

Phytochemical characterization of *Irvingia gabonensis* (Aubry-Lecomte Ex o'rorke) Balil seeds: Insights into its bioactive compounds and potential nutraceutical, pharmaceutical and cosmetic applications

Unoh Florence Ben^{1*}, Monday Isaiah Akpanabiatu², Nsude Linus Odinakachukwu³, Samuel Adeyeye⁴, Egor PromiseUmet⁵

^{1,4,5}**Department of Science Laboratory Technology, University of Calabar, Calabar, Cross River State, Nigeria.**

²**Department of Biochemistry, Akwa Ibom State University, Ikot Akpeden, Mkpato Enin, Akwa Ibom State, Nigeria.**

³**State University of Medical and Applied Sciences, Igbo-Eno, Enugu State, Nigeria**

***Corresponding author: Email/Phone: pivot.platform@gmail.com/+2349050501852**

Abstract

The benefits of bush mango *Irvingia gabonensis* extends beyond its culinary importance, it possesses remarkable phytochemical properties. This highlights the need for further biochemical analysis, hence the present study aimed to conduct an extensive phytochemical screening of *I. gabonensis* seed using GC-MS profiling. Mature fruits were obtained from Watt market, a local market in Calabar, and were manually de-pulped to extract the seeds. The seeds were air-dried under shade at room temperature (25–30°C) for 14–21 days. The dried seeds were ground into fine powder using a mortar and pestle. The powder was stored in airtight, amber containers at 4°C to prevent oxidation and degradation before extraction. Following standard protocols, a combination of qualitative and quantitative phytochemical screening techniques was employed to detect the presence of key bioactive compounds such as alkaloids, flavonoids, tannins, phenolics, and terpenoids. Bioactive compounds were extracted using Soxhlet extraction with analytical-grade methanol (99.9%) as the solvent. The extract was filtered and concentrated using a rotary evaporator at 40°C under reduced pressure to prevent thermal degradation. Phytochemical screening data were analyzed using mean $\pm$ standard deviation values for triplicate experiments. GC-MS data were evaluated using relative peak area (%) to determine the major bioactive constituents. Results indicate a strong presence of saponins, terpenoids, and moderate presence of flavonoid, alkaloids, and phenols. GC-MS chromatographic analysis revealed a complex chemical composition comprising 20 distinct chromatographic peaks, detected compounds exhibited retention times ranging from 4.070 to 22.869 min, reflecting differences in their chemical properties and molecular characteristics. Among detected peaks, Peak 4, with a retention time of 8.610 min, was the predominant constituent, accounting for 74.777% of the total chromatographic peak area. This study concludes that *I. gabonensis* seed extract is a valuable source of bioactive compounds with significant nutritional, therapeutic, and industrial potential.

Keywords: Bioactive compounds, GC-MS profiling, *Irvingia gabonensis*, Pharmaceutical, Phytochemical.

INTRODUCTION

The increasing global interest in medicinal plants and their bioactive compounds has driven significant research into the phytochemical constituents of various botanicals. Among these, *Irvingia gabonensis*, commonly known as bush mango, has gained attention due to its nutritional, medicinal, and industrial applications [1]. Indigenous to West and Central Africa, bush mango is traditionally valued for its edible fruit and seed, often referred to as "ogbono," which is widely used in local cuisine and herbal medicine [2]. Beyond its culinary importance, research suggests that the seeds of *I. gabonensis* possess remarkable phytochemical properties, making them a valuable candidate for further biochemical analysis and therapeutic applications [3].

Phytochemicals are naturally occurring bioactive compounds e.g. flavonoids, alkaloids, tannins, phenolics, and essential oils, which exhibit antioxidant, antimicrobial, and anti-inflammatory activities [4]. Several studies have investigated the phytochemical composition of mango (*Mangifera indica*) varieties, revealing the presence of bioactive compounds with potential applications in food, pharmaceutical, and cosmetic industries [5,6]. However, research focusing specifically on *I. gabonensis* seed remains limited, particularly in the context of gas chromatography-mass spectrometry (GC-MS) profiling, which is a powerful analytical technique for identifying volatile and semi-volatile compounds [6].

GC-MS is widely used for phytochemical screening as it provides detailed insights into the molecular composition of plant extracts [7]. This technique has been instrumental in identifying bioactive compounds in various plant species, including mango and tamarind seeds, as well as their potential pharmacological

effects [8,9]. The identification of these compounds is crucial for understanding the potential therapeutic applications of plant-derived extracts. Previous studies on *I. gabonensis* have primarily focused on proximate composition and traditional medicinal uses, with limited emphasis on advanced analytical techniques such as GC-MS for comprehensive phytochemical profiling [10].

Given the increasing global demand for natural and sustainable sources of bioactive compounds, it is essential to explore underutilized plant species such as bush mango. The identification of bioactive phytochemicals in its seed could offer new opportunities for pharmaceutical and nutraceutical development [11]. Furthermore, the antioxidant and antimicrobial properties of *I. gabonensis* seed extracts have been reported, but there remains a need for a more detailed characterization of its volatile and semi-volatile constituents using GC-MS [12,13].

Additionally, previous studies have demonstrated that phytochemicals from mango species possess significant anti-inflammatory, anticancer, and antimicrobial activities, which suggests the potential of bush mango as a valuable source of therapeutic compounds [14,15]. The application of GC-MS profiling will provide an advanced approach to identifying these compounds and their possible contributions to health benefits. Research on bioactive compounds in various plant species has also highlighted their potential use in combating chronic diseases such as diabetes, cardiovascular disorders, and microbial infections ([16,17]. Given these findings, a comprehensive GC-MS analysis of *I. gabonensis* seed could uncover novel bioactive compounds that contribute to its pharmacological potential. This study aims to conduct an extensive phytochemical screening of *I. gabonensis* seed using GC-MS profiling.

MATERIALS AND METHOD

Sample Collection

Mature *I. gabonensis* fruits were obtained from Watt market, a local market in Calabar, Cross River State, Nigeria. The selection of mature fruits was based on morphological characteristics, such as size, weight, and color, ensuring uniformity and minimizing variability in phytochemical content [2]. To ensure sample authenticity, the botanical identity of the plant was confirmed by a qualified taxonomist at University of Calabar. Voucher of specimens were deposited at the institution's herbarium under the accession number [UNICAL/SAB/26/2025] for future reference.

Sample Preparation

The bush mango fruits were manually de-pulped to extract the seeds, seeds were washed with water to remove residual pulp and surface contaminants. The seeds were air-dried under shade at room temperature (25–30°C) for 14–21 days to prevent thermal degradation of bioactive compounds according to method of Krakowska-Sieprawska [18]. The dried seeds were ground into fine powder using a mortar and pestle. The powder was stored in airtight, amber containers at 4°C to prevent oxidation and degradation before extraction.

Phytochemical screening methods

A combination of qualitative and quantitative phytochemical screening techniques was employed to detect the presence of key bioactive compounds such as alkaloids, flavonoids, tannins, phenolics, and terpenoids. Standard protocols from Evans [19] were followed.

Qualitative phytochemical tests

Alkaloids (Mayer's test [20]): Ten milligram (10 mg) of the seed extracts was taken and dissolved in dilute hydrochloric acid, few drops of Mayer's reagent was added to the acidified extract. A white/creamy precipitate indicates the presence of alkaloids.

Flavonoids (Lead acetate test [21]): Ten milligram (10 mg) of the extract was dissolved in distilled water, a few drops of 10% Lead acetate solution ($\text{Pb}(\text{CH}_3\text{COO})_2$) were added to the extract. The appearance of a yellow or buff color precipitate indicates the presence of flavonoid.

Tannins (Ferric Chloride test [22]): Five milligram (5 mg) of extract was taken and 0.5 ml of 5% ferric chloride was added. The development of dark blueish black color indicates the presence of tannins.

Terpenoids (Salkowski test [23]): Take 1 ml of extract of each solvent and add 0.5ml of chloroform followed by a few drops of concentrated sulphuric acid. Formation of reddish-brown precipitate indicates the presence of terpenoids in extract.

Phenols (Lead acetate test [21]): A small amount of the concentrated plant extract was dissolved in distilled water, a few drops of 10% Lead acetate solution ($\text{Pb}(\text{CH}_3\text{COO})_2$) were added to the extract. A yellow or buff colored precipitate indicates the presence of phenols.

Saponins (Froth test [24]): A small amount of the concentrated extract was dissolved in distilled water in a Test tube, the test tube vigorously shaken for 15-30 seconds. The formation of stable foam that persists for several minutes indicates the presence of saponins.

Steroids (Liebermann-burchard test [25]): A small amount of the concentrated

extract was dissolved in chloroform or acetic anhydride, a few drops of concentrated sulfuric acid (H_2SO_4) were added to the solution. The appearance of green, blue or violet color indicates the presence of steroids.

Glycosides (Keller-kilian test [26]): A small amount of concentrated extract was dissolved in glacial acetic acid containing a trace amount of ferric chloride ($FeCl_3$), concentrated sulfuric acid (H_2SO_4) was carefully added down the side of the test tube. A blue-green color at the interface of the two later indicates the presence of deoxy sugars in cardiac glycosides.

GC-MS Analysis Procedure

Extraction of Bioactive Compounds

Bioactive compounds were extracted using Soxhlet extraction with analytical-grade methanol (99.9%) as the solvent. The extract was filtered and concentrated using a rotary evaporator at 40°C under reduced pressure to prevent thermal degradation [6].

Gas Chromatography-Mass Spectrometry (GC-MS) Protocol

The operational parameter

An Agilent 6890N gas chromatography equipped with an auto sampler connected to an Agilent Mass Spectrophotometric Detector was used according to methods of Buiarelli [27]. One microlitre of the sample was injected in the pulsed splitless mode onto a 30m x 0.25mm ID DB 5MS coated fused silica column with a film thickness of 0.15 micrometre. Helium gas was used as a carrier gas, and the column head pressure was maintained at 20psi to give a constant of 1 ml/min. Other operating conditions were preset. The column temperature was initially held at 55°C for 0.4min, increased to 200°C at a rate of 25°C/mins, then to 280°C at a rate of 8°C/mins and to a final temperature of 300°C at a rate of

25°C/mins, held for 2mins. The identification time was based on retention time. Components with lower retention time elute first before the ones of higher retention time

Data analysis techniques

The study utilizes descriptive and inferential statistical analyses to interpret the results. Phytochemical screening data were analyzed using mean $\pm$ standard deviation values for triplicate experiments. GC-MS data were evaluated using relative peak area (%) to determine the major bioactive constituents.

RESULTS

Phytochemical Composition of Bush Mango Seed

Qualitative phytochemical screening

The preliminary qualitative phytochemical tests confirm the presence of various bioactive compounds, as summarized in Table 1. Results revealed the presence of several bioactive secondary metabolites with potential biological significance. Saponins showed a strong presence (++), suggesting possible hypocholesterolemic and immunomodulatory effects. Terpenoids were also strongly detected (++), supporting their reported broad-spectrum antimicrobial and anti-inflammatory activities. Flavonoids and alkaloids were moderately present (+), indicating potential antioxidant, neuroprotective, and anti-inflammatory properties. Phenolic compounds were detected (+) and may contribute to antimicrobial activity and the mitigation of oxidative stress. However, tannins, steroids, and glycosides were not detected (-) under the standard qualitative screening conditions employed in this study. The results indicate a strong presence of saponins, terpenoids, and moderate presence of flavonoid, alkaloids, and phenols.

GC-MS profiling and identification of bioactive compounds

GC-MS chromatographic analysis of *I. gabonensis* seed extract in Table 2 revealed a complex chemical composition comprising 20 distinct chromatographic peaks, indicating the presence of diverse volatile and semi-volatile constituents. The detected compounds exhibited retention times ranging from 4.070 to 22.869 min, reflecting differences in their chemical properties and molecular characteristics. Among the detected peaks, Peak 4, with a retention time of 8.610 min, was the predominant constituent, accounting for 74.777% of the total chromatographic peak area and 100.00% of the corrected peak area, suggesting that it is the major bioactive component in the extract. The next most abundant constituents were represented by Peak 7 (5.711%) and Peak 3 (4.651%), while the remaining peaks individually contributed between 0.585% and 1.388% of the total chromatographic area. Peak heights also varied considerably, ranging from 951 to 60,005, with Peak 4 recording the highest value, further confirming its dominance. The wide variation in peak intensities and area percentages demonstrates that although the extract is dominated by one principal constituent, it also contains several minor compounds that may contribute synergistically to its biological, nutritional, and therapeutic activities. Overall, the chromatographic profile highlights the rich phytochemical composition of *I. gabonensis* seed extract and provides a strong basis for subsequent compound identification and functional characterization. The chromatogram, shown in Figure 1, displays distinct peaks representing different compounds.

Identified Compounds

The identified bioactive compounds are presented in Table 3. GC-MS analysis of *I. gabonensis* seed extract revealed a complex chemical profile comprising twenty identified volatile and semi-volatile compounds distributed across several chemical classes, including ketones, fatty acids, esters, alcohols, aldehydes, hydrocarbons, and furan derivatives. The major constituent was 2-tridecanone, accounting for 74.779% of the total composition, indicating its potential contribution to the biological activities of the seed extract. Other prominent compounds included tetradecanoic acid (5.711%), 3,4-furandiol, tetrahydro-, cis- (4.651%), and glycerin (0.723%).

Additional compounds such as n-hexadecanoic acid, dodecanoic acid esters, N-lauroyl-L-aspartic acid, and unsaturated aldehydes were also detected. These compounds are associated with diverse biological functions, including antioxidant, antimicrobial, anti-inflammatory, emollient, and nutritional properties. The presence of fatty acids and their derivatives highlights the potential value of *I. gabonensis* seeds as a source of functional lipids for nutraceutical and cosmetic applications.

The identification of ketones, polyols, and ester compounds further supports the potential versatility of the extract in pharmaceutical and industrial formulations. Overall, the GC-MS profile demonstrates that *I. gabonensis* seeds contain a rich array of bioactive compounds, providing scientific support for their traditional uses and potential applications in health, nutrition, and natural product development.

Table 1: Qualitative Phytochemical Composition of *I. gabonensis* Seed Extract

Phytochemical	Test Method	Observation	Inference
Alkaloids	Mayer's Test	Creamy precipitate	+
Flavonoids	Lead acetate test	Yellow precipitate	+
Saponins	Froth test	Stable froth formation	++
Tannins	Ferric chloride test	No greenish-black color change	-
Phenols	Lead acetate test	White precipitate	+
Terpenoids	Salkowski test	Reddish-brown interface	++
Steroids	Liebermann-Burchard test	No distinct colour change	—
Glycosides	Keller-Kiliani test	No reddish-brown ring formation	—

“+” indicates presence, “++” strong presence, “—” absence of phytochemical compound.

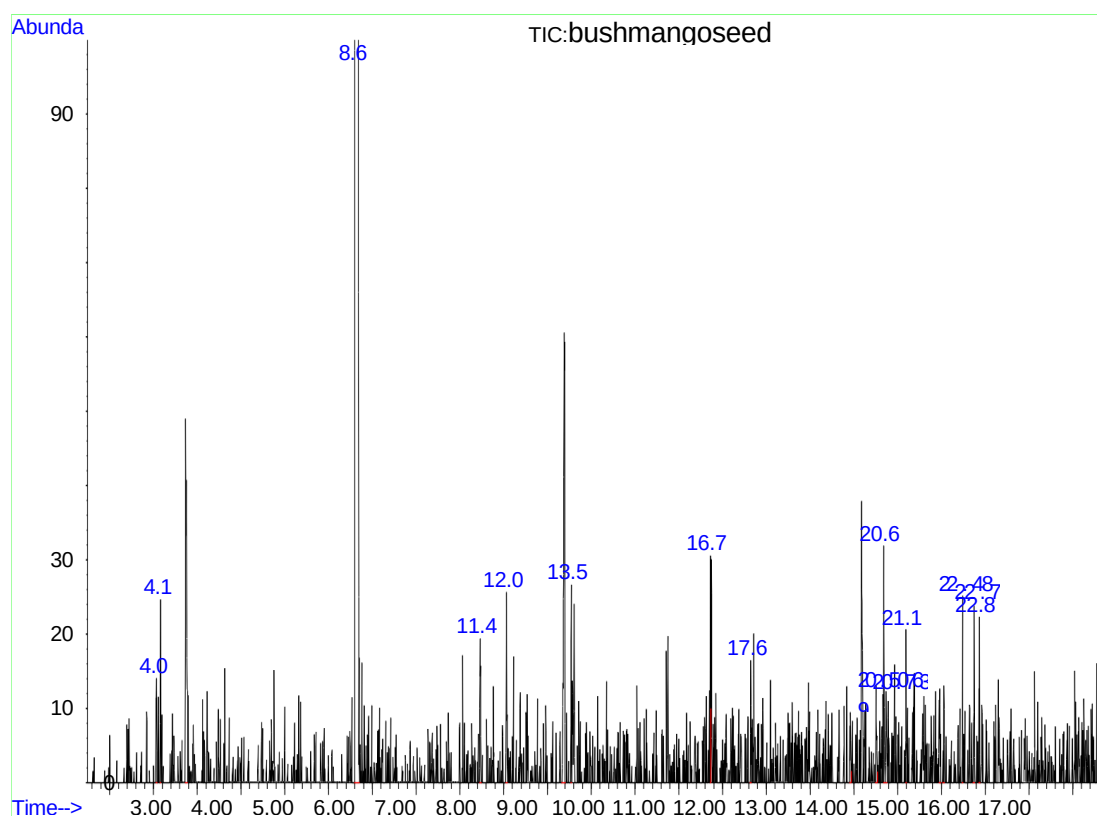


Figure 1: GC-MS Chromatogram of *I. gabonensis* seed extract (chromatogram showing peaks at different retention times)

Table 2. GC-MS Chromatographic Peak Characteristics of *Irvingia gabonensis* Seed Extract

peak #	R.T. first min	max last scan	PK scan	scan	TY	peak height	corr. area	corr. % max.	% of total
1	4.070	268	272	275	rBB	1409	1406	0.97%	0.723%
2	4.163	285	288	290	rBB	2471	1139	0.78%	0.585%
3	4.733	383	386	395	rBB	4904	9050	6.22%	4.651%
4	8.610	1048	1052	1069	rBB6	60005	145509	100.00%	74.779%
5	11.461	1538	1542	1547	rBB6	1945	2366	1.63%	1.216%
6	12.067	1641	1646	1650	rBB6	2569	2700	1.86%	1.388%
7	13.382	1862	1872	1877	rBB	6060	11112	7.64%	5.711%
8	13.545	1896	1900	1902	rBB	2668	1988	1.37%	1.022%
9	16.723	2444	2446	2448	rBV	3059	2076	1.43%	1.067%
10	17.642	2601	2604	2608	rBB	1651	1516	1.04%	0.779%
11	19.924	2991	2996	2999	rBV	951	1207	0.83%	0.620%
12	20.506	3092	3096	3102	rBV	1307	1473	1.01%	0.757%
13	20.680	3125	3126	3131	rBB	3191	2664	1.83%	1.369%
14	20.739	3132	3136	3140	rBB	1237	1412	0.97%	0.726%
15	21.193	3211	3214	3217	rBB	2066	1343	0.92%	0.690%
16	21.961	3342	3346	3351	rBB	1266	1854	1.27%	0.953%
17	22.054	3357	3362	3366	rBB	1308	1254	0.86%	0.644%
18	22.485	3433	3436	3438	rBB	2521	1204	0.83%	0.619%
19	22.747	3475	3481	3485	rBB	2380	1957	1.34%	1.006%
20	22.869	3498	3502	3505	rBB	2230	1356	0.93%	0.697%

Table 3. Bioactive Compounds Identified in Bush Mango Seed Extract (GC-MS Analysis)

No.	Name of Compound	Retention Time	Concentration (%)	Compound Group
1.	Glycerin	4.070	0.723	Polyol / Alcohol
2.	2-Undecanone	4.163	0.585	Ketone
3.	3,4-Furandiol, tetrahydro-, cis-	4.733	4.651	Diol / Furan Derivative
4.	2-Tridecanone	8.610	74.779	ketone
5.	Dodecanoic acid, 11-amino-, methyl ester	11.461	1.216	Amino fatty acid Ester
6.	Dodecanoic acid, but-3-enyl ester	12.067	1.388	Fatty Acid Ester
7.	Tetradecanoic acid	13.382	5.711	Saturated Fatty Acid
8.	n-Hexadecanoic acid	13.545	1.022	Saturated Fatty Acid
9.	N-Lauroyl-L-aspartic acid	16.723	1.067	Amino Acid Derivative / Fatty Amide
10.	Dimethylmalonic acid, octyl propyl ester	17.642	0.779	Dicarboxylic Acid Ester
11.	Adipic acid, ethyl 2-heptyl ester	19.924	0.620	Dicarboxylic Acid Ester
12.	Benzene, (trichloromethyl)-	20.506	0.757	Halogenated Aromatic Compound
13.	Dodecanoic acid, cyclohexyl ester	20.680	1.369	Fatty Acid Ester
14.	9,12-Octadecadienal	20.739	0.726	Unsaturated Aldehyde/Fatty Aldehyde
15.	E-1,6-Undecadiene	21.193	0.690	Alkene / Hydrocarbon
16.	1,12-Tridecadiene	21.961	0.953	Alkene / Hydrocarbon
17.	1,15-Pentadecanediol	22.054	0.644	Diol / Alcohol
18.	DL-Glyceraldehyde, dimethyl ether	22.485	0.619	Ester / Aldehyde
19.	Triethylene glycol	22.747	1.006	Polyether / Alcohol
20.	Ethane, 1-methoxy-2-(methoxymethoxy)-	22.869	0.697	Ester

DISCUSSION

The phytochemical and GC-MS analysis of *I. gabonensis* seed revealed some complex chemical profile rich in biologically significant secondary metabolites and volatile organic compounds. These findings provide substantial evidence for the plant's traditional and potential therapeutic, nutritional, and cosmetic application. The results of this study corroborate existing research [2,28] on the phytochemical composition and bioactive properties of *I. gabonensis* seed extract. The qualitative phytochemical screening revealed a

significant presence of flavonoids, phenols, saponins, alkaloids, and terpenoids, which are known for their antioxidant, anti-inflammatory, and antimicrobial properties. This aligns with the findings of Chukwuemeka [2,29], who reported similar phytochemical constituents in bush mango seeds. Although tannins, steroids, and glycosides were not detected, the bioactivity demonstrated by the presence of the compounds remains highly significant, especially considering the synergy often observed among polyphenols, flavonoids, and terpenes in plant matrices.

The GC-MS analysis revealed the presence of twenty (20) volatile and semi volatile constituents, with 2-tridecanone being the most abundant compound. Its dominance in the seed extract suggests a central role in the seed's biological activity and potential utility in antimicrobial formulations and cosmetic product [10]. Others notable compounds such as tetradecanoic acid, and n-Hexadecanoic acid, saturated fatty acids, are known for their antimicrobial, anti-inflammatory, and skin-conditioning properties as corroborated by Patil & Biranje [30]. 3,4-furandiol, tetrahydro-cis, a furan derivative, contribute antioxidant properties, potentially enhancing the free radical scavenging potential of the extract. Fatty acid esters, such as Dodecanoic acid esters, have been identified in previous studies [31] to contribute to emollient and moisturizing effects. These findings are consistent with those of Ramya [7]. The presence of these fatty acids is particularly significant, as linoleic acid, and oleic acid, are well-documented for their cardio protective, anti-inflammatory, and skin-regenerative properties [6].

Compared to previous studies, this research provides a more comprehensive GC-MS profile, identifying bioactive compounds with high pharmaceutical and nutritional value. Earlier studies [12] focused primarily on the proximate composition and nutritional aspects of bush mango seed, highlighting its high protein and lipid content but lacking detailed bioactive compound profiling. This study builds upon their findings by identifying specific, ketone, fatty acid, and their esters, diols, alcohols and polyethers thereby enhancing the scientific understanding of the seed's nutraceutical potential. Furthermore, this study expands on the work of

Maharaj [16] by linking the bioactive components of *I. gabonensis* to potential pharmaceutical applications, thereby bridging the gap between nutritional and medicinal research on bush mango seeds.

A major strength of this study lies in its dual approach, combining phytochemical screening and GC-MS profiling to provide a holistic evaluation of the bioactive potentials of *I. gabonensis* seeds. Unlike previous studies that primarily focused on either phytochemical screening or nutritional composition, this study integrates both methods, offering a broader perspective on its applications in food, pharmaceuticals, and cosmetics. These findings not only validate previous research but also introduce new insights into the synergistic effects of identified bioactive compounds, which could be further explored in clinical and industrial applications. The findings of this study have significant implications for the food and pharmaceutical industries, particularly in the areas of functional food development, dietary supplements, and natural therapeutics.

The presence of terpenoids, phenolic, and flavonoids observed in *I. gabonensis* seed extract suggests that it could serve as anti-inflammatory, and natural antioxidant source, which is crucial in preventing oxidative stress-related diseases such as cardiovascular disorders, neurodegenerative diseases, and certain cancers. The strong antioxidant properties of terpenoids, flavonoids and phenolics make them valuable for food preservation, as they help prevent lipid oxidation in food products, thereby extending shelf life and enhancing nutritional value. This aligns with previous research by Torres-León [12], who emphasized the role of phenolic compounds in improving food stability and quality.

Study also agrees with a recent study [32] which established haematotoxicity ameliorating effect of flavonoid from bitter leaf on albino rats.

In addition to its nutritional benefits, the high concentration of 2-Tridecanone, phenols, and fatty acid attributed antimicrobial activities, makes bush mango seed oil a viable alternative to conventional vegetable oils. the essential fatty acids that contribute to heart health, lipid metabolism, and skin barrier function, making them ideal for use in nutraceutical formulations and skincare products. The presence of saponins, which are known for their immunomodulatory and cholesterol-lowering effects, further strengthens the potentials of *I. gabonensis* in the development of functional foods aimed at managing hyperlipidemia and metabolic disorders. These findings support earlier studies [11], which suggested that plant sterols could be incorporated into functional food products to aid in cholesterol reduction and cardiovascular health.

The pharmaceutical applications of bush mango seeds are equally promising. The detection of phytosterols and essential fatty acids suggests potential use in the formulation of anti-inflammatory, anti-diabetic, and cholesterol-lowering drugs. Several studies [7] have indicated that plant-based sterols can modulate lipid metabolism and enhance immune responses, making them beneficial for the management of chronic diseases such as diabetes and cardiovascular disorders. Furthermore, the antioxidant-rich composition of bush mango seed extract makes it an excellent candidate for pharmaceutical formulations targeting oxidative stress and inflammation-related conditions.

Beyond food and pharmaceuticals, the cosmetic and skincare industry could

also benefit from the bioactive properties of *I. gabonensis*. The high content of fatty acids suggests potential applications in moisturizing creams, anti-aging formulations, and wound-healing products. These fatty acids play a crucial role in maintaining skin hydration, elasticity, and protection against UV damage, making bush mango seed oil a valuable ingredient in natural skincare formulations. This aligns with findings from Maharaj [16], who highlighted the role of plant-based oils in enhancing skin health and preventing premature aging.

In conclusion, the high bioactive potential of *I. gabonensis* seed extract suggests wide-ranging applications in nutrition, medicine, and cosmetics. Its ability to provide natural antioxidants, essential fatty acids, and sterols makes it a sustainable and valuable resource in addressing health and wellness challenges globally. Future explorations into its bioavailability, stability, and commercial viability could further enhance its impact on health, nutrition, and industry.

CONCLUSION

This study concludes that *I. gabonensis* seed extract is a valuable source of bioactive compounds with significant nutritional, therapeutic, and industrial potential. The detection of phenolic compounds and flavonoids suggests strong antioxidant activity, which may contribute to protection against oxidative stress-related disorders, including cardiovascular diseases and other chronic conditions. The combined phytochemical screening and GC-MS profiling provided a comprehensive characterization of the seed extract, highlighting its nutraceutical importance beyond traditional applications.

The identification of bioactive sterols, particularly stigmasterol and β -

sitosterol, further supports its potential in cholesterol regulation, lipid metabolism, and inflammation management. These findings indicate promising applications in functional foods, dietary supplements, pharmaceuticals, and cosmetic formulations. However, further investigations involving bioavailability studies, in vivo experiments, clinical validation, and safety assessments are

required to confirm its therapeutic efficacy.

Overall, the findings provide scientific evidence supporting the commercial utilization of *I. gabonensis* seed extract as a sustainable plant-based resource for developing natural health products and therapeutic interventions. Further research into compound interactions and long-term effects will enhance understanding of its full biological potential.

REFERENCES

1. Hassan, Y. R., El-Shiekh, R. A., El Hefnawy, H. M., & Michael, C. G. (2024). *Irvingia gabonensis* baill.(African Mango): A comprehensive review of its ethnopharmacological significance, unveiling its long-standing history and therapeutic potential. *Journal of Ethnopharmacology*, 117942.
2. Chukwuemeka, I. S., Chizoruo, I. F., & Ugochukwu, I. W. (2020). Phytochemical screening, Gas chromatography mass spectroscopy studies and antioxidant property of aqueous extract of Ogbono (*Irvingia gabonensis*). *J. Med. Plants Res.*, 8(6), 1-5.
3. Sunday, E. A., Nnedimma, N. C., Peter, W. G., & Orlando, G. B. (2021). Phytochemistry and Antioxidant Activity of *Irvingiagabonensis* (Bush mango) Seed Sample. *Asian Journal of Biochemistry, Genetics and Molecular Biology*, 7(4), 25-34.
4. Maldonado-Celis, M. E., Yahia, E. M., Bedoya, R., Landázuri, P., Loango, N., Aguillón, J. & Guerrero Ospina, J. C. (2019). Chemical composition of mango (*Mangifera indica* L.) fruit: *Nutritional and phytochemical compounds*. *Frontiers in plant science*, 10, 1073.
5. Albrahim, J. S., El-Fakharany, E. M., El-Gendi, H., Saleh, A. K., & El-Maradny, Y. A. (2025). Therapeutic perspectives of *Mangifera indica* L. peel extract: phytochemical profile, antimicrobial, anticancer, and antiviral efficacy. *Biomass Conversion and Biorefinery*, 1-24.
6. Ballesteros-Vivas, D., Álvarez-Rivera, G., Morantes, S. J., del Pilar Sánchez-Camargo, A., Ibáñez, E., Parada-Alfonso, F., & Cifuentes, A. (2019). An integrated approach for the valorization of mango seed kernel: Efficient extraction solvent selection, phytochemical profiling and antiproliferative activity assessment. *Food Research International*, 126, 108616.
7. Ramya, S., Chandran, M., King, I. J., Jayakumararaj, R., Loganathan, T., Pandiarajan, G. & Dhakar, R. C. (2022). Phytochemical Screening, GCMS and FTIR Profile of Bioactive Compounds in *Solanum lycopersicum* Wild Fruits collected from Palani Hill Ranges of the Western Ghats. *Journal of Drug Delivery and Therapeutics*, 12(6), 56-64.
8. Sangeetha, K., Swaminathan, C., Subramanian, E., Sivasankari, B., & Kannan, P. (2023). Influence of tree botanicals on seed germination and enzyme activity in blackgram (*Vigna mungo* L.) and cowpea

- (*Vigna unguiculata* L.). *Allelopathy Journal*, 59(1).
9. Kamble, V. A., Somkuwar, D. O., & Wankhade, S. J. (2016). Chemical composition, antioxidant and antisalmonella activity of *Mangifera indica* L. flower and seed kernel extracts. *International Current Pharmaceutical Journal*, 5(10), 82-93.
 10. Anake, A. (2023). Chemical composition of *Irvingia gabonensis* seed oil and its nutritional potential on streptozotocin-induced adult Wistar rats. *Int Res J. Edu and Tech*, 5(6), 368-381.
 11. Abubakar, A., Shagal, M. H., & Milan, C. (2024). Isolation and Characterisation of Essential oils of Mango (*M. indica*) Leave. *Biology, Medicine, & Natural Product Chemistry*, 13(1), 1-6.
 12. Torres-León, C., Correia, M. T. D. S., Carneiro-Da-Cunha, M. G., Serna-Cock, L., Ventura-Sobrevilla, J., Ascacio-Valdés, J. A., & Aguilar, C. N. (2021). Mango seed byproduct: A sustainable source of bioactive phytochemicals and important functional properties. In *Bioprocessing of Agri-Food Residues for Production of Bioproducts* (pp. 33-60). Apple Academic Press.
 13. Kabbashi, A. S. A. (2022). Biological Activities and Phytochemical Analysis of Some Selected Medicinal plants (Doctoral dissertation, International University of Africa).
 14. Selim, D. A., Eldin, S. M. S., González, F. P., Ghareeb, D. A., & Shawky, E. (2024). Metabolomics and chemometrics-driven valorisation of mango leaves: Unveiling putative α -amylase and α -glycosidase inhibitory metabolites. *Food Bioscience*, 61, 104652.
 15. Khanum, Z., Tiznado-Hernández, M. E., Ali, A., Musharraf, S. G., Irshad, R., Nizamani, Z. A., & Khan, I. A. (2020). Cytotoxic Evaluation of Antioxidant and Gamma-Amino Butyric Acid (GABA) Enriched Mango (*Mangifera indica* cv. Chaunsa) Mesocarp Extract on HER2-Positive Breast Cancer Cells. *Journal of the Chemical Society of Pakistan*, 42(6).
 16. Maharaj, A. (2021). Morphology, phytochemistry, and medicinal properties of South African *Mangifera indica* L. leaves for summer and winter seasons (Doctoral dissertation).
 17. Dar, M. S., Dholakia, B. B., Puneekar, S. A., Gupta, V. S., & Giri, A. P. (2023). Volatile Profiles of Mango (*Mangifera indica* L.) Fruits from Natural Accessions and Cultivated Alphonso. *Proceedings of the National Academy of Sciences, India Section B: Biological Sciences*, 93(3), 659-667.
 18. Krakowska-Sieprawska, A., Kielbasa, A., Rafińska, K., Ligor, M., & Buszewski, B. (2022). Modern methods of pre-treatment of plant material for the extraction of bioactive compounds. *Molecules*, 27(3), 730.
 19. Evans, W. C. (2009). *Trease and Evans' pharmacognosy*. Elsevier Health Sciences. Trease & Evans (2002)
 20. Hadi, S., & Bremner, J. B. (2001). Initial studies on alkaloids from Lombok medicinal plants. *Molecules*, 6(2), 117-129.
 21. Niaz, M., Abrar, H., Ashfaq, S., Khan, N., Awais, M., e Baseerat,

- N., ... & Ullah, K. (2024). Qualitative phytochemical analysis and in vitro antibacterial activity of Punica Granatum. *Phytopharmacology Research Journal*, 3(1), 31-38.
22. Auwal, M. S., Saka, S., Mairiga, I. A., Sanda, K. A., Shuaibu, A., & Ibrahim, A. (2014). Preliminary phytochemical and elemental analysis of aqueous and fractionated pod extracts of *Acacia nilotica* (Thorn mimosa). In *Veterinary research forum: an international quarterly journal* (Vol. 5, No. 2, p. 95).
23. Patel, M. R., Panchal, H. S., & Saluja, A. K. (2016). Identification of terpenoids and steroidal compounds in *Caryota urens* leaves by column chromatography and various spectroscopic techniques. *World J Pharm Pharm Sci*, 5(5), 1610-22.
24. Usman, H., Abdulrahman, F. I., & Usman, A. (2009). Qualitative phytochemical screening and in vitro antimicrobial effects of methanol stem bark extract of *Ficus thonningii* (Moraceae). *African Journal of Traditional, Complementary and Alternative Medicines*, 6(3).
25. Nath, M. C., Chakravorty, M. K., & Chowdhury, S. R. (1946). Liebermann-Burchard reaction for steroids. *Nature*, 157(3978), 103-104.
26. Kyembeni, C., & Kangethe, S. (2025). Phytochemical profile of *jatropha curcas* leaves and stem bark extracts from Mwingi Sub-County, Kitui, Kenya.
27. Buiarelli, F., Di Filippo, P., Pomata, D., Riccardi, C., & Bartocci, M. (2017). A liquid chromatography tandem mass spectrometry method for simultaneous analysis of 46 atmospheric particulate-phase persistent organic pollutants and comparison with gas chromatography/mass spectrometry. *International Journal of Environmental Analytical Chemistry*, 97(9), 797-818.
28. Akano, O. P., Akinsomisoye, O. S., & Ayoka, A. O. (2024). Antioxidant and phytochemical profile of crude ethanol extract and fractions of *Irvingia gabonensis* (Aubry-Lecomte ex O'Rorke) baill seed. *Ajayi Crowther Journal of Pure and Applied Sciences*, 3(1).
29. Etim, D. O., Bassey, R. A., Imalele, E. E., & Gbaji, M. N. (2026). Synergistic potential of *Leucaena leucocephala* leaf extract and *Trichoderma reesei* in managing *Meloidogyne arenaria* on cowpea. *Dutse Journal of Pure and Applied Sciences*, 12(2c), 86-100.
30. Patil, A., & Biranje, S. (2022). Biochemical characterization of *Ophiocordyceps nutans* (Pat.) GH Sung. JM Sung, Hywel-Jones and Spatafora. *Anvesak*, 52, 70-83.
31. Nasution, R., Zahwari, F., Bahi, M., Bastian, R. A., & Marianne, M. (2026). Hexane Extract from Squirrel-Tail Palm Fruit (*Wodyetia bifurcata*) as a Moisturizing Cream: Phytochemical Profile, Formulation, and Evaluation. *Malacca Pharmaceutics*, 4(2), 55-65.
32. Ben, Unoh Florence, and Chinyere Osondu Anyanwu. (2024). "Effects of the Anti-Inflammatory Properties of Bitter Leaf (*Vernonia Amygdalina*) Ethanolic Extract on *Streptococcus Pyrogenes* Induced Wister Rats". *Asian Journal of Biochemistry, Genetics and Molecular Biology* 16 (9):59-71.