



**Phytochemical and Proximate Composition of *Cymbopogon citratus*, *Vernonia amygdalina*, and *Garcinia kola* and Their Antimicrobial Activity Against Selected Bacterial Pathogens**

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**Abstract**

The aim of this study was to evaluate the phytochemical and proximate composition, mineral content, and antimicrobial activity of three medicinal plants commonly used in West African traditional medicine: *Cymbopogon citratus* (lemon grass), *Vernonia amygdalina* (bitter leaf), and *Garcinia kola* (bitter kola). Ethanolic and hot aqueous extracts of the plant materials were prepared and tested against three clinically relevant bacterial pathogens: *Staphylococcus aureus*, *Escherichia coli*, and *Pseudomonas aeruginosa*, using standard agar well diffusion methods. Phytochemical screening revealed the presence of bioactive secondary metabolites including alkaloids, flavonoids, tannins, phenols, and saponins. Proximate and mineral analyses showed notable variations: *Vernonia amygdalina* had the highest crude fibre content ( $26.21 \pm 0.15$  %), while *Cymbopogon citratus* was rich in calcium/magnesium ( $114.90 \pm 2.32$  mg/100 g) and phosphorus ( $328.66 \pm 0.40$  mg/100 g). Antimicrobial testing demonstrated that all extracts exhibited inhibitory activity, with ethanol extracts generally producing larger zones of inhibition than aqueous extracts. *Garcinia kola* showed strong activity against *Pseudomonas aeruginosa*, and *Cymbopogon citratus* was most effective against *Staphylococcus aureus*. These findings confirm the therapeutic potential of the studied plants and highlight their value as sources of bioactive compounds for developing alternative antimicrobials, particularly against drug-resistant bacteria. It is recommended that further studies, including in vivo testing and compound isolation, be conducted to validate their pharmacological efficacy and safety for medicinal applications.

**Keywords:** Phytochemical composition, antimicrobial activity, proximate analysis, mineral content, medicinal plants

**Introduction**

Medicinal plants have long been recognized for their rich phytochemical compositions and therapeutic potentials, particularly in traditional medicine systems across Africa and Asia [1–2]. Among these, *Cymbopogon citratus* (lemon grass), *Vernonia amygdalina* (bitter leaf), and *Garcinia kola* (bitter kola)

have attracted significant attention due to their antimicrobial, antioxidant, and nutraceutical properties [3–4]. Previous studies have reported that these plants contain bioactive compounds such as alkaloids, flavonoids, tannins, saponins, and phenolic compounds, which are associated with broad-spectrum antimicrobial activity [5–8]. For example, flavonoids are known to disrupt microbial membranes, while saponins can interfere with bacterial cell wall integrity [8].

Specifically, *Vernonia amygdalina* has been documented to inhibit the growth of both Gram-positive and Gram-negative bacteria and is traditionally used in West Africa for its antidiabetic and antimicrobial effects [9–10]. *Garcinia kola* exhibits antimicrobial and anti-inflammatory properties, largely attributed to its flavonoid and biflavonoid content [11]. *Cymbopogon citratus* has also shown antimicrobial and antioxidant activity due to its essential oils and phenolic compounds [12]. While these studies provide important insights, most focus on individual plants, limited bacterial strains, or qualitative phytochemical screening. Moreover, few studies in West Africa have simultaneously assessed phytochemical composition, proximate and mineral content, and antimicrobial activity in the same experimental framework. This knowledge gap limits a holistic understanding of the nutritional, pharmacological, and therapeutic potential of these plants.

The increasing prevalence of antibiotic-resistant pathogens highlights the urgent need for alternative antimicrobial agents from natural sources. Evaluating both the chemical composition and antimicrobial efficacy of these plants provides essential baseline data that can support the development of plant-based therapeutics and functional foods.

The aim of this study is to evaluate the phytochemical constituents, proximate and mineral compositions, and antimicrobial activities of *Cymbopogon citratus*, *Vernonia amygdalina*, and *Garcinia kola* against selected bacterial pathogens.

The objectives are:

1. To determine the phytochemical constituents of the selected plants.
2. To assess the proximate and mineral composition of the plant materials.
3. To evaluate the antimicrobial activity of ethanolic and aqueous extracts against *Staphylococcus aureus*, *Escherichia coli*, and *Pseudomonas aeruginosa*.
4. To compare the antimicrobial efficacy of the plant extracts and identify the most potent candidates for potential therapeutic applications.

## Experimental

### Chemicals and Reagents

All chemicals and reagents used were of analytical grade and sourced from reputable suppliers. These included 95% ethanol, distilled water, Mayer's reagent, Ferric chloride, Dragendorff's reagent, Lead acetate, Sodium hydroxide, Benedict's solution, sulfuric acid, hydrochloric acid, and chloroform, and were used for phytochemical screening, extraction, and antimicrobial testing [1,2].

### Plant Material Collection and Authentication

Fresh plant materials of *Cymbopogon citratus* (leaves), *Vernonia amygdalina* (leaves), and *Garcinia kola* (seeds) were collected from Lodu-Ndume farms and Ahiaeke markets, Umuahia, Abia State, Nigeria. The plant materials were sorted to remove extraneous matter, washed with distilled water, and air-dried under shade for 7–10 days. The dried materials were pulverized into fine powder using a mechanical grinder and stored in airtight containers for subsequent analyses. The plants were authenticated at the Department of Plant Science and Biotechnology, College of Natural Sciences, Michael Okpara University of Agriculture (MOUUA), Umudike, and voucher numbers were issued and deposited in the departmental herbarium for reference [3].

### Preparation of Plant Extracts

Ethanol and aqueous extracts were prepared as follows:

**Ethanol extraction:** Powdered plant material (100 g) was soaked in 500 mL of 95% ethanol for 72 hours with intermittent shaking.

**Aqueous extraction:** Powdered plant material (100 g) was boiled in 500 mL of distilled water for 30 minutes. All mixtures were filtered through Whatman No. 1 filter paper, concentrated using a rotary evaporator, and stored at 4 °C until use [4,5].

### Experimental Design

A laboratory-based experimental design was adopted to evaluate the phytochemical composition, nutritional quality (proximate analysis), mineral content, and antimicrobial activity of the selected medicinal plants. All analyses were carried out in triplicate to ensure reproducibility, and results were expressed as mean  $\pm$  standard deviation [6,7].

### Phytochemical Analysis

Quantitative phytochemical analyses were performed to determine the concentrations of alkaloids, flavonoids, saponins, phenols, and tannins using standard methods described by Trease and Evans [8].

### Proximate (Nutritional) Composition Analysis

The nutritional quality of the plant samples was assessed through proximate analysis according to AOAC [9], determining moisture, ash, crude fiber, and fat contents. Results were expressed as percentages of dry weight.

### Mineral Analysis

The mineral content of calcium, magnesium, and phosphorus was determined after sample ashing in a muffle furnace at 550°C and acid digestion. Calcium and magnesium were measured using Atomic Absorption Spectrophotometry (AAS), while phosphorus was determined using UV-Visible spectrophotometry [10].

### Test Organisms

Three bacterial pathogens were used: *Staphylococcus aureus* (Gram-positive), *Escherichia coli* (Gram-negative), and *Pseudomonas aeruginosa* (Gram-negative). The cultures were obtained from the

Department of Microbiology, College of Natural Sciences, MOUAAU, Umudike, and maintained on nutrient agar slants at 4°C [11].

**Antimicrobial Activity Assay**

The agar well diffusion method was employed to assess the antimicrobial activity. Mueller-Hinton agar plates were seeded with standardized bacterial inoculum equivalent to 0.5 McFarland standard. Wells (6 mm) were bored, and 100 µL of each plant extract was added. Plates were incubated at 37°C for 24 hours, and zones of inhibition were measured in millimeters. All tests were performed in triplicate [12].

**Statistical Analysis**

Data were presented as mean ± SD. Statistical analysis was performed using ANOVA, with significance accepted at p < 0.05 [13].

**Results and Discussion**

Table 1: Phytochemical Composition

Phytochemical Composition	A	B	C
Alkaloids	1.20±0.04	1.1±0.05	0.90±0.05
Flavonoids	0.79±0.02	0.66±0.02	0.73±0.03
Saponins	0.53±0.04	1.37±0.01	0.78±0.07
Phenols	0.17±0.01	0.48±0.63	0.24±0.32
Tannins	0.50±0.02	0.50±0.02	0.42±0.07

This table presents the concentration (mean ± standard deviation) of various phytochemicals: Alkaloids, Flavonoids, Saponins, Phenols, and Tannins in three different samples labeled A, B, and C.

Table 2: Diameter zone of inhibition (mm) of microbes treated with ethanolic and aqueous plant extracts of *Veronia amygdalina*, *Garcinia kola* and *Cymbopogon citratus*

Pathogen	<i>Veronia amygdalina</i>		<i>Cymbopogon citratus</i>			
	Ethanol	Hot	Ethanol	Hot	Ethanol	Hot
<i>Staphylococcus aureus</i>	14.33±0.5774	10.33±0.05774	15.5±0.5	14.33±1.15471	11.33±0.5774	14.67±1.577
<i>Escherichia coli</i>	10±1.00	16.17±0.76377	12±1	13.33±2.52	12.33±3.6395	13.33±1.5275
<i>Pseudomonas aeruginosa</i>	12.24±0.2939	12.24±0.2887	15.5±0.5	12.83±0.28871	15.33±0.577	9.17±0.2887

Microbial inhibition zones (in mm) were measured to assess the antibacterial activity of ethanolic and hot aqueous extracts of *Vernonia amygdalina*, *Garcinia kola*, and *Cymbopogon citratus* against three pathogens: *Staphylococcus aureus*, *Escherichia coli* and *Pseudomonas aeruginosa*

Table 3: Proximate Composition of *Cymbopogon citratus*, *Garcinia kola* and *Veronia amygdalina* plant parts.

STD			
Proximate Composition			
	A	B	C
Ash	5.52±0.087	6.18±0.05099	2.38±0.0316
Crude fibre	3.94±0.70	16.25±0.0905	26.21±0.1475
Moisture content	11.67±0.612	11.67±0.0381	8.40±0.024
Flat	4.97±0.025	6.84±0.014	5.36±0.014

This table presents the mean ± standard deviation of various nutritional components Ash, Crude Fibre, Moisture Content, and Fat in three plant parts labeled: A = *Cymbopogon citratus*, B = *Garcinia kola*, C = *Vernonia amygdalina*. All values represent the mean of triplicate analyses.

Table 4: Mineral Composition of *Cymbopogon citratus*, *Garcinia kola* and *Veronia amygdalina* plant parts.

STD			
Macro			
Element	A	B	C
Calcium/Magnesium	114.90±2.315	10.7±2.309	14.69±2.315
Phosphorus	328.66±0.4	239.70±0.339	347.8±0.8

Table 4 shows the levels (mean ± standard deviation) of key macroelements, Calcium/Magnesium and Phosphorus in three different plant samples: A = *Cymbopogon citratus*, B = *Garcinia kola* and C = *Vernonia amygdalina*. All values represent the mean of triplicate analyses.

The results from this study revealed that all three plant species, *Cymbopogon citratus*, *Vernonia amygdalina*, and *Garcinia kola* contain diverse phytochemical constituents, including alkaloids, flavonoids, tannins, saponins, and phenols. These secondary metabolites are known to exhibit a broad spectrum of bioactivities, especially antimicrobial properties [15].

Among the three plants, *C. citratus* showed the highest concentration of alkaloids ( $1.20 \pm 0.0374$  mg/g), which have been reported to disrupt bacterial cell wall integrity and interfere with nucleic acid synthesis [16]. Flavonoids were found in significant quantities across all samples, with *C. citratus* again showing the highest level. Flavonoids are potent antioxidants and have demonstrated antibacterial efficacy by forming complexes with bacterial proteins and cell walls [15].

The antimicrobial assay indicated that ethanolic extracts generally had greater zones of inhibition than aqueous (hot water) extracts across all bacterial pathogens. This is consistent with earlier findings suggesting that ethanol is a better solvent for extracting bioactive compounds compared to water [17-18]. The ethanol extract of *G. kola* produced the highest inhibition zone against *Pseudomonas aeruginosa* (15.5 mm), while the ethanol extract of *C. citratus* showed strong activity against *Staphylococcus aureus* (14.67 mm), indicating species-specific efficacy of these plants [11].

*Escherichia coli*, a Gram-negative bacterium often resistant to several antibiotics, was moderately susceptible to all three plant extracts. This supports reports that plant-derived compounds, particularly phenolics and alkaloids, can breach the outer membrane of Gram-negative bacteria [14].

Proximate analysis revealed that *V. amygdalina* had the highest crude fiber content ( $26.21 \pm 0.1475\%$ ), which supports its use as a dietary plant with gut-health benefits [19]. Moisture content was lowest in *G. kola*, suggesting a longer shelf life and lower susceptibility to microbial spoilage [13].

Mineral analysis showed that *C. citratus* had significantly higher levels of calcium/magnesium ( $114.90 \pm 2.31$  mg/g) and phosphorus ( $328.66 \pm 0.4$  mg/g), indicating its potential in improving bone health and metabolic functions [20-22]. These nutrients not only enhance the plant's nutritive value but also contribute to its medicinal efficacy.

Our findings align with earlier literature that supports the use of these plants in traditional medicine for treating infections and promoting health. The presence of both phytochemicals and essential nutrients enhances the plants' functionality as antimicrobial and nutritional agents.

### Conclusion

This study confirms that *Cymbopogon citratus*, *Vernonia amygdalina*, and *Garcinia kola* possess significant phytochemical and antimicrobial properties. The ethanolic extracts, in particular, demonstrated stronger antibacterial activity, especially against *Pseudomonas aeruginosa* and *Staphylococcus aureus*. In addition to their antimicrobial potentials, the high levels of fiber, calcium and phosphorus underscore the nutritional value of these plants. These findings support the integration of these plants into phytotherapeutic formulations and functional foods aimed at managing microbial infections and improving health.

### References

1. Alaebo, P.O., Onuoha, U.D., Ukpabi-Ugo, J.C., Enya, E., Okakpu, J.C., Anah, J.O., Ugwu, P., Okolie, J.C. & Onwuatuelo, C.O. (2023). Phytochemical analysis and antimicrobial evaluation of *Aloe vera* gel against some human and plant pathogens. *International Journal of Phytology Research*, 3(2): 1–6.
2. Alaebo, P.O., Nwuke, C.P., Achi, N.K., Ezurike, P.U., Egbuonu, A.C.C., Chukwuka, W.E., Onochie, A.U. & Abuchi, F.J. (2025). Phytochemical composition, antibacterial activity, proximate and mineral analysis of methanol extract from combined seeds and peels of *Picralima nitida*. *Universal Journal of Pharmaceutical Research*, 10(1): 39–44.
3. Akinmoladun, B.O., Akinrinlola, F.O. & Olaleye, A.O. (2007). Phytochemical and antimicrobial studies of some Nigerian medicinal plants. *African Journal of Biotechnology*, 6(12): 1429–1433.
4. Doughari, U.P. & Manzara, S. (2008). Antimicrobial activity of some medicinal plants. *African Journal of Microbiology Research*, 2(9): 153–157.
5. World Health Organization (WHO). (2014). *WHO traditional medicine strategy 2014–2023*.
6. Cowan, M.M. (1999). Plant products as antimicrobial agents. *Clinical Microbiology Reviews*, 12(4): 564–582.

7. Fabricant, D.S., & Farnsworth, N.R. (2001). The value of plants used in traditional medicine for drug discovery. *Environmental Health Perspectives*, 109(1), 69-75.
8. Igbinosa, E.O., Oba, A.I. & Ikponmwosa, O.A. (2009). Antimicrobial activity of plants used in traditional medicine. *African Journal of Pharmacy and Pharmacology*, 3(6): 255–260.
9. Igile, O.O., Oleszek, A.A., Jurzysta, J., Jurzysta, B.F. & Komsta, A.F. (1994). Flavonoids from some Nigerian medicinal plants. *Journal of Natural Products*, 57(10): 1227–1230.
10. Nwaeze, I.C. & Abarikwu, O.O. (2006). Evaluation of medicinal plants for antioxidant properties. *African Journal of Biotechnology*, 5(21): 2042–2045.
11. Farombi, O.O., Ogundipe, O.O. & Akinmoladun, O. (2005). Antioxidant activity of medicinal plants. *Journal of Ethnopharmacology*, 99(2): 269–276.
12. Akinpelu, A.A., Dada, A.O. & Aiyegoro, A.O. (2008). Antimicrobial properties of extracts of selected plant species used in folklore medicine in the treatment of respiratory tract infections in South Africa. *African Journal of Biotechnology*, 7(11): 1505–1509.
13. AOAC (Association of Official Analytical Chemists). (2005). *Official methods of analysis* (18th ed.). AOAC International.
14. Evans, W.C. & Trease, G.E. (2002). *Trease and Evans' pharmacognosy* (15th ed.). Saunders Ltd.
15. Doughari, U.P., Ndakidemi, A.G., Human, N.C. & Ben, E.M. (2009). Antimicrobial activity of some medicinal plants from Nigeria. *African Journal of Microbiology Research*, 3(2): 54–60.
16. Cushnie, T.P. & Lamb, A.J. (2005). Antimicrobial activity of flavonoids. *International Journal of Antimicrobial Agents*, 26(5): 343–356.
17. Onuoha, U.N., Appeh, O.G., Nwachukwu, I., Itaman, V.O. & Alaebo, P.O. (2025b). Assessment of microbial dynamics and hydrocarbon-degrading bacteria in water and bacterial populations from different sources. *Nigerian Research Journal of Biological Sciences*, 3(1): 1–11.
18. Akinpelu, O.B., Akinrinlola, O.O. & Akinmoladun, F.O. (2008). Phytochemical screening and antimicrobial activity of medicinal plants. *African Journal of Biomedical Research*, 11(3): 217–222.
19. Onuoha, U.N., Appeh, O.G., Nwachukwu, I., Umeh, M.N. & Alaebo, P.O. (2025c). Antimicrobial activity of ethanolic extracts of *Zingiber officinale* and *Curcuma longa* against selected clinical bacterial isolates. *Nigerian Research Journal of Chemical Sciences*, 13(2): 348–358.
20. Onuoha, U.N., Appeh, O.G., Nwachukwu, I., Umeh, M.N. & Alaebo, P.O. (2025d). Antimicrobial activities of essential oils from selected local spices against food-borne microbial isolates. *Nigerian Research Journal of Chemical Sciences*, 13(2): 336–347.
21. Ríos, J.L. & Recio, M.C. (2005). Medicinal plants and antimicrobial activity. *Journal of Ethnopharmacology*, 100(1–2): 80–84.
22. Gopalan, S., Rama Sastri, B.V. & Balasubramanian, S.C. (2007). Nutritive value of Indian foods. *National Institute of Nutrition*,