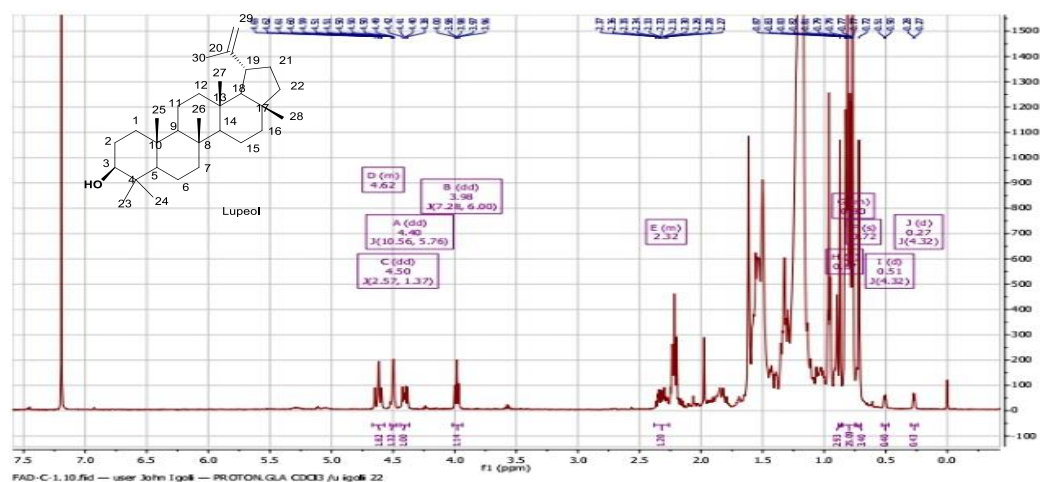


figure 2: Proton NMR of lupeol

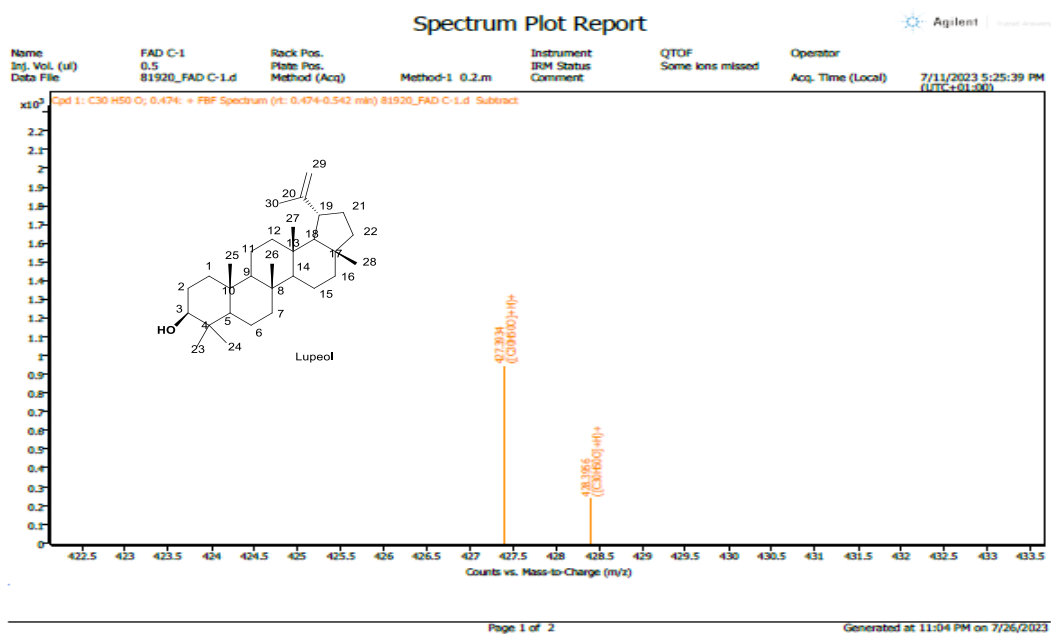


Figure 3: LCMS of compound C1 (Lupeol)

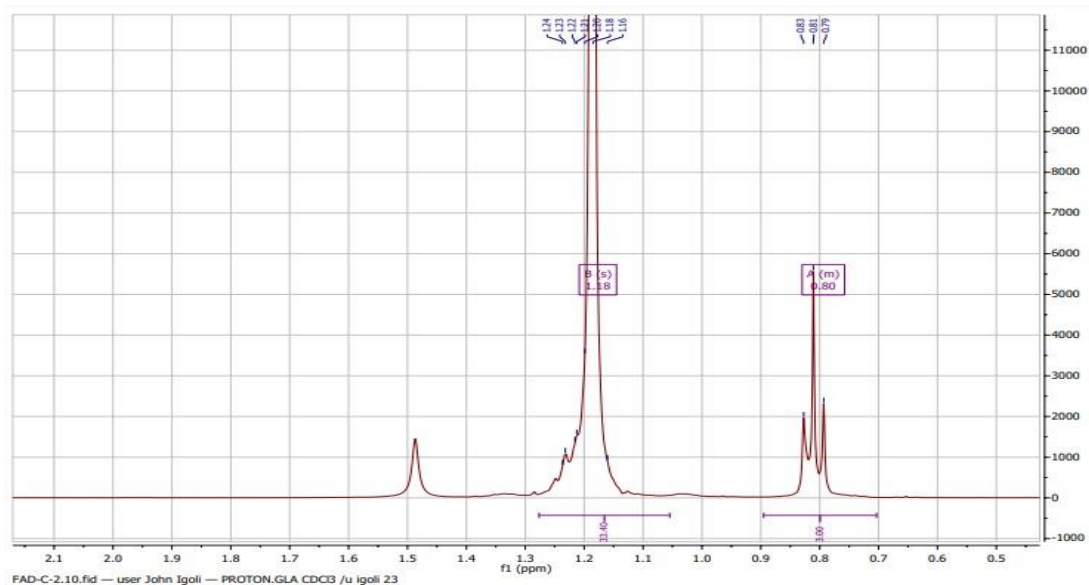


Figure 4: ^1H -NMR spectrum compound C2(Methyl (9Z)-octadec-9-enoate)

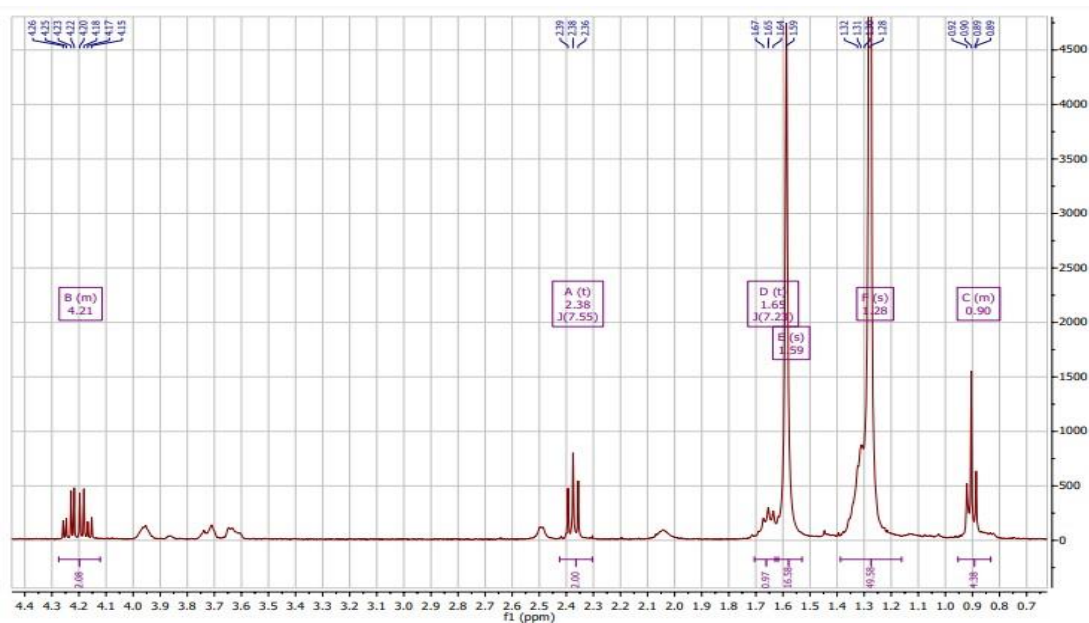


Figure 5: ^1H NMR of Compound C3 (Squalene)

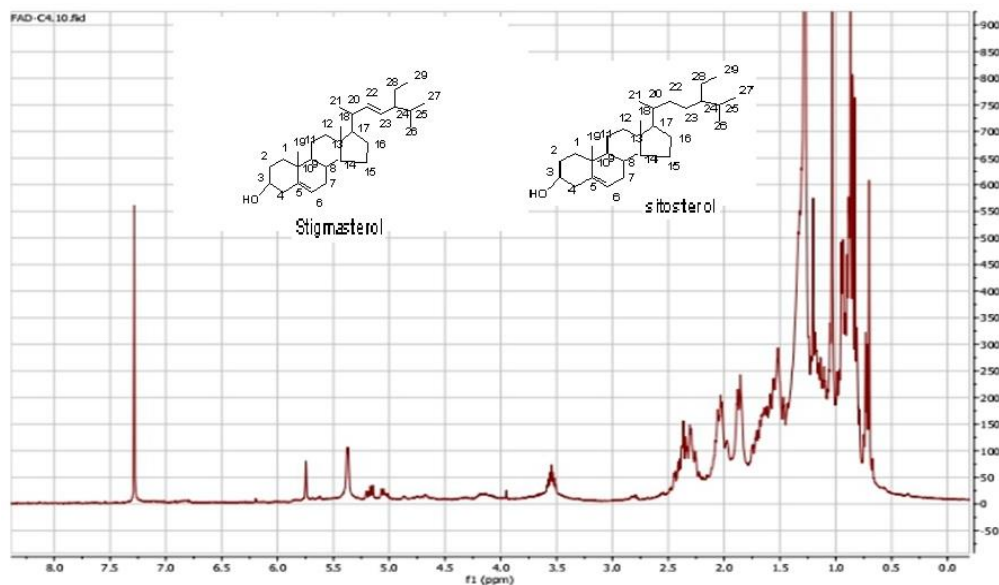


Figure 6: Proton NMR of compound C4 (mixed stigmasterol and sitosterol)

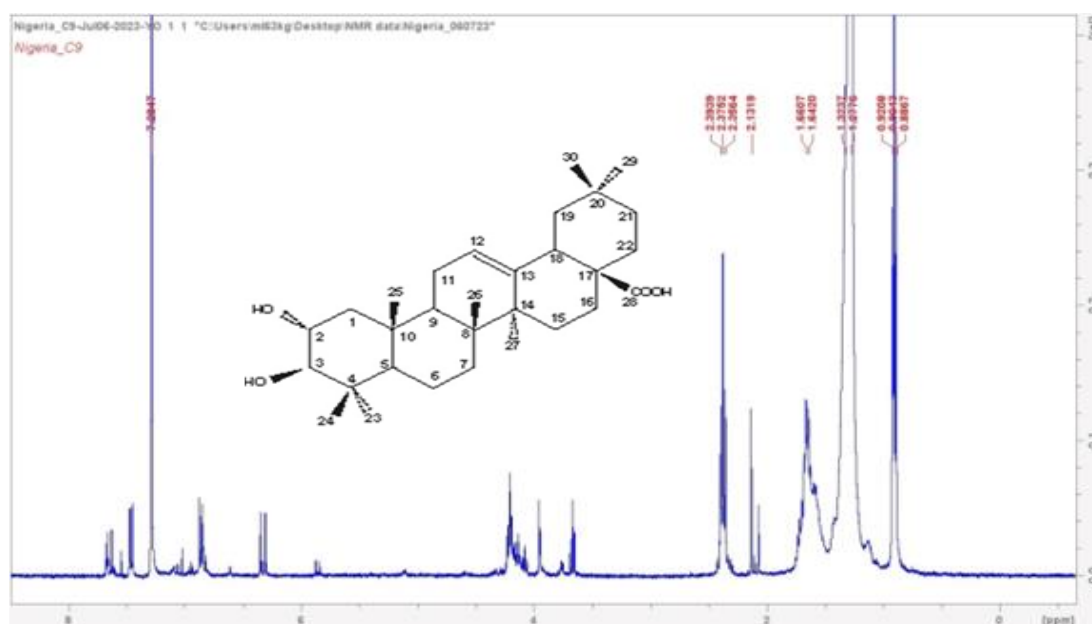


Figure 7: ¹H NMR spectrum of C9 (maslinic acid)

3. Research methodology

- Plant materials:** The plant was identified at the National Institute for Pharmaceutical Research and Development (NIPRD), located in Nigeria (herbarium number NIPRD/H/7251). Leaves and stem bark of PO were allowed to air dry for three weeks, and subsequently pulverised. The pulverised samples were stored for further use.
- Extraction:** Using n-hexane, ethyl acetate, and methanol as extracting solvents, cold maceration was the extraction method employed. The non-polar hexane was used as the starting solvent for the extraction, which was then followed by ethyl acetate and then methanol. After the successive extraction, the extracts were concentrated, and a rotary evaporator was used to

recover the solvents. After complete removal of solvents, the percentage yield was calculated thus:

$$\% \text{Yield} = \frac{\text{Weight dried extract (g)}}{\text{Weight of dried powdered sample (g)}} \times 100$$

The dried plant extracts were kept in the fridge until needed for further use.

Preliminary phytochemical screening, quantification, nutritional/antinutritional, and biological analyses of PO

Preliminary phytochemical screening, quantification, nutritional evaluation, and antioxidant analyses have been investigated and reported in our previous studies to determine the phyto-constituents, nutritional, and biological potentials of the leaf and stem bark of the PO (Fadeyi *et al.*, 2022; 2023).

- **Thin-layer chromatography analysis:** On a precoated silica gel (Merk. Co. Inc., Kiesel gel 60 F256) plate, the extracts were analysed via thin-layer chromatography (TLC) examination to identify the components present in each extract's fraction using a variety of solvent combinations in varying ratios. The spotted plates were sprayed with tetraoxosulphate VI acid in methanol (10%), which was then baked in an oven. Commercial-grade solvents and reagents were used.
- **Column chromatographic separation and isolation of organic compounds:** The extract fractions (8g each) were in turn subjected to rigorous column chromatographic analyses on silica gel as the stationary phase and step-by-step elution, first with 100% hexane and 100% ethyl acetate, respectively, and afterwards, ethyl acetate and n-hexane in varying volume combinations. Fractions from each method of extraction of the samples were pooled according to observed TLC values. The compounds obtained were purified by recrystallization.
- **Spectroscopic analyses:** Fourier transform infrared techniques (FTIR), proton nuclear magnetic resonance (¹H-NMR), carbon 13 NMR (¹³C-NMR), heteronuclear single quantum coherence spectroscopy (HSQC), correlated spectroscopy (COSY), gas chromatography/mass spectrometry (GC-MS), and liquid chromatography/mass spectrometry (LC-MS/MS) spectroscopic analyses were performed on the six compounds that were isolated from PO to characterize and elucidate them.

4. Results and discussions

The results of the preliminary studies done and reported earlier (Fadeyi *et al.*, 2022) revealed that PO contains alkaloids, flavonoids, saponins, tannins, steroids, phenols, terpenoids, and cardiac glycosides. Flavonoids and phenols are known to have anticancer, antioxidant, anti-inflammatory, antimicrobial, and anti-allergy potentials (Enechi *et al.*, 2016; Ombouma *et al.*, 2022). Tannins are recognized to aid in wound healing (Zheng *et al.*, 2022). Alkaloids have demonstrated the ability to lower stress and treat hypertension (Ain Q-U *et al.*, 2016). Saponins have antifungal, anti-tumor, and antiviral potentials (Sacramento *et al.*, 2023). Antioxidant attribute of the plant may be due to the content of phenols, flavonoids, and tannins content of the plant (Nahak & Sahu, 2010; Naco *et al.*, 2023). The yield of the fractions of extracts is reported in Table 1. For the leaf sample, the yield of the

samples was in the order: methanol crude fraction (4.716%)>n-hexane fraction (2.261%)>ethyl acetate fraction (2.081%). The FTIR analysis of the isolated compounds provided the functional groups present in each of the compounds. These are summarised in Table 2. The functional groups are notably present in the single bond region, double bond region, and the fingerprint region of their spectra. No significant absorption in the triple bond region. Figure 3 is the LC-MS spectrum of compound C1. As shown in Figure 1, the structures of the isolated compounds from the samples depict the presence of compounds which include Lupeol, Maslinic acid, β -sitosterol, Stigmasterol, squalene, and Methyl (9Z)-octadec-9-enoate. The NMR data provide valuable information about the chemical structure of the molecule. The chemical shifts give insights into the electron density and magnetic environment of each proton, while the coupling constants reveal the connectivity and interactions between protons in the molecule.

Compound C1 (Lupeol) was isolated from the *P. osun* leaf extract's ethyl acetate fraction using column chromatography. A white powder (93 mg; 0.44%) was yielded in 9.5Hex:0.5EtOAc, with a melting point of 214–216 °C and an R_f value of 0.580. The ^1H NMR is in Figure 2. Visible in the FTIR spectra (Table 2) are the OH absorption band (3429 cm^{-1}), sp^3 C-H stretching (2919 and 2860 cm^{-1}), C-O stretching (1042 cm^{-1}), and olefinic C=C (1638 cm^{-1}). In the LC-MS spectrum (Figure 3), observed at m/z 426, is a triterpenoid, found at the molecular ion peak $[\text{M}]^+$. This is in agreement with the $\text{C}_{30}\text{H}_{50}\text{O}$ chemical formula. The cleavage of ring C produced the base peak in the LC-MS spectra at m/z 189. In the ^1H NMR spectrum (Figure 2), seven angular tertiary methyl signals were observed at δ 0.78, 0.84, 0.89, 0.97, 0.99, and 1.05 (H-24, H-28, H-25, H-27, H-23, and H-26, respectively), alongside a signal of the isopropenyl proton. The olefinic protons, H-29, were identified by two singlets at δ 4.71 and 4.58, while the oxymethine proton, H-3, was identified by a doublet of doublets at δ 3.21 ($J=11.2\text{Hz}$ and 5.2Hz).

The literature-reported spectrum data supported the postulated identity of compound C1 as a triterpenoid with a secondary hydroxyl group at position 3 (Sharma & Gupta, 2022; Salleh et al., 2016; Petronelli et al., 2009). Consequently, the component C1 structure was determined to be 3β -lup-20(29)-en-3-ol. Compound C2(Methyl (9Z)-octadecyl-9-enoate), with formula $\text{C}_{19}\text{H}_{36}\text{O}_2$, with molecular mass 296.27 g/mol. The proton NMR result (Figure 4) shows that the 0.80 (m) ppm signal is a multiplet, suggesting that the proton experiences coupling with neighbouring protons, leading to a complex NMR signal. The 1.18 (s) ppm signal is a singlet, indicating that the proton does not have significant coupling with nearby protons and therefore appears as a single peak. The singlet signal at 3.68 ppm is due to the protons in the methoxy group ($-\text{OCH}_3$). The aliphatic chain methylene protons ($-\text{CH}_2-$) generated multiplet signals that ranged from 1.25 to 2.35 ppm. The olefinic protons ($-\text{CH}=\text{CH}-$) produced a signal measured between 5.30 and 5.95 ppm. Methyl (9Z)-octadec-9-enoate, (aka Methyl oleate), $\text{C}_{19}\text{H}_{36}\text{O}_2$, is a fatty acid methyl ester. It is useful as an anti-inflammatory agent and skin care ingredient (Ayoola et al., 2020; Mensah & Thompson, 2023).

Compound C3: $\text{C}_{30}\text{H}_{50}$ (Squalene) is a polyunsaturated hydrocarbon (triterpene) with a molecular mass of 410.39 g/mol. The proton NMR spectrum (Figure 5) indicates these spectra data: 2.38 (t) ppm, $J(7.55\text{ Hz})$; 4.21 (m); 0.90(m); 1.65(t), $J(7.23\text{ Hz})$; 1.59(s) $J(7.55\text{ Hz})$, 2.38 (t) ppm:4.21 ppm multiplet: six (6) olefinic proton resonances between δH 4.15 and 4.27 were identified in the ^1H NMR spectrum as belonging to H-3, 7, 11, 14, 18, and 22; ten (10) methylene proton resonances between δH 2.35 and δH 2.41; and eight (8) methyl groups between δH 1.28 and 1.69. Results from some research

demonstrated the specific bioactivities of squalene. Current drug-carrying, skin-hydrating, emollient, antioxidant, and detoxifying properties have been reported (Kim & Karadeniz, 2012). Compound C4 (Stigmasterol and β -sitosterol) was discovered that compounds C4a and b were a combination of two sterols. The proton NMR spectrum is in Figure 6. Compound C4 was separated using an eluting solvent of Hexane: Ethyl acetate (7:3) and needle-like white crystals with R_f values of 0.60 from the ethyl acetate portion of the stem bark of column chromatography. Typically, stigmasterol and β -sitosterol coexist. It is challenging to obtain pure forms of stigmasterol or β -sitosterol when they are found in mixtures (Okoro et al., 2018; Newman & Cragg, 2016; Chaturvedula, 2012).

The single bond of C22-C23 in β -sitosterol and the double bond of C22=C23 in stigmasterol are the primary differences between the two molecules. The proton NMR spectrum of compound (C4) ranges from 0.736 to 5.378 ppm. The spectrum shows six high-intensity peaks at δ 0.736, 0.843, 0.967, 1.037, 1.200, and 1.534 ppm, which correspond to six methyl groups; the proton associated with H-3 of a sterol moiety was seen as a doublet at δ 3.529 ppm; and only as a single signal at δ 5.197 ppm and δ 5.378 ppm, which suggests that there may be three protons near the ethylene protons. The literature suggests that β -sitosterol and stigmasterol are always present together, with the potential for a maximum concentration of stigmasterol. Pure stigmasterol is very difficult to obtain (Habib et al., 2007; Kamboj & Saluja, 2011; Okoro et al., 2018). Compound C4 was observed as a white, needle-like solid with a melting point of 147–149°C. The main difference between stigmasterol and β -sitosterol is that the former has a C22=C23 bond, while the latter has a C22-C23 bond.

The ^1H -NMR results showed a sharp similarity between β -sitosterol and stigmasterol, aside from the methylene group signals for H-22 and H-23 of β -sitosterol, which differed from the two olefinic proton signals of stigmasterol (Demgne et al., 2024; Pusparohmana et al., 2020). The chemical shifts for the stigmasterol methylene protons usually occur at δ 1.1-1.3 ppm in deuterated chloroform (CDCl_3). In contrast, the olefinic protons resonate in the ^1H NMR spectra of stigmasterol in CDCl_3 at δ 5.4–5.6 ppm. In Compound C9 (Maslinic acid), the proton NMR is shown in Figure 7. Starting with the proton H12, which yields a distinct characteristic triplet at δ 5.30 with a $2J$ (12,11) of 3.65 Hz due to interaction with protons H11a and H11b at δ 1.95/1.89, was the basis for the NMR assignment of maslinic acid. The proton H3 couples with the proton H2 at δ 3.95, resulting in a doublet appearance at δ 3.00 and a $2J$ (3,2) of 9.50 Hz.

5. The contribution of the study

Without a doubt, this study supports traditional medicine's veracity and advances the scientific hunt for novel natural medicinal formulations.

6. Research findings of the study

The leaves and stem bark of the medicinal plant *Pterocarpus osun*, which has been utilized by African traditional medicine practitioners for many years, yielded six substances with biological and therapeutic qualities that were identified and characterized.

7. Recommendations and suggestions

It is recommended that clinical studies be conducted, though the plant has been traditionally used by herbal medicine practitioners. Also, the tree should be preserved from extinction by woodworkers and other users.

8. Conclusion

Pterocarpus Osun's stembark and leaves yielded six chemical substances with medicinal potential that were separated and described. These are known compounds with biological and pharmacological activities and have been previously reported from some other plant sources; however, there is a dearth of information that their have been heretofore isolated, characterization, and reporting from the *Pterocarpus Osun* leaf and stembark of *Pterocarpus Osun*. Further studies are recommended to fully exploit the medicinal potential of the plant.

ORCID

Adewale Fadeyi^{} <https://orcid.org/0000-0001-7152-7131>

Oluremi Adeniran^{} <https://orcid.org/0000-0001-7235-6549>

References

1. Ain, Q. U., Khan, H., Mubarak, M. S., & Pervaiz, A. (2016). Plant alkaloids as antiplatelet agent: Drugs of the future in the light of recent developments. *Frontiers in pharmacology*, 7, 292.
2. Arbain, D., Saputri, G. A., Syahputra, G. S., Widiyastuti, Y., Susanti, D., & Taher, M. (2021). Genus *Pterocarpus*: A review of ethnopharmacology, phytochemistry, biological activities, and clinical evidence. *Journal of Ethnopharmacology*, 278, 114316.
3. Ayoola, A. A., Ekunseitan, D. A., Muhammad, S. B., Oguntoye, M. A., & Adejola, Y. A. (2020). Phytochemicals analysis and GC-MS determination of ethanolic extracts of *Azadirachta indica* and *Mangifera indica* stem bark and their biological potentials. *Pacific Journal of Science and Technology*, 21(1), 219-229.
4. Demgne, L. W., Eckhardt, P., Kianfé, B. Y., Tchuenguem, R. T., Dzoyem, J. P., Ponou, B. K., ... & Tapondjou, L. A. (2024). Two new steroids from the medicinal plant *Physalis peruviana* L. *Phytochemistry Letters*, 59, 5-9.
5. Dias, D. A., Urban, S., & Roessner, U. (2012). A historical overview of natural products in drug discovery. *Metabolites*, 2(2), 303-336.
6. Enechi, O. C., Mbahotu, A. C., & Ikechukwu, U. R. (2016). Antibacterial Study of Flavonoid Extract of *Peltophorum pterocarpum* Stem Bark.
7. Fadeyi, A. E., Adeniran, O. I., & Akiode, S. O. (2022). Nutrients, Phytochemical, Antioxidant and Antimicrobial Analysis of *Pterocarpus osun* stem bark and leaf for their nutritional, medicinal capacity. *Indonesian Journal of Chemical Research*, 10(1), 58-67.
8. Fadeyi, A., Adeniran, O. I., & Orishadipe, A. (2023). FTIR characterization, phytochemical, antibacterial, and antioxidant properties of *Pterocarpus Osun* stembark and leaf extracts. *Nigerian Journal of Science and Engineering Infrastructure*, 1(1).

9. Chaturvedula, V. S. P., & Prakash, I. (2012). Isolation of Stigmasterol and Sitosterol from the dichloromethane extract of *Rubus suavissimus*. *International current pharmaceutical journal*, 1(9), 239-242.
10. Katewa, S. S., Chaudhary, B. L., & Jain, A. (2004). Folk herbal medicines from tribal area of Rajasthan, India. *Journal of Ethnopharmacology*, 92(1), 41-46.
11. Kim, S. K., & Karadeniz, F. (2012). Biological importance and applications of squalene and squalane. *Advances in food and nutrition research*, 65, 223-233.
12. Kinki AB. (2021). A review on the production and uses of herbal teas. *Journal of Nutrition and Food Processing*, 4(2), 1-3.
13. Maroyi A. (2017). Diversity of use and local knowledge of wild and cultivated plants in the Eastern Cape province, South Africa. *Journal of Ethnobiology and Ethnomedicine*, 13, 1-16.
14. Mensah, J. K., & Thompson, P. T. (2023). Antioxidant, anti-microbial and anti-inflammatory activities of *Saba thompsonii* fruit extracts. *International Journal of Biological and Chemical Sciences*, 17(4), 1323-1340.
15. Naco, M. E. B., Tirera, H., Tangara, B. Y., Sarr, S. O., Fall, D., Diop, Y. M., ... & Diop, A. (2023). Therapeutic and nutritional potential of some samples of green tea consumed in the Dakar region of Senegal.
16. Nahak, G., & Sahu, R. K. (2011). Evaluation of antioxidant activity of flower and seed oil of *Azadirachta indica* A. juss. *Journal of Applied and Natural Science*, 3(1), 78-81.
17. Nasrin F. (2013). Antioxidant and cytotoxic activities of *Ageratum conyzoides* stems. *International Current Pharmaceutical Journal*, 2(2), 33-37.
18. Newman, D. J., & Cragg, G. M. (2016). Natural products as sources of new drugs from 1981 to 2014. *Journal of natural products*, 79(3), 629-661.
19. Okoro, I., Tor-Anyiin, T., Igoli, J., Noundou, X., & Krause R. (2018). Isolation and Characterisation of Stigmasterol and β -Sitosterol from *Anthocleista djalonensis* A. Chev. *Asian Journal of Chemical Sciences*, 3(4), 1-5.
20. Oluchi, I. M., Constance, O. N., Lilian, O. C. (2019). Phytochemicals and antibacterial activity of leaf and stem extracts of *Ageratum conyzoides* (linn) on some clinical isolates. *International Journal of Plant Science and Horticulture*, 1, 95-105.
21. Ombouma, J. G., Mebale, A. J. A., Abessolo, D. D. M., Mve, O. A., & Mboma, R. (2022). Phytochemical screening, total polyphenols and flavonoids content and antiradical activity of methanolic extract of *Lannea welwitschii* (Hiern) Engl. (Anacardiaceae) from Gabon. *International Journal of Biological and Chemical Sciences*, 16(1), 308-314.
22. Petronelli, A., Pannitteri, G., & Testa U. (2009). Triterpenoids as new promising anticancer drugs. *Anti-cancer drugs*, 20(10), 880-892.
23. Pusparohmana, W. R., Safitry, R. D., Marliana, E., & Kusuma, I. W. (2020). Isolation and characterization of stigmasterol and β -sitosterol from wood bark extract of *Baccaurea macrocarpa* Miq. Mull. Arg. *Rasayan Journal of Chemistry*, 13(4).
24. Sacramento, T. I., Anani, P. Y., Sangare, O. M., Dikpe, T., Kommy, B., & Ategbo, J. M. (2023). Etude ethnopharmacologique des plantes médicinales utilisées dans le traitement traditionnel de parasitoses gastro-digestifs des aulacodes d'élevage dans quelques départements du Bénin. *International Journal of Biological and Chemical Sciences*, 17(7), 2663-2676.

25. Salleh, W. M. N. H. W., Ahmad, F., Khong, H. Y., & Zulkifli, R. M. (2016). Chemical constituents and bioactivities from the leaves of *Beilschmiedia glabra* Kosterm (Lauraceae). *Marmara Pharmaceutical Journal*, 20(3), 401-407.
26. Sharma, D., & Gupta, N. (2022). Lupeol: an alternative approach towards cancer treatment. *J Phytopharmacol*, 11, 425-431.
27. Tchamadeu, M. C., Dzeufiet, P. D. D., Nana, P., Nougba, C. K., Tsofack, F. N., Allard, J., ... & Dimo, T. (2011). Acute and sub-chronic oral toxicity studies of an aqueous stem bark extract of *Pterocarpus soyauxii* Taub (Papilionaceae) in rodents. *Journal of Ethnopharmacology*, 133(2), 329-335.
28. Uddin, M. J., & Zidorn, C. (2020). Traditional herbal medicines against CNS disorders from Bangladesh. *Natural Products and Bioprospecting*, 10(6), 377-410.
29. Ullah, S., & Muhammad, N. (2018). Evaluation of informant consensus factor of medicinal plants used in Shamoza Valley SWAT, KPK, Pakistan. *IJMPNP*, 4(2), 1-7.
30. Venthodika, A., Chhikara, N., Mann, S., Garg, M. K., Sofi, S. A., & Panghal, A. (2021). Bioactive compounds of *Aegle marmelos* L., medicinal values and its food applications: A critical review. *Phytotherapy Research*, 35(4), 1887-1907.
31. Zheng, Y. Z., Deng, G., & Zhang, Y. C. (2022). Multiple free radical scavenging reactions of flavonoids. *Dyes and Pigments*, 198, 109877.



This article is licensed and distributed under a Creative Common [Attribution \(CC BY-SA 4.0\) International License](#). Copyright (c), 2025 by the author/s.