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Comparative Evaluation of the Antimicrobial Efficacy of *Dracaena arborea* L. (Asparagaceae) Root, Stem and Leaf Extracts on Clinical Isolates

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ABSTRACT

The need for efficient antimicrobials has arisen due to the emergence and spread of antibiotic resistance as well as the advent of new strains of disease-causing agents. The antimicrobial activities of ethanol extracts of *Dracaena arborea* L. (Asparagaceae) were investigated against some clinical isolates using the agar disc diffusion technique. The phytochemical analysis of *D. arborea* revealed the presence of tannins, saponins, cardiac glycosides, flavonoids, and alkaloids. The highest mean inhibition zone (IZ) of 30.5 ± 2.5 mm and the lowest mean IZ of 10.0 ± 0.0 mm were obtained when ethanol extracts of *D. arborea* were tested against the isolates. The mean IZ of Metronidazole against *E. faecalis* was 17.0 ± 0.0 mm and *S. fonticola* was 16.0 ± 1.41 mm. The Cephalexin was effective against the isolates, with the highest mean IZ against *K. pneumoniae* (27.5 ± 3.54 mm), *S. fonticola* (15.0 ± 1.41 mm), and *E. faecalis* (12.0 ± 0.0 mm). Fluconazole was effective against *C. albicans* and *T. tonsurans*, with a mean IZ of ≤ 20.8 ± 0.7 mm. The MIC and MBC values of ethanol extracts of *D. arborea* on the isolates ranged between 50 mg/mL and 200 mg/mL, respectively, with an MBC/MIC or MFC/MIC of ≤ 4. The R^2 values of ethanol extracts of *D. arborea* and diameters of IZs as exhibited by the isolates ranged from 0.6425 to 0.9672**.** The study has confirmed the efficacy of extracts of *D. arborea* against clinical isolates and, therefore, suggests their consideration in developing synthetic drugs.

Keywords: Antimicrobial, Isolates, *Dracaena arborea*, Extracts, Minimum Inhibitory, Concentration, Minimum Fungicidal Concentration, Minimum Bactericidal Concentration

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Introduction

Infectious diseases resulting from multidrug-resistant (MDR) microorganisms have increased dramatically in recent decades, resulting in high mortality, disability in children under the age of ten, and an increase in the length of stay in hospitals.[1] The continuous emergence of new pathogens is worrisome and has increasingly posed a significant problem globally. A sustained effort is required to discover new and better therapeutic agents, and more effective strategies for the prevention of endogenous infections and the transmission of infections within the hospital setting.[2]

Plants and other substances of natural origin have been a resource for healing in local communities around the world for thousands of years and remain of contemporary importance as a primary healthcare mode for approximately 85% of the world's population [3, 4, 5] and as a resource for drug discovery, with 80% of all synthetic drugs derived from them. [6] Chemical compounds isolated from some medicinal plants have similarly served as the models for many clinically proven drugs and are now being re-assessed as antimicrobial agents.

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Myriads of plant species have been tested *in vitro* against micro-organisms such as Gram-positive bacteria (*Staphyloccocus aureus***,** *Streptococcus* spp., *Bacillus cereus* and *Enterococcus faecalis***),** Gram-negative bacteria (*Klebsiella pneumoniae***,** *Escherichia coli*, *Enterobacter* spp., and *Pseudomonas aeruginosa*) and fungi such as *Aspergillus flavus*, *Candida albicans*, and *Fusarium* spp.[7, 8, 9]

Among the medicinal plants locally used in ethnomedicine is *Dracaena*, which consists of about 150 species.[10] *Dracaena arborea*, belonging to the family *Asparagaceae* and order *Asparagales*, is commonly found in the southern parts of Nigeria.[5] This small perennial and palm-like plant, known as African dragon tree and locally in Nigeria as Okono (Ibibio), Odo (Igbo), Peregun (Yoruba) and Akuku (Hausa), is used locally as an aphrodisiac,[11] as a treatment of inflammation, gonorrhoea, small pox, malaria and leishmaniasis,[12] and as an insecticide.[13] These medicinal properties of *D. arborea* could be attributed to the presence of flavonoids, alkaloids, saponins, cyanides**,** and phytates.[14] Flavonoids have antioxidant activity such as anti-allergic, anti-inflammatory**,** and antioxidant.[15] Saponins are known to possess antibacterial and antifungal properties,[16] and alkaloids have an intensely bitter taste**,** and their effects on humans have led to the development of painkiller medications.[17]

Despite the reports on the antimicrobial efficacy of some species of *Dracaena*, there is still a need to evaluate and validate its inhibitory effects on the growth of some bacterial and fungal isolates from this region. Thus, this study evaluated the antimicrobial efficacy of *Dracaena arborea* root, stem, and leaf extracts on some clinical isolates.

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Materials and Methods

Collection and Identification of Plant

Fresh roots, stems, and leaves of *Dracaena arborea* L. (Figure 1) were collected in July 2020 from the Pharmaceutical Plantation of the Faculty of Pharmacy, University of Uyo, Akwa Ibom State, Nigeria (5.0374° N and 7.9240° E). The roots, stems, and leaves of *D. arborea* (Voucher name: UUPHB 30) were separately transported using black polythene bags and were identified by a taxonomist (Prof. Margaret Bassey) in the Department of Botany and Ecological Studies, University of Uyo, Akwa Ibom State. Then, the roots, stems, and leaves of *D. arborea* were transferred to the Pharmacognosy and Natural Medicine Laboratory, University of Uyo, for processing. The undesirable particles in parts of *D. arborea* were removed by washing thoroughly using distilled water. The washed parts of *D. arborea* were cut into small pieces; air-dried separately at room temperature for 7 days; and pulverized into fine powdered form using a mortar and pestle. The powdered materials were separately packed into black polythene bags, labelled and stored at room temperature until extraction.

Figure 1: *Dracaena arborea* L.

Preparation of the Extracts

Each powdered plant material was weighed (600 g) and ethanol extracts were separately prepared by soaking 600g of the pulverized parts into 70% ethanol for 72 h with intermittent shaking at room temperature (26-33ºC). After 72 h, the liquid ethanol extracts of the root, stem, and leaf were filtered using Whatman filter paper No. 1 (Sigma-Aldrich Inc., USA) and concentrated in a *vacuum* at 40°C using a rotary evaporator. The dried extracts obtained were weighed and stored in stoppered sample vials at 4 ºC. The graded concentrations (12.5, 25, 50, 100, and 200 mg/mL) of the extracts were aseptically prepared using Dimethyl Sulphoxide (DMSO, USA) and shaken vigorously to obtain a homogenous mixture.[18]

Source and Re-identification of Test Clinical Isolates

The clinical isolates of *Klebsiella pneumoniae*, *Serratia fonticola*, *Staphylococcus aureus*, *Enterococcus faecalis*, *Candida albicans*, and *Trichophyton tonsurans* used in this study were obtained from the Research Laboratory of the University of Uyo Teaching Hospital, Uyo. The bacterial strains were checked for purity, maintained on nutrient agar slant at 4ºC, and re-identified using both conventional biochemical tests and the results obtained were compared with databases for bacterial isolates in *Bergey's Manual of Systematic Bacteriology*.[19] The fungi were re-identified using standard mycological protocol.[20]

Antimicrobial Activities of Ethanol Extracts of D. arborea

The antimicrobial activities of the leaf, stem, and root extracts of *D. arborea* were evaluated using the agar well diffusion method.[8] Approximately, 10 µL of bacterial suspension, prepared directly from an overnight agar plate and adjusted to a 0.5 McFarland standard, was streaked onto each nutrient agar (NA) plates, and the plates were allowed to dry for 5 min. The fungal isolates were also streaked onto each plate containing Sabouraud dextrose agar (SDA). Then, wells (6 mm in diameter) were punched over the culture plate using a sterile cork borer and each well was filled with 100 µL of 12.5, 25, 50, 100, and 200 (mg/mL) of each extract fraction. The plates were left for pre-diffusion for about 30 min at 37°C for 24 h (for bacteria) and at 28°C ± 2 for 3-5 days (for fungus and dermatophyte). Cephalexin and Metronidazole were the standard drugs used as positive controls for bacteria, while Fluconazole was used as a positive control for fungi and dermatophyte. The experiments were performed in triplicates. The culture plates were observed for the zone of inhibition (ZI) around the wells and were measured (in millimetres) using a metre rule.

Minimum Inhibitory Concentration (MIC) of Ethanol Extracts of D. arborea

The MIC of ethanol extracts of the leaf, stem, and root of *D. arborea* on the organisms was determined by the micro-broth dilution technique. One hundred microliters (100 µL) of each stock solution (200 mg/mL) of ethanol extracts of the leaf, stem, and root of *D. arborea* were serially diluted using nutrient broth in test tubes to obtain concentrations of 100, 50, 25, 12.5, and 6.25 mg/mL, respectively. In each test tube, 100 µL of each concentration of leaf, stem, and root of *D. arborea* were separately added to 9.9 mL of nutrient broth to give final concentrations of 200, 100, 50, 25, 12.5 and 6.25 µg/mL, respectively. Thereafter, each bacterial / fungal suspension was added to each test tube. All test tubes for bacteria were incubated at 37ºC for 24 h, while tubes for fungi were incubated at 28°C ± 2 for 3-5 days, and all tubes were examined for microbial growth. The MIC value was taken as the lowest concentration of the extracts that visibly inhibited the growth of the test bacteria / fungi after incubation.

Determination of Minimum Bactericidal Concentration (MBC) and Minimum Fungicidal Concentration (MFC) of Ethanol Extracts of D. arborea

The Minimum Bactericidal Concentration (MBC) of the crude ethanol extracts of root, stem, and leaf of *D. arborea* was determined after re-incubating the plates from the dilution test without visible bacterial growth at 37 ºC for 24 h.[7, 21] The mode of activity of the extracts was determined as either static (if there was no growth at 24 h but there was growth at 48 hrs) or cidal (if there was neither growth at 24 h nor 48 h).[22] The minimum fungicidal concentration was obtained by re-incubating the plates that showed no growth after 3-5 days at 28°C ± 2 for fungi (MIC) and dermatophyte (MIC). The lowest concentrations that did not show bacterial growth, and fungal and dermatophyte growth was taken as the MBC and MFC, respectively.

Statistical analysis

The Statistical Package for Social Sciences (SPSS Version 24.0) was used to analyze the data. The mean and standard deviation of zones of inhibition were calculated. The diameters of zones of inhibition with reference to the isolates were evaluated by linear regression analysis and were statistically significant at a p-value <0.05.

Results and Discussion

The problem of antibiotic resistance has persisted in many regions of the world, including both developing and developed nations, and has continued to pose difficulties for the healthcare sector.[18] The emergence and spread of multidrug-resistant organisms have posed a serious threat to the effectiveness of antibiotic therapy, necessitating a search for natural products of different higher plants that produce a variety of bioactive compounds with medicinal and antimicrobial capabilities.[23] Phytochemical analysis of ethanol root, stem, and leaf extracts of *D. arborea* showing antimicrobial activity revealed the presence of cardiac glycosides, flavonoids, tannins, saponins, and alkaloids. (Table 1). In this investigation, the detection of alkaloids, tannins, saponins, and flavonoids in the extracts of *D. arborea* substantiated the findings of Udo [13] on the phytochemical screening of *D. arborea*. The detection of saponins and flavonoids in the leaves, stems, and roots of *D. arborea* is consistent with the results of Ilodibia *et al*.[5] on the phytochemistry of various parts of *D. arborea* Link and *D. mannii* Bak. Alkaloids are naturally occurring and widely distributed chemical constituents in plants,[1] have an extremely bitter taste, [10] and the presence of alkaloids in the extracts of *D. arborea* supports the validity of their usage for therapeutic purposes. Saponins are glycosides with distinctive foaming characteristics and possess biological properties such as antimicrobial and antiinflammatory properties that make them useful as drugs. All vascular plants contain flavonoids, which are extensively dispersed throughout them. The phenolic structure of flavonoids contains one

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carbonyl group, which forms complexes with soluble extracellular proteins and bacterial cell walls to demonstrate antibacterial action,[24] while tannins have the ability to inactivate microbial adhesion, enzymes, cells envelop and transport proteins.[25]

The ethanol extracts of D. arborea root, stem, and leaf had no inhibitory effect on *S. aureus* at the concentration of 12.5 to 50 mg/mL, while the ethanol extracts of *D. arborea* root, stem, and leaf were active against *S. aureus* at concentration ranging from 100 to 200 mg/mL, with mean inhibition zone diameters ranging between 12.0 ± 1.0 and 20.0 ± 1.5 mm (Table 1). Of the three extracts tested, the ethanol extracts of *D. arborea* stem had the highest inhibitory activities against *E. faecalis*. The mean zones of inhibition measured were 10.0 ± 0.5 mm at 25 mg/mL, 13.0 ± 0.8 mm at 50 mg/mL, 16.7 ± 1.2 mm at 100 mg/mL, and 20.0 ± 1.0 mm at 100 mg/mL, respectively. The ethanol extracts of *D. arborea* root and leaf did not exert an inhibitory effect on *E. faecalis* at concentrations of ≤ 25 mg/mL, indicating non-antibacterial activity against *E. faecalis* (Table 2). The results of the antibacterial and antifungal activities of ethanol extracts of *D. arborea* in our investigation indicate these extracts have a broad spectrum of activity. However, our findings showed that the degree of the susceptibilities of the Gram positive and Gram-negative bacteria to ethanol extracts of *D. arborea* root, stem, and leaf differed, as evidenced by the zone of inhibition, and this may be a result of the physical and chemical compositions of the bacterial cell walls. The antibacterial and antifungal activities of these extracts may be attributed to their phytochemical constituents, most especially saponins.[5]

The ethanol extracts of *D. arborea* root had no inhibitory effect on *K. pneumoniae* at concentrations ranging between 12.5 and 200 mg/mL, while the ethanol extracts of *D. arborea* stem and leaf had a growth inhibitory effect on *K. pneumoniae* with mean inhibition zones ranging from 10.0 ± 0.0 to 18.0 ± 0.5 mm and 10.0 ± 0.0 to 18.8 ± 1.2 mm, respectively (Table 3).

Table 1: Phytochemical Analysis of Ethanol Root, Stem and Leaf Extracts of *D. arborea*

Phytochemical Constituents		Extracts of *D. arborea*		
		Leaf	**Stem**	**Root**
Tannins	Ferric Chloride	+	+	+
Saponins	Frothing	+	+	+
Flavonoids	Shinoda	+	-	+
Alkaloids	Dragendorff	-	+	-
Cardiac	Salkowski	+	+	+
glycosides	Lieberman	-	+	+
	Keller Kiliani	+	+	-
Anthraquinones	Bontrager	-	-	-

Keys: +: Detected -: Not detected

Table 2: Antimicrobial Efficacy of Ethanol Root, Stem and Leaf Extracts of *D. arborea* on *Staphylococcus aureus*

Concentration (mg/mL)	Inhibition zone diameter ($\bar{x}$ ± S.D)		
	Root	**Stem**	**Leaf**
200	20.0 ± 1.5^{b}	15.0 ± 0.5^{b}	16.3 ± 2.0^{b}
100	12.0 ± 1.0^{a}	14.0 ± 1.2^{a}	14.8 ± 1.0^{a}
50	NZ	NZ	NZ
25	NZ	NZ	NZ
12.5	NZ	NZ	NZ

Keys: No Zone of Inhibition (NZ); mm ($\bar{x}$); Standard Variation (S.D). Each value represents the means of triplicate and standard deviation; the mean within the column followed by the different superscript letters is significant according to Duncan's multiple range test ($p < 0.05$).

Table 3: Antimicrobial Efficacy of Ethanol Root, Stem and Leaf Extracts of *D. arborea* on *Enterococcus faecalis*

Concentration (mg/mL)	Inhibition Zone Diameter ($\bar{x}$ ± S.D)		
	Root	**Stem**	**Leaf**
200	14.0 ± 2.0^{a}	20.0 ± 1.0^{c}	16.1 ± 1.1^{b}
100	11.0 ± 0.0^{a}	16.7 ± 1.2^{b}	14.6 ± 1.0^{a}
50	10.0 ± 1.0^{a}	13.0 ± 0.8^{a}	12.3 ± 0.3^{a}
25	NZ	10.0 ± 0.5^{a}	NZ
12.5	NZ	NZ	NZ

Keys: No Zone of Inhibition (NZ); mm ($\bar{x}$); Standard Variation (S.D). Each value represents the means of triplicate and standard deviation; the mean within the column followed by the different superscript letters is significant according to Duncan's multiple range test ($p < 0.05$).

Table 4: Antimicrobial Efficacy of Ethanol Root, Stem and Leaf Extracts of *D. arborea* on *Klebsiella pneumoniae*

Concentration (mg/mL)	Inhibition Zone Diameter ($\bar{x}$ ± S.D)		
	Root	**Stem**	**Leaf**
200	NZ	18.0 ± 0.5^{b}	18.8 ± 1.2^{b}
100	NZ	15.2 ± 0.2^{b}	16.5 ± 0.5^{b}
50	NZ	11.0 ± 0.0^{a}	13.0 ± 0.5^{a}
25	NZ	10.0 ± 1.0^{a}	10.0 ± 0.0^{a}
12.5	NZ	NZ	NZ

Keys: No Zone of Inhibition (NZ); mm ($\bar{x}$); Standard Variation (S.D). Each value represents the means of triplicate and standard deviation; the mean within the column followed by the different superscript letters is significant according to Duncan's multiple range test ($p < 0.05$).

Table 5: Antimicrobial Efficacy of Ethanol Root, Stem and Leaf Extracts of *D. arborea* on *Serratia fonticola*

Concentration (mg/mL)	Inhibition Zone Diameter ($\bar{x}$ ± S.D)		
	Root	**Stem**	**Leaf**
200	20.0 ± 1.0^{c}	15.0 ± 1.5^{b}	23.0 ± 1.5^{c}
100	10.5 ± 1.0^{a}	12.0 ± 0.5^{a}	17.0 ± 1.5^{b}
50	NZ	10.0 ± 0.0^{a}	13.0 ± 0.5^{a}
25	NZ	NZ	NZ
12.5	NZ	NZ	NZ

Keys: No Zone of Inhibition (NZ); mm ($\bar{x}$); Standard Variation (S.D). Each value represents the means of triplicate and standard deviation; the mean within the column followed by the different superscript letters is significant according to Duncan's multiple range test ($p < 0.05$).

The results of the antimicrobial efficacies of ethanol root, stem, and leaf extracts of *D. arborea* on *S. fonticola* are presented in Table 4. A growth inhibitory effect of ethanol root, stem, and leaf extracts of *D. arborea* on *S. fonticola* ranged from 10.0 ± 0.0 to 18.0 ± 0.5 mm, 10.0 ± 0.0 to 18.8 ± 1.2 mm, and 10.0 ± 0.0 to 18.8 ± 1.2 mm, respectively (Table 4). The results of the anti-Candida activities of ethanol root, stem, and leaf extracts of *D. arborea* on *C. albicans* are presented on Table 5. It was observed that ethanol root, stem, and leaf extracts of *D. arborea* at the 200 mg/mL concentration possessed considerable anti-candida activity, as evinced in the highest mean zones of inhibition of ≤ 30.5 ± 2.5 mm, compared with the values obtained for the lower concentrations of the extracts. The ethanol root and leaf extracts of *D. arborea* did not exert an inhibitory effect on *C. albicans* at ≤ 25 mg/mL. The stem and leaf extracts of *D. arborea* have not shown any inhibitory effect on the growth of *T. tonsurans*, while the leaf extracts of *D. arborea* were strongly active against the *T. tonsurans* at concentrations ranging from 12.5 to 200 mg/mL, with mean inhibition zones ranging between 18.5 ± 0.5 and 30.0 ± 1.0 mm (Table 6). Similarly, the mean zone of

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inhibition of Metronidazole (2 mg/mL), against *E. faecalis* was 17.0 ± 0.0 mm, *K. pneumoniae* was 22.5 ± 3.54 mm, and *S. fonticola* was 16.0 ± 1.41 mm. The Cephalexin (50 mg/mL) showed a significant effect on the bacterial isolates, with the highest mean inhibition zone against *K. pneumoniae* (27.5 ± 3.54 mm), followed by *S. fonticola* (15.0 ± 1.41 mm) and *E. faecalis* (12.0 ± 0.00 mm), while *S. aureus* was resistant to Metronidazole and Cephalexin. *C. albicans and T. tonsurans* were sensitive to Fluconazole (2 mg/mL), with mean inhibition zones of ≤ 20.8 ± 0.7 mm (Table 7). In this study, the highest mean IZ (mm ± S.D) of 30.5 ± 2.5 mm and the lowest mean IZ (mm ± S.D) of 10.0 ± 0.0 mm were obtained when ethanol extracts of *D. arborea* were tested against the bacterial and fungal isolates, indicating that the higher the concentrations of the extracts, the higher the sensitivities of the organisms to the extracts, as shown by the increased size of the growth inhibitory zones. This observation is in conformity with Okigbo *et al*.[26] and Jagtap *et al*.[27] The increase in inhibitory effects of the extracts as the concentrations increased may be attributed to the ethanol extracting most of the active ingredients of the plants.[25]

Table 6: Antimicrobial Efficacy of Ethanol Root, Stem and Leaf Extracts of *D. arborea* on *Candida albicans*

Concentration (mg/mL)	Inhibition Zone Diameter ($\bar{x}$ ± S.D)		
	Root	Stem	Leaf
200	20.0 ± 1.0^{c}	30.5 ± 2.5^{c}	23.0 ± 0.5^{c}
100	15.0 ± 0.0^{b}	25.0 ± 1.0^{c}	19.0 ± 1.0^{b}
50	12.0 ± 0.5^{a}	22.5 ± 1.5^{c}	NZ
25	NZ	15.0 ± 0.5^{b}	NZ
12.5	NZ	10.5 ± 0.0^{a}	NZ

Keys: No Zone of Inhibition (NZ); mm ($\bar{x}$); Standard Variation (S.D). Each value represents the means of triplicate and standard deviation; the mean within the column followed by the different superscript letters is significant according to Duncan's multiple range test ($p < 0.05$).

Table 7: Antimicrobial Efficacy of Ethanol Root, Stem and Leaf Extracts of *D. arborea* on *Trichophyton tonsurans*

Concentration (mg/mL)	Inhibition Zone Diameter ($\bar{x}$ ± S.D)		
	Root	Stem	Leaf
200	30.0 ± 1.0^{c}	NZ	NZ
100	25.5 ± 0.5^{c}	NZ	NZ
50	22.0 ± 1.0^{b}	NZ	NZ
25	21.0 ± 0.0^{b}	NZ	NZ
12.5	18.5 ± 0.5^{a}	NZ	NZ

Keys: No Zone of Inhibition (NZ); mm ($\bar{x}$); Standard Variation (S.D). Each value represents the means of triplicate and standard deviation; the mean within the column followed by the different superscript letters is significant according to Duncan's multiple range test ($p < 0.05$).

Table 8: Antimicrobial Susceptibility of Bacterial and Fungal Isolates to Standard Drugs

Organisms	Inhibition Zone Diameter ($\bar{x}$ ± S.D)		
	Metronidazole	Cephalexin	Fluconazole
Bacteria			
S. aureus	NZ	NZ	NA
E. faecalis	17.0 ± 0.0	12.0 ± 0.0	NA
K. pneumoniae	22.5 ± 2.5	27.5 ± 1.5	NA
S. fonticola	16.0 ± 0.5	15.0 ± 1.0	NA
Fungi			
C. albicans	NA	NA	20.8 ± 0.7
T. tonsurans	NA	NA	18.0 ± 1.0

Keys: No Zone of Inhibition (NZ); mm ($\bar{x}$); Standard Variation (S.D); Not Applicable (NA) Each value represents the means of triplicate and standard deviation.

Table 9: MIC, MBC AND MFC of Ethanol Root, Stem and Leaf Extracts of *D. arborea* on Bacterial and Fungal Isolates

Organisms	Root			Stem			Leaf		
Bacteria	MIC	MBC	MBC/MIC	MIC	MBC	MBC/MIC	MIC	MBC	MBC/MIC
S. aureus	100	200	2	100	100	1	100	100	1
E. faecalis	50	200	4	50	200	4	50	100	2
K. pneumoniae	0	0	0	25	100	4	25	100	4
S. fonticola	100	200	2	50	100	2	50	100	2
Fungi	MIC	MFC	MFC/MIC	MIC	MFC	MFC/MIC	MIC	MFC	MFC/MIC
C. albicans	50	100	2	12.5	50	4	100	200	2
T. tonsurans	12.5	25	2	0	0	0	0	0	0

Keys: MIC: Minimum Inhibitory Concentration; MBC: Minimum Bactericidal Concentration; MFC: Minimum Fungicidal Concentration

The values for the MIC and MBC of ethanol root extracts of *D. arborea* on *S. aureus* and *S. fonticola* was 100 mg/mL and 200 mg/mL, respectively; the MIC and MBC values of ethanol leaf extracts of *D. arborea* on *E. faecalis* and *S. fonticola* was 50 mg/mL and 100 mg/mL, respectively, with a MBC/MIC ratio of 2, indicating bacteriocidal activities. The MIC and MFC values of ethanol stem extracts of *D. arborea* on *C. albicans* was 12.5 mg/mL and 50 mg/mL, respectively, with a MBC/MIC ratio of 4, indicating fungistatic activity (Table 8). Our results showed the bacteriocidal and fungicidal activities of extracts of *D. arborea*, and this agrees with Benjamin *et al*.[28] that MBC/MIC or MFC/MIC that is ≤ 4 is regarded as being bacteriocidal or fungicidal.
The regression values of extracts of *D. arborea* and zone of Inhibitions (ZIDs) as displayed by the microbial isolates ranged between 0.6525 and 0.9672 (Table 10). The relationship between concentrations of extracts of *D. arborea* and IZDs as exhibited by isolates are shown in Figure 1-6. The finding on the R^2 is consistent with the results of Ijato *et al*.,[8] who conducted the regression analysis between concentrations of extracts and diameters of IZs as exhibited by isolates.

Conclusion

The present study has shown additional detailed findings and information regarding the phytochemical constituents of ethanol root, leaf, and stem extracts of *D. arborea* and also revealed their considerable antibacterial and antifungal activities against clinical isolates, thus justifying their usage for therapeutic purposes and the consideration of developing synthetic drugs against clinical pathogenic isolates.

Conflict of Interest

The authors declare no conflict of interest.

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Authors' Declaration

The authors hereby declare that the work presented in this article is original and that any liability for claims relating to the content of this article will be borne by them.

Table 10: Regression Coefficient between Different Concentrations of Extracts of *D. arborea* and Inhibition Zones Diameters Exhibited by Isolates

	Regression (R^2)		
Isolates	Root	Stem	Leaf
S. aureus	0.9381	0.7883	0.8014
E. faecalis	0.7121	0.6909	0.6525
K. pneumoniae	-	0.6746	0.6425
S. fonticola	0.9573	0.7399	0.8173
C. albicans	0.7939	0.8261	0.8431
T. tonsurans	0.9672	-	-

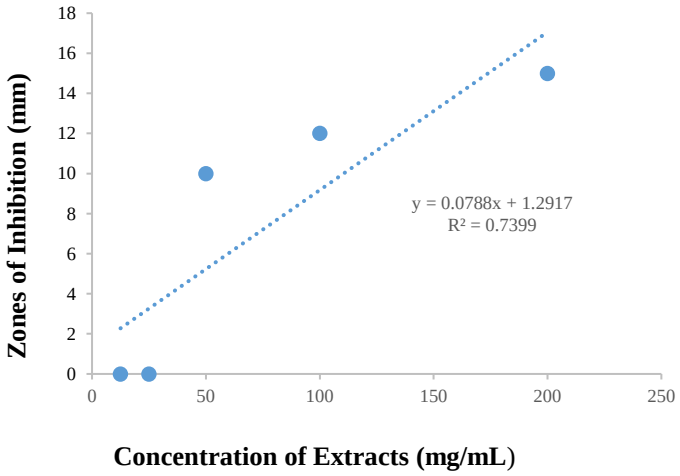

Figure 1: Relationship between conc. of the extracts of *d. arborea* inhibition exhibited by *E. faecalis*

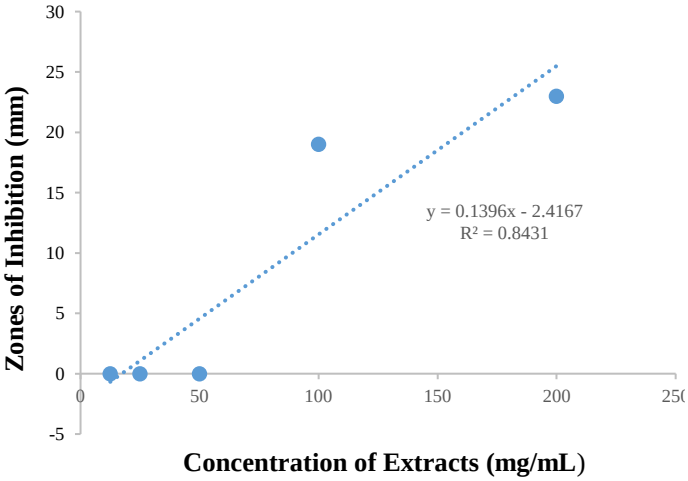

Figure 2: Relationship between conc. of the root extracts of *d. arborea* inhibition zones as exhibited by *S. fonticola*

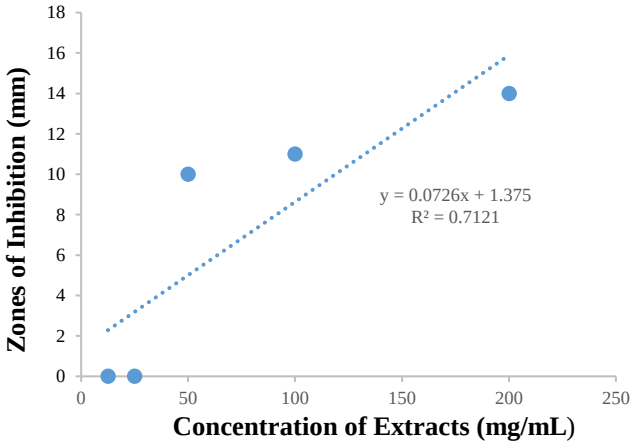

Figure 3: Relationship between conc. of the stem extracts of *D. arborea* inhibition leaf zones as exhibited by *C. albicans* zones as exhibited by *E. faecalis*

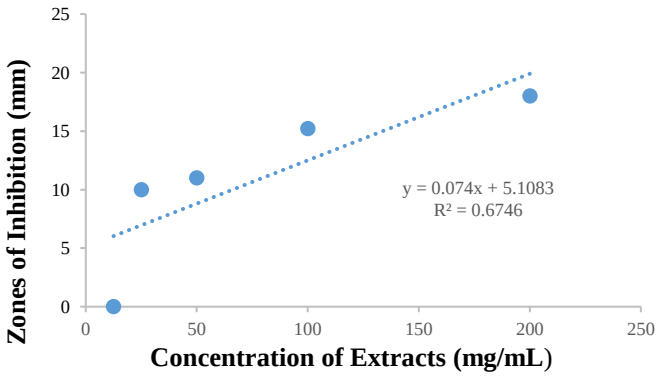

Figure 4: Relationship between conc. of the stem extracts of *D. arborea* inhibition zones as exhibited by *K. pneumoniae*

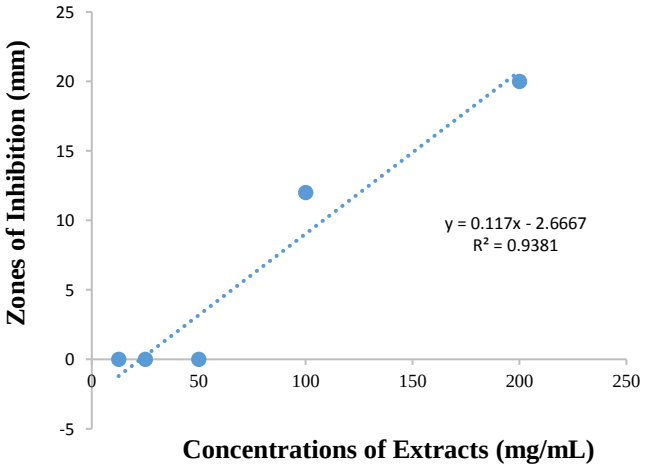

Figure 5: Relationship between conc. of the leaf extracts of *D. arborea* inhibition zones as exhibited by *S. aureus*

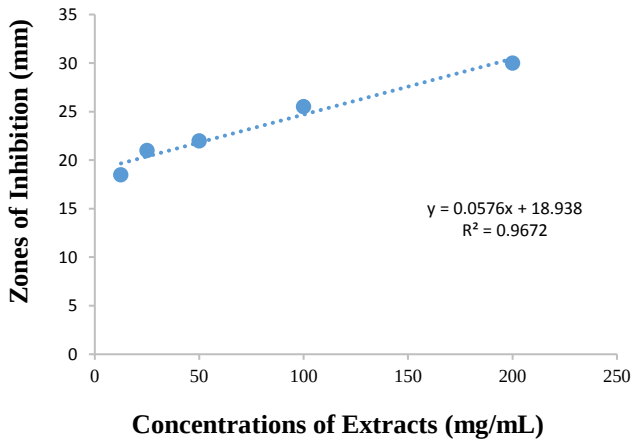

Figure 6: Relationship between conc. of the root extracts of *D. arborea* inhibition zones as exhibited by *T. tonsurans*

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