

# Antibacterial Activity and Phytochemical Profile of *Dialium guineense* (Velvet Tamarind).

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**Abstract:** The need to substantiate the widely acclaimed antibacterial potentials of *Dialium guineense* leaf informed the present study. Two extract types of *Dialium guineense* leaf; aqueous extract of *Dialium guineense* (DAE) and methanol extract of *Dialium guineense* (DME) were prepared and analysed for phytochemical constituents following standard protocols. The antibacterial activities of both extracts were evaluated against clinical isolates of *Staphylococcus aureus*, *Bacillus cereus*, *Enterobacter species*, and *Pseudomonas aeruginosa* using the agar-well diffusion technique. The minimum inhibitory concentration (MIC) and minimum bactericidal concentration (MBC) were also determined using standard methods. The results of the phytochemical analysis revealed the presence of ten (9) bioactive compounds, which varied with extract type. The compounds include anthraquinone, tannins, terpenoids, flavonoids, carbohydrate, protein and amino acid, cardiac glycoside, saponins, and glycoside. The antibacterial analysis revealed that both leaf extracts of *Dialium guineense* were inhibitory to all the clinical isolates used in this study, indicating that both extracts have broad spectrum activity. The zone of inhibition (cm) ranged between  $4.48 \pm 0.13$  and  $1.22 \pm 0.05$  with DAE having the highest inhibition against *Pseudomonas aeruginosa*. While DME had the lowest lowest against *Staphylococcus aureus*. The minimum inhibitory concentration (MIC) value ranged between 25.00 mg/mL and  $< 0.781$  mg/mL with DME having the highest value against *Pseudomonas aeruginosa*, while DAE had the least value against *Staphylococcus aureus*, *Enterobacter species*, and *Pseudomonas aeruginosa*. The minimum bactericidal concentration value ranged between  $> 50.00$  mg/mL and 0.781 mg/mL. The results of this work suggest further exploitation of the leaves of *Dialium guineense* to possibly unveil its potential use for treatment of diseases.

**Keywords:** *Dialium guineense*, aqueous and methanolic extracts, phytochemical, antibacterial.

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## Introduction

Medicinal plants have long been valued for their therapeutic properties, offering natural alternatives to conventional pharmaceuticals for managing various health conditions, including anemia (Obeagu et al., 2023). In economically challenged regions, the affordability and accessibility of many beneficial plant-based remedies make them a preferred choice for healthcare (Chibuogwu et al., 2021).

Velvet tamarind, commonly known as black velvet, refers to *Dialium guineense*, a legume from the Fabaceae family, subfamily Caesalpinioideae. Its sweet, edible fruit pulp contains relatively low levels of ascorbic acid and tannin (Gloria et al., 2022). This plant thrives in the humid and dry dense forests and forest galleries of West and Central Africa. *Dialium guineense* is recognized throughout Africa for its dietary and nutritional benefits. Extensive research has explored its diverse pharmacological activities and therapeutic applications, including antibacterial, antiulcer, antioxidant, analgesic, anti-hepatotoxic, antimicrobial, antiplasmodial, anti-haemorrhoidal, anti-vibrio, antidiarrheal, molluscicidal, oral care, and vitamin supplementation (Besong et al., 2016).

The leaves of *D. guineense* are notably hairy, with a common stalk measuring 5 to 13 cm. They typically feature an odd terminal leaflet and two pairs of opposing or alternating leaflets, with the lower pair being smaller. These leaves are generally elliptic to broadly elliptic, sometimes slightly ovate, blunt or briefly pointed at the apex, symmetrical, and rounded or slightly indented, occasionally having fine hairs on their underside (Besong et al., 2016).

The origin of the generic name remains unknown, a fact that puzzled 18th-century English botanist J.E. Smith and continues to elude modern botanists. The specific name, "guineense," indicates its probable origin in Guinea, from where it was subsequently introduced as a cultivated crop in tropical and subtropical regions (Besong et al., 2016). The plant is found in various Central and West African nations, including Cameroon, Central African Republic, Chad, Benin, Burkina Faso, Ivory Coast, Ghana, the Guineas, Liberia, Senegal, Sierra Leone, and Togo. It is locally known as "Icheku" by the Igbo people in eastern Nigeria, "awin" by the Yoruba in western Nigeria, and "tsamiyar kurm" by the Hausa in northern Nigeria (Akinpelu et al., 2011).

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Traditional medicine widely utilizes the bark, leaves, and fruits of *D. guineense*. Various parts are traditionally used to treat fever, prenatal discomfort, and oedema, while the fruit is a remedy for diarrhoea. The stem bark is employed in treating coughs, toothaches, and bronchitis (Arbonnier, 2004). The pulp can be consumed raw or steeped in water to make a beverage. The bitter leaves are an ingredient in the Ghanaian dish called *domoda*. Its durable wood is valuable for construction, firewood, and charcoal production. Studies have also reported the spermatogenic and anti-ulcerogenic effects of *D. guineense* leaf meal in animal models (Iwuji et al., 2020). Anecdotal claims among women in southeastern Nigeria suggest that the fruit pulp improves lactation (Ogbuewu et al., 2023).

Proximate analysis is a common method for initial nutritional assessment of plant materials in both research and industry. While it may not provide a complete nutritional profile, it offers valuable insights for further investigation. Velvet tamarind has garnered considerable interest in animal production due to its nutritional advantages (Besong et al., 2016). Summaries from various authors detailing the nutrient content of *D. guineense* leaves and stem barks are presented in Tables 1 and 2. The chemical composition data suggest that *D. guineense* leaves and stems are rich sources of essential nutrients. However, results indicate that the fruit pulp is low in protein, making it unsuitable as a primary protein source in animal feed (Awotedu et al., 2020). Conversely, the leaves and whole seeds have moderate protein content, suggesting their potential as a protein supplement for non-ruminant animals (Atawodi et al., 2016). The high digestible fibre content in *D. guineense* leaves could enhance nutrient digestibility when added to feed. The total ash content of *D. guineense* leaf pulp surpasses that of the whole seeds. Given that most animal feed components exist in inorganic forms, their bioavailability can be limited by mineral antagonism, which hinders nutrient absorption (Soetan et al., 2010). The high ash content in *D. guineense* leaf pulp, indicative of its mineral composition, suggests that this plant is rich in beneficial minerals. Black velvet tamarind, especially its fruit pulp, is abundant in complex carbohydrates, vitamins, and minerals. These characteristics likely contribute to its therapeutic potential. Furthermore, the stem bark of *D. guineense* contains significant amounts of B vitamins, including B1 (thiamine), B2 (riboflavin), and B3 (niacin) (Abu & Onoagbe 2020). Phytochemical analysis represents a crucial initial step in isolating novel compounds with promising biological activities (Adindu et al., 2016; Agu et al., 2013; Obianom et al., 2023; Ubaoji et al., 2020; Awah et al., 2017).

The aim of this research was to **substantiate the widely acclaimed antibacterial potentials of *Dialium guineense* leaf.**

## Materials and Methods

### Collection and Authentication of Plant Material

Fresh leaves of *Dialium guineense* were harvested in Uga, Aguata South LGA, Anambra State (Nigeria). Voucher specimens were forwarded to the Department of Biological Sciences, Chukwuemeka Odumegwu Ojukwu University, Uli Campus, where botanists confirmed the species identity.

### Preparation of Leaf Extracts

The leaves were rinsed, air-dried at room temperature for roughly two weeks, destalked and milled to a coarse powder with an

industrial blender. Exactly 20 g of powder were immersed in 200 mL distilled water plus 300 mL methanol in a 500 mL conical flask, shaken and left to macerate for 72 h. After double filtration (muslin cloth then Whatman No. 1), the combined filtrates were evaporated to dryness in a 45 °C water bath and stored in a desiccator until use (Oso et al., 2018; Ubaoji et al., 2020).

### Qualitative Phytochemical Screening

Aqueous and methanolic extracts were assayed for alkaloids, tannins, anthraquinones, terpenoids, cardiac glycosides, saponins, flavonoids, proteins and carbohydrates using the protocols of Okaiyeto et al. (2019) and Karthigaiselvi & Rameshwari (2016) with minor modifications. Results were recorded simply as present (+) or absent (-).

### Antibacterial Assay

Antimicrobial activity was evaluated by the agar-well diffusion method (Adindu et al., 2016; Agu et al., 2013; Obianom et al., 2023; Ubaoji et al., 2020; Awah et al., 2017). Bacterial lawns of *Staphylococcus aureus*, *Pseudomonas aeruginosa*, *Enterobacter* sp. and *Bacillus cereus* ( $1.5 \times 10^8$  CFU mL<sup>-1</sup>) were prepared on Mueller–Hinton agar. Wells (9 mm) were filled with 100 µL of each extract concentration. Dimethyl sulfoxide served as the negative control, while ciprofloxacin (1 mg mL<sup>-1</sup>) was the positive control. Plates were pre-diffused at 4 °C for 2 h, incubated at 37 °C for 24 h, and zones of inhibition were measured in millimetres.

### Determination of MIC and MBC

A 100 mg mL<sup>-1</sup> stock (1 g extract in 10 mL nutrient broth containing 0.2 % TTC) was serially two-fold diluted in Mueller–Hinton broth to obtain 100–0.781 mg mL<sup>-1</sup> (Adegoke et al., 2010; Agu et al., 2013). Each tube received 0.1 mL of standardized bacteria and was incubated at 37 °C for 24 h. The lowest concentration preventing visible growth was recorded as the MIC. Broth from growth-free tubes was streaked onto nutrient agar; the lowest concentration that yielded no colonies after 24 h was taken as the MBC (Adegoke et al., 2010).

### Statistical Analysis

Mean inhibition zones ± standard deviation were calculated in Microsoft Excel 2010. One-way ANOVA determined significant differences between aqueous and methanolic extracts for each bacterium, with  $p < 0.05$  considered significant.

## Results

The qualitative phytochemical profile of the different plants extracts (DAE and DME) are shown in table 1. The analysis of both crude extracts revealed the presence of Nine(09) medically active compounds. However, their presence were dependent on the solvent extraction type. Eight(08) compounds namely, tannins, anthraquinones, terpenoids, glycoside, saponins, flavonoids, protein and amino acid, carbohydrate, cardiac glycoside, glycosides were detected in DME, while three (3) namely, protein and amino acid, carbohydrate, cardiac glycosidewere detected in DAE (table 1). There was no presence of alkaloids in any of the extracts.

**Table 1: Qualitative phytochemical profile of the different plant extracts**

Component	DAE	DME
Anthroquinone	-	+
Tannins	-	+
Terpenoids	-	+
Flavonoids	-	+
Carbohydrate	+	+
Alkaloids	-	-
Protein and amino acid	+	++
Cardiac glycoside	+	++
Saponins	-	+
Glycoside	-	++

Key: DAE = *Dialium guineense* aqueous extract; DME = *Dialium guineense* methanolic extract; (+) = presence; (-) = absence.

**Table 2:** The effects of aqueous leaf extract of *Dialium guineense* (DAE) and methanolic extract of *Dialium guineense* (DME) on the test isolates (*Staphylococcus aureus*, *Pseudomonas aeruginosa*, *Enterobacter* sp. and *Bacillus cereus*) were presented in table 2. All

the test isolates exhibited sensitivity to both extracts. The zones of inhibition (cm) ranged between 4.48± and 1.22 ±0.05 with DAE having the highest value against *Pseudomonas aeruginosa*, while DME had the lowest value against *Staphylococcus aureus*.

Table 2: Antibacterial activity profile of the different plant extracts used in this study

Extract code (100 mg/mL)	<i>Bacillus cereus</i>	<i>Staphylococcus aureus</i>	<i>Enterobacter</i> sp.	<i>Pseudomonas aeruginosa</i>
DAE	4.38±0.76	4.00±0.08	4.40±0.16	4.48±0.13
DME	1.70±0.08	1.22±0.05	1.58±0.10	1.58±0.05

Key: DAE = *Dialium guineense* aqueous extract; DME = *Dialium guineense* methanolic extract ; mg/mL = milligram per millilitre ; ± plus or minus ; DMSO = Dimethylsulfoxide; % = percent

Table 3: shows the minimal inhibitory concentration (MIC)(mg/mL) profile of the different plant extracts used in this study. The values of MIC for DME is higher than those of DAE for all the test isolates. The MIC for DAE ranged between 1.56 and <

0.781 with *Bacillus cereus* having the highest value, while the rest had the least value. For DME, the MIC ranged between 25.00 and 12.50 with the highest value against *Pseudomonas aeruginosa*, while the lower values are against the rest of the test isolates.

Table 3: Minimal inhibitory concentration (mg/mL) profile of the different plant extracts used in this study

Extract code (100 mg/mL)	<i>Bacillus cereus</i>	<i>Staphylococcus aureus</i>	<i>Enterobacter</i> sp.	<i>Pseudomonas aeruginosa</i>
DAE	1.56	< 0.781	< 0.781	< 0.781
DME	12.50	12.50	12.50	25.00

Key: DAE = *Dialium guineense* aqueous extract; DME = *Dialium guineense* methanolic extract; JME = *Jatropha tanjorensis* methanolic extract; JAE = *Jatropha tanjorensis* aqueous extract; < = less than. Mg/mL = milligram per milliliter.

Table 4: shows the minimal bactericidal concentration (MBC)(mg/mL) profile of different plant extracts used in this study. The MBC for DAE ranged between 25.00 and 0.781 with the highest value against *Bacillus cereus*, while, the lowest was

against *Staphylococcus aureus*. For DME, the MBC ranged between > 50.00 and 50.00 with highest value against *Enterobacter species* and *Pseudomonas aeruginosa*, while the lower values were against *Bacillus cereus* and *Staphylococcus aureus*.

Table 4: Minimum bactericidal concentration (mg/mL) profile of the different plant extracts used in this study

Extract code (100 mg/mL)	<i>Bacillus cereus</i>	<i>Staphylococcus aureus</i>	<i>Enterobacter</i> sp.	<i>Pseudomonas aeruginosa</i>
DAE	25.00	0.781	12.50	12.50
DME	50.00	50.00	>50.00	>50.00

Key: DAE = *Dialium guineense* aqueous extract; DME =

*Dialium guineense* methanolic extract; mg/ml = milligram per .milliliter; > = greater than

## Discussion

Across many regions of the world, leafy green plants are commonly used in daily diets either as vegetables or traditional medicinal remedies, often without adequate consideration for their potential toxicological risks. This study aimed to assess both the antibacterial properties and phytochemical composition of aqueous and methanolic extracts derived from the leaves of *Dialium guineense*. Methanol is widely recognized as a versatile solvent capable of dissolving compounds across a range of polarities—polar, non-polar, and semi-polar. Several factors can influence the quality and composition of plant extracts, including the type and condition of the raw plant material, extraction method, temperature, duration, and the solvent used. Notably, the yield of secondary metabolites in methanol extracts often remains below 10%, and may be greatly affected by the plant part used and the environmental conditions during collection (Van Beek, 1999).

Qualitative analysis of the aqueous leaf extract of *D. guineense* (DAE), as shown in Table 1, revealed the presence of proteins, carbohydrates, amino acids, and cardiac glycosides. Other compounds such as flavonoids, tannins, terpenoids, anthraquinones, saponins, and general glycosides were not detected. The absence of these compounds may be attributed to differences in solvent polarity or external environmental factors influencing the plant's phytochemical profile. In comparison, findings by Besong et al. (2016) reported the detection of several bioactive constituents in *D. guineense*, including cardiac glycosides, flavonoids, tannins, alkaloids, terpenoids, saponins, steroids, and resins—many of which align with the current study's findings.

The observed bioactivities of *Dialium guineense* extracts are likely due to the presence of phenolic compounds, which are known to exert a wide range of health benefits. These phenolic constituents—particularly tannins, flavonoids, and glycosides—are reported to possess antimicrobial, antioxidant, anti-inflammatory, antidiarrheal, hepatoprotective, and antiplasmodial properties (Besong et al., 2016). Although the exact phytochemicals responsible for the observed antibacterial effects remain unidentified, the presence of these compounds supports further investigation into the isolation and pharmacological profiling of active constituents.

As shown in Table 2, both aqueous and methanol-based extracts exhibited inhibitory effects against a variety of bacterial strains, indicating broad-spectrum antimicrobial potential. These findings are consistent with those of Olajubu et al. (2012), who also documented the antibacterial efficacy of *D. guineense* leaf extracts. The broad antimicrobial spectrum observed in this study may be linked to the plant's phenolic compounds, which are known to enhance antimicrobial effectiveness (Besong et al., 2016).

Interestingly, the aqueous extract demonstrated a stronger antibacterial response than even the commercial antibiotics used as controls in this experiment. This could be due to the synergistic interactions among various phytochemicals within the crude extract, which together may enhance overall antimicrobial activity.

## Conclusion

The findings of this research confirm that leaf extracts of *Dialium guineense* possess notable antibacterial effects against multiple bacterial species including *Staphylococcus aureus*, *Bacillus cereus*, *Enterobacter* spp., and *Pseudomonas aeruginosa*. Given these results, the plant shows promise as a source of therapeutic and nutritional agents and supports its continued use in traditional health practices, while also highlighting the need for further pharmacological studies to isolate its active components.

## References

1. Abu, O.D., and Onoagbe, I.O. (2020). Vitamin contents of extract of *Dialium guineense* stem bark. *Biomed Journal of Sci and Tech Res*, 30: 23263–23267.
2. Adegoke, S.A., Opata, O.M., and Olajide, J.E. (2010). Antimicrobial activity of the aqueous, methanol and chloroform leaf extracts of *Cissus multistriata*. *African Journal of Biotechnology*, 9(8): 1168–1172.
3. Adindu, C.S., Odili, L.C., Nwagu, E.E., Agu, K.C., Awah, N.S., and Orjionwe, R.N. (2016). Phytochemical and Antimicrobial Screening of *Cola gigantea* Leaves, Stem and Bark. *Universal Journal of Microbiology Research*, 4(2): 49–54.
4. Agu, K.C., Awah, N.S., Sampson, P.G., Ikele, M.O., Mbachu, A.E., Ojiagu, K.D., Okeke, C.B., Okoro, N.C.N., and Okafor, O.I. (2014). Identification and Pathogenicity of Rot-Causing Fungal Pathogens Associated with *Xanthosoma sagittifolium* Spoilage in South Eastern Nigeria. *International Journal of Agriculture Innovations and Research*, 2(6): 1155–1159.
5. Agu, K.C., Igweoha, C.A., and Umeh, C.N. (2013). Antimicrobial Activity of the Ethanolic and Petroleum Ether Extracts of Tangerine Seeds on Selected Bacteria. *International Journal of Agriculture and Bioscience*, 2(1): 22–24.
6. Akinpelu, A.D., Awoterebo, T.O., Agunbiade, O.M., Aiyegoro, A.O., and Okoh, I.A. (2011). Antivibrio and Preliminary Phytochemical Characteristics of Crude Methanolic Extract of the Leaves of *Dialium guineense* (Wild). *Journal of Medicinal Plant Research*, 5(11): 2398–2404.
7. Arbonnier, M. (2004). *Trees, Shrubs and Lianas of West Africa Dry Zone*, 2nd edn. GMBH: Margaraf Publisher.
8. Atawodi, S.E., Yakubu, O.E., and Umar, I.A. (2013). Antioxidant and hepatoprotective effects of *Parinari*

- curatellifolia* root. *International Journal of Agriculture and Biology*, 15: 523–528.
9. Awah, N.S., Agu, K.C., Ikedinma, J.C., Uzoechi, A.N., Eneite, H.C., Victor-Aduloju, A.T., Umeoduagu, N.D., Onwuatuogwu, J.T.C., and Ilikannu, S.O. (2017). Antibacterial Activities of the Aqueous and Ethanolic Extracts of the Male and Female *Carica papaya* Leaves on Some Pathogenic Bacteria. *Bioengineering and Bioscience*, 5(2): 25–29. DOI: 10.13189/bb.2017.050201
  10. Awah, N.S., Agu, K.C., Okorie, C.C., Okeke, C.B., Iloanus, C.A., Irondi, C.R., Udemezue, O.I., Kyrian-Ogbonna, A.E., Anaukwu, C.G., Eneite, H.C., Ifediegwu, M.C., Umeoduagu, N.D., Abah, N.H., and Ekong, U.S. (2016). In-vitro Assessment of the Antibacterial Quality of Some Commonly Used Herbal and Non-herbal Toothpastes on *Streptococcus mutans*. *Open Journal of Dentistry and Oral Medicine*, 4(2): 21–25. DOI: 10.13189/ojdom.2016.040201
  11. Awari, V.G., Umeoduagu, N.D., Agu, K.C., Okonkwo, N.N., Ozuah, C.L., and Victor-Aduloju, A.T. (2023). The Ubiquity, Importance and Harmful Effects of Microorganisms: An Environmental and Public Health Perspective. *International Journal of Progressive Research in Engineering Management and Science*, 3(12): 1–10.
  12. Awotedu, O.L., Ariwoola, O.S., Chukwudebe, E., and Ajekigbe, J.M. (2020). Analytical Evaluation of Four Accessions of *Dialium guineense* (L) Leaves. *International Journal of Sustainable Agriculture Research*, 7: 134–142.
  13. Besong, E.E., Balogun, M.E., Djobbissie, S.F.A., Obu, D.C., and Obimma, J.N. (2016). Medicinal and Economic Value of *Dialium guineense*. *African Journal of Biomedical Research*, 19: 163–170.
  14. Chibuogwu, C.C., Njoku, U.O., Nwodo, F.C., Ozougwu, E.O., and Nweze, V.N. (2021). Toxicity Assessment of the Methanol Extract of *Jatropha tanjorensis* (Euphobiaceae) Leaves. *Future Journal of Pharmaceutical Sciences*, 7: 143.
  15. Gloria Tochukwu Onah, Eze Elija Ajaegbu, and Ifeoma Bessie Enweani (2022). Proximate, Phytochemical and Micronutrient Compositions of *Dialium guineense* and *Napoleona imperialis* Plant Parts. *GSC Biological and Pharmaceutical Sciences*.
  16. Iwuji, T.C., Uzor, V.C., Kadurumba, O.E., Okere, P.C., and Egenuka, F.C. (2020). Reproductive Characteristics of Adult Rabbit Bucks Fed Diets Containing *Dialium guineense* Leaf Meal. *Nigerian Journal of Animal Science*, 22: 98–105.
  17. Karthigaiselvi, K., and Rameshwari, K.S. (2016). Green Synthesis of Silver Nanoparticles from Aqueous Extract of *Stemodia viscosa* and its Evaluation of Antimicrobial Activity. *European Journal of Pharmaceutical Medical Research*, 3: 417–421.
  18. Obeagu, E.I., Nimo, O.M., Bunu, U.O., Ugwu, O.P.C., and Alum, E.U. (2023). Medical Plants Alternative to Pharmacological Agents Used in the Treatment of Anaemia. *Newport International Journal of Scientific and Experimental Sciences (NIJSES)*, 4(2).
  19. Obianom, O.A., Ogbonna, U.S.A., Agu, K.C., Ozuah, C.L., Okonkwo, N.N., Victor-Aduloju, A.T., and Umeoduagu, N.D. (2023). Microbiological and Phytochemical Evaluation of Jackfruit and Soursop. *International Journal of Science Academic Research*, 4(11): 6662–6674.
  20. Ogbo, F.C., and Agu, K.C. (2015). Evaluation of a New Method for Testing the Pathogenicity of Molds to Yam Tubers. *Edorium Journal of Microbiology*, 1: 9–17.
  21. Ogbuewu, P.I., Orwaledi, M.C., Mokolopi, B.C., and Mbajiogu, C.A. (2023). Nutritional and Chemical Composition of Black Velvet Tamarind (*Dialium guineense* Willd) and its Influence on Animal Production: A Review. *De Gruyter, Open Agriculture*, 8: 20220174.
  22. Okaiyeto, K., Ojemaye, M.O., Hoppe, H., Mabinya, L.V., and Okoh, A.I. (2019). Phytofabrication of Silver/Silver Chloride Nanoparticles Using Aqueous Leaf Extract of *Oedera genistifolia*: Characterization and Antibacterial Potential. *Molecules*, 24: 4382. <https://doi.org/10.3390/molecules24234382>
  23. Okigbo, R.N., Enweremadu, C.E., Agu, K.C., Irondi, R.C., Okeke, B.C., Awah, N.S., Anaukwu, C.G., Okafor, I.O., Ezenwa, C.U., and Iloanus, A.C. (2015). Control of White Yam (*Dioscorea rotundata*) Rot Pathogen Using Peel Extract of Water Yam (*Dioscorea alata*). *Advances in Applied Science Research*, 6(10): 7–13.
  24. Olajubu, F., Akpan, I., Ojo, D., and Oluwalana, S. (2012). Antimicrobial Potential of *Dialium guineense* (Willd) Stem Bark on Some Clinical Isolates in Nigeria. *International Journal of Applied Basic Medical Research*, 2: 58–62.
  25. Orji, M.U., Agu, K.C., Nwafor, H.C., Ogbonna, U.S.A., Egurefa, S.O., Umeoduagu, N.D., Igwilo, C.Q., Awari, V.G., and Uwanta, L.I. (2025). Harnessing the Antifungal Properties of *Ocimum gratissimum* for Sustainable Water-Based Paint Formulations. *International Journal of Innovative and Applied Research*, 13(1): 12–29. <http://dx.doi.org/10.58538/IJIAR/2119>
  26. Oso, B.A., Ogunnusi, T.A., and Fagbem, M.E. (2018). Antimicrobial Effect of Some Plant Extracts on Plant Pathogens that Cause Food Spoilage. *Microbiology Research Journal International*, 24(5): 1–15.
  27. Soetan, K.O., Olaiya, C.O., and Oyewole, O.E. (2010). The Importance of Mineral Element for Humans, Domestic Animals and Plants: A Review. *African Journal of Food Science*, 4: 200–222.
  28. Ubaoji, K.I., Nwosu, O.K., Agu, K.C., Nwozor, K.O., Ifedilichukwu, N.H., and Okaka, A.N.C. (2020). Gas Chromatographic Analysis of the Phyto-Constituents and the Assessment of the Anti-Microbial Properties of the Leaf Extracts of Nigeria-Grown *Gingko biloba*. *Journal of Scientific Research in Medical and Biological Sciences*, 1(2): 45–56.
  29. Umeoduagu, N.D., Chidozie, C.P., Ifemeje, E.M., Anazodo, C.A., Okoli, F.A., Okonkwo, N.N., Uwanta, L.I., Agu, K.C., and Azuka, G.E. (2023). Halitosis: The Antimicrobial Susceptibility Pattern of Some Commercially Sold Toothpaste on Selected Isolates. *International Journal of Scientific Research & Engineering Trends*, 9(5): 1309–131.
  30. Umeoduagu, N.D., Egurefa, S.O., Awari, V.G., Agu, K.C., Udenweze, E.C., and Uwanta, L.I. (2023). Bacteriological and Antibiotic Resistance Evaluation of Bacteria Isolated from Fresh Meat Sold at Afor Oba Market, Anambra State. *International Journal of Research Publication and Reviews*, 4(8): 554–560.