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Evaluation of Phytochemical Constituents and Antimicrobial Activity of Leaves and Stem Bark Extracts of *Sarcocephalus latifolius*

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Authors' contributions

This work was carried out in collaboration between all authors. Author OB designed the study and wrote the protocol. Authors FET and LMA wrote the first draft of the manuscript and carried out the bench work. Author OJJ managed the analyses of the study. Authors OB and OJJ managed the literature searches. All authors read and approved the final manuscript.

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ABSTRACT

Sarcocephalus latifolius is reported to have a wide range of medicinal properties and it is commonly used in the treatment of malaria, hypertension, diarrhea, dysentery and dental problems. Considering its characteristics, it is important to identify the phytochemical constituents and further evaluate the antimicrobial activity. Thus, this study was designed to identify the phytochemical constituents and to evaluate the antimicrobial activity of the leaf and stem bark extracts of *Sarcocephalus latifolius* on bacteria strains isolated from dental samples. The phytochemical compounds in leaf and stem bark extracts of *Sarcocephalus latifolius* were analyzed using GC-QP-MS. The mixture of bioactive compounds present in leaf and stem extracts of *Sarcocephalus latifolius* were tested against Gram-positive and Gram-negative bacteria for inhibition of growth

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using agar-cup-diffusion method. Results emerging from this study show that a total of 19 compounds and 25 compounds were identified from the leaf and stem bark extracts respectively. Decanoic acid, decanoic acid, benzene carboxylic acid and terpenes; phytol and farnesyl acetate were identified to be the main constituents. Furthermore, the extracts at concentrations of 25-50 mg/ml inhibited the growth of bacteria isolates in a manner that is comparable to the standard antibiotic ($p<0.05$). The significant zones of inhibition of bacterial growth by leaf and stem extracts of *Sarcocephalus latifolius* validates the use of extracts of *Sarcocephalus latifolius* in traditional medicine and as a promising source of antimicrobial agents.

Keywords: Sarcocephalus latifolius; phytochemical constituents; Zones of inhibition; antimicrobial activity; Minimum Inhibitory Concentration.

1. INTRODUCTION

Plants have been in use as a source of medicines that form the backbone of human healthcare from ancient times [1]. Plants are rich in a wide variety of secondary metabolites, such as tannins, terpenoids, alkaloids, and flavonoids, which have been found *in vitro* to have antimicrobial properties [2]. Africa's traditional healers use hundreds of indigenous plants extracts as remedies [3] in traditional medicine which is still the first point of healthcare for many people in sub-Saharan Africa where there has been a long and rich tradition of obtaining treatments from herbs and trees [4]. Most importantly, plant extracts represent a continuous effort to find new compounds with the potential to act against multi-resistant bacteria [5].

Sarcocephalus latifolius (African peach) is one of the numerous plant species strongly reported to have medicinal value. The plant is usually known as 'Africa cinchona' or 'Africa quinine' because of its reported anti-malarial activity [6]. Extracts from various parts of *Sarcocephalus latifolius* are reported to have a wide range of medicinal properties and it is commonly used in the treatment of malaria, hypertension, diarrhea and dysentery, dental problems, antimalarial, [7, 8, 9, 10]. The use of *Nauclea latifolia* extract as antimicrobial agent has also been justified by other workers [11-13].

Phytochemical compounds are biologically active components that have protective or disease preventive properties found in medicinal plants. Studies have shown that extracts of various parts of *Sarcocephalus latifolius* have shown the presence of bioactive compounds such as; tannins, flavonoids, alkaloids, saponins and anthraquinones [14]. Although the antimicrobial activity of extracts from *Sarcocephalus latifolius* has been reported, studies to determine the chemical compounds present in the extracts are scarce. Herein, the antimicrobial activity of phenolic compounds, terpenes, benzoic acid derivatives, decanoic acid and decanoic acid derivatives identified was evaluated.

2. METHODOLOGY

2.1 Chemicals, Reagents and Media

Glacial acetic acid (99.7%), Hydrochloric acid (99.6%), Sulphuric acid (98%), Sodium chloride (99.5%), Tannic acid (95%), Fehling's solution A & B, Absolute methanol (99.9%), Gentamicin, Sodium sulphate (99%), Lead sulphate (95%), Acetic acid anhydride (98.5%), 3,5-Dinitrobenzoic acid (99%), Ferric chloride (97%), Cetrimide agar and Mannitol salt agar were purchased from Sigma-Aldrich chemicals (Madrid, Spain). Chloroform (99.8%), Picric acid (97%), Ziehl-Neelson carbolfuchsin stain, Gram iodine solution, Gram decolorizer, Urea broth base, Blood agar, Muller Hinton agar, MRS agar, MacConkey agar, Nutrient agar and Nutrient broth were purchased from Fischer Chemicals (ThermoFisher, Waltham, MA, USA).

2.2 Extraction of Plant Sample

The leaf and stem bark of *Sarcocephalus latifolius* were separately collected from Iwo in Iwo Local Government Area of Osun state, Nigeria and identified at Forestry Research Institute of Nigeria (FRIN) Ibadan, Oyo state, Nigeria. The FHI number was 110286. Pulverized leaf and stem bark of *Sarcocephalus latifolius* (1 Kg each) were weighed respectively and extracted separately at 72hrs by cold maceration in purified re-distilled methanol [15]. The two extracts were concentrated at 40°C and pressure of 600 mmHg, using rotary evaporator so as to remove any trace of the solvent. Extracts obtained were freeze-dried, the percentage yield were determined and finally stored at 4°C until used.

2.3 Preliminary Phytochemical Screening

The presence or absence of phytochemical compounds of each extract was analyzed using qualitative tests as described [16-18]. Briefly,

Saponins: 1 gramme of each powdered extract + 10 ml distilled water + boiled for 10minutes on a water bath.

Frothing Test: 0.5 ml filtrate + 10 ml distilled water + shaken rigorously for 2 minutes. Frothing indicates saponin.

Emulsifying Test: 0.5 ml Filtrate + 2 drop of castor oil + shaken rigorously emulsification of the mixture indicates positive result.

Alkaloids: 1 gramme of each sample was extracted with 1 ml 10% HCI, on a water bath, filtered and the pH adjusted to about 6.

Dragendorff's reagent + 0.5 ml of the filtrate, brown to reddish brown indicates alkaloids.

Meyer's reagent + 0.5 ml of the filtrate, and was observed after several minutes. Yellow precipitate indicates the presence of alkaloid.

Wagner's reagent + 0.5 ml of the filtrate and brown precipitate indicates the presence of alkaloid.

Tannins: I g extract + 20 ml of distilled water + boiled for 5 minutes, filtered and readjusted to 20 ml. 1 ml of filtrate + dil. water + 0.1% $FeCl_3$, a dark blue coloration indicates tannins. 1ml of filtrate + 2 drops of bromine water added, white mucilaginous precipitate indicates tannins.

Cardiac glycosides: Keller-Killian test; One ml of each of extract was mixed with 5 ml of 70% alcohol for 2 minutes and filtered. 10 ml of water + filtrate + 0.5 ml of lead acetate and the mixture filtered. The filtrate + 5 ml chloroform. Chloroform layer + 3 ml glacial acetic acid + 2 drops of 5% ferric chloride solution. Solution + 2 ml conc. H_2SO_4 acid, a reddish brown layer formed at the junction of the two liquids indicated the presence of cardiac glycosides.

Anthraquinone glycosides: Borntrager's test; 2 drops of dilute H_2SO_4 + 1 ml of each extract, boiled and filtered. Filtrate +chloroform. Chloroform extract + 1 ml of ammonia, red color on the ammoniacal layer was observed indicating the presence of anthraquinone glycosides.

Flavonoids: Shinoda's test; To dry powder or extract, add 5 ml of 95% ethanol, few drops of conc. HCl and 0.5 g magnesium turnings. Pink color observed indicated the presence of flavonoid. To small quantity of the residue, add lead acetate solution. Yellow colored precipitate is formed. Addition of increasing amount of sodium hydroxide to the residue show yellow coloration, which decolorized after addition of acid is a positive test for flavonoid.

2.4 Determination of Chemical Constituents by GC-QP MS

Compounds identification was performed on a gas chromatography (GC) system coupled with quadruple (QP) mass spectrometer instrument (GC MS-QP 2010 plus) Shimadzu, Japan with split injection mode and linear velocity flow control mode.

To determine the chemical profile of leaf and stem bark extracts of *Sarcocephalus latifolious*, 8.0 µl of methanol extracts (1 mg/ml) was injected into a gas chromatography system with a microbore Agilent J & W DB-W 8270D with a triple axis detector (quadruple). The separation was achieved using capillary column (0.25 mm X 30 mm, particle size 0.25 µm) [Agilant Technologies, Palo Alto, California, USA] at a flow rate of 1.58 mL/min throughout the gradient. The mobile phase/carrier gas used was Helium gas. UV spectra were recorded using continuous scanning at a scanning speed of 1250 scan/min. The column was operated at a temperature of 80°C and pressure of 108.0 kpa.

The major operating parameters for the QP-2010 MS were set as follows: gas temperature 250°C, collision gas helium at 6.2 mL/min. The voltages were optimized and set at appropriate polarity for working in negative ionization mode. MS spectra were acquired over a mass range from m/z 40-600 Da. Automatic MS/MS experiments were carried out using constant collision energy of 70 eV. Integration and data elaboration were performed using Lab solution version 2.0 software (Shimazu, Japan).

2.5 Microbiological Screening of Plant Extracts

2.5.1 Collection of the dental sample and culture preparation

Microbial samples were collected from the Department of Oral and maxillofacial surgery,

University College Hospital Ibadan, Nigeria. A total of 30 samples were collected from a different part of the mouth of patients who came for check-ups at the University College Hospital, dental clinic, Ibadan. The examples included; 10 samples from plaque in the tooth, ten samples of buccal swab and ten samples from the carious or decayed tooth. Using sterile swabs, oral swab and carious samples were picked and introduced into the sterile peptone water in the sample bottles. This was then incubated for 24hours. Afterwards, each sample was streaked on mannitol salt agar, MRS agar and blood agar.

2.5.2 Identification of microbial cultures

Microbial cultures obtained from the dental clinics were isolated and identified using basic microbiological methods: microscopy and biochemical tests (Catalase, citrate, urease, coagulase, oxidase and indole tests). Standard laboratory strains; *Escherichia coli* ATCC 11175*, Salmonella enterica Typhimurium* ATCC 14028 from the Molecular and Biotechnology, Department of Pharmaceutical Microbiology, Faculty of Pharmacy, University of Ibadan were used as controls strains.

An overnight broth bacterial culture was used for each screening.

2.5.3 The antimicrobial assay using agar-cup-diffusion method

The agar-cup-diffusion method [19] was used with overnight broth. Appropriate cultures measuring 0.5 ml were inoculated into proper volumes of sterile molten and cooled Mueller Hinton agar, mixed, poured into a petri dish (14 cm) and allowed to set. Four equidistant holes were bored in the agar using sterile stainless steel cork borer (7 mm diameter). Forty (40) µl of extracts at various concentrations (50 mg/ml, 25 mg/ml and 12.5 mg/) were introduced into separate wells and the plates allowed to stand for 1 hour at room temperature and afterwards incubated at 37°C for 24 hours. Zones of inhibition were measured. Each extract was tested in duplicate, and a standard antibiotic (gentamicin 10 µg/ml) was used as positive control, while methanol served as negative control.

2.5.4 Determination of minimum inhibitory concentrations

Minimum inhibitory concentrations (MICs) for each test organism were assayed by a modification of microtitre plate broth dilution method where doubling dilutions of the compounds were employed [20]. Briefly, the test stock solutions were serially diluted with methanol to give the required working concentrations. Ten (10) µl of a 3-hour old broth culture of each test organism grown at 37°C in sterile nutrient broth was added to each well of a 48-well plate. The microtitre plates were covered and incubated at 37°C for 24 hours and observed for bacterial growth. One well contained standard antibiotic to provide reference MIC values for each test organism, while another well was used as the negative control, including only methanol. The MICs was recorded as the lowest dilution that inhibited bacterial growth.

2.6 Data Analysis

Unpaired Student's T-test was used to analyze all data using Statistical Package for the Social Sciences (SPSS) statistical software. Results are expressed as standard error of the means. $P < 0.05$ was considered statistically significant.

3. RESULTS

3.1 Phytochemical Screening of *Sarcocephalus latifolious* Extracts

Preliminary qualitative testing for the presence of phytochemical compounds was carried out on both leaf and stem bark extracts. The results indicate that both the leaf and stem extracts tested positive for the presence of all phytochemicals assayed except the leaf extract in which anthraquinones were absent (Table 1).

3.2 Compounds Identified In Leaf and Stem Extract of *Sarcocephalus latifolious* Extracts GC-MS

A total of 19 and 25 compounds were identified as summarized in Fig 1a, 1b and Table 2a, 2b respectively including retention time, m/z and molecular formula. In both the leaf and stem extracts, decanoic acid and its derivatives were

present in significant amounts. Other compounds detected were decanoic acid and its derivatives, 1,2,3-propanetriol, derivatives of benzoic acid (α-Hydroxytoluene, Benzene carboxylic acid, 1-Ethyl-2-nitrobenzene), 3,5-Dihydroxy-6-methyl-2,3-dihydro 4H-pyran-4-one, N-(5-Hydroxy-7-oxacyclohept-2-Cyl) acetamide, methylene, squalene, phytol, trans-squalene, farnesyl acetate and two sugars (β-D-glucopyranose and α-Methyl mannopyranoside).

Table 1. Phytochemical screening of *Sarcocephalus latifolious* extracts

Extract/ Phytochemical Group	Leaf	Stem bark
Alkaloids	++	+++
Anthraquinone	–	++
Glycoside	++	+
Flavonoids	++	+
Saponins	+	+
Tannins	+	++
Terpenoids	+	+

Key: +++: *Appreciable Amount, ++: Moderate Amount, +: Minute Amount, –:Not detected, initial weight of extract= 1Kg*

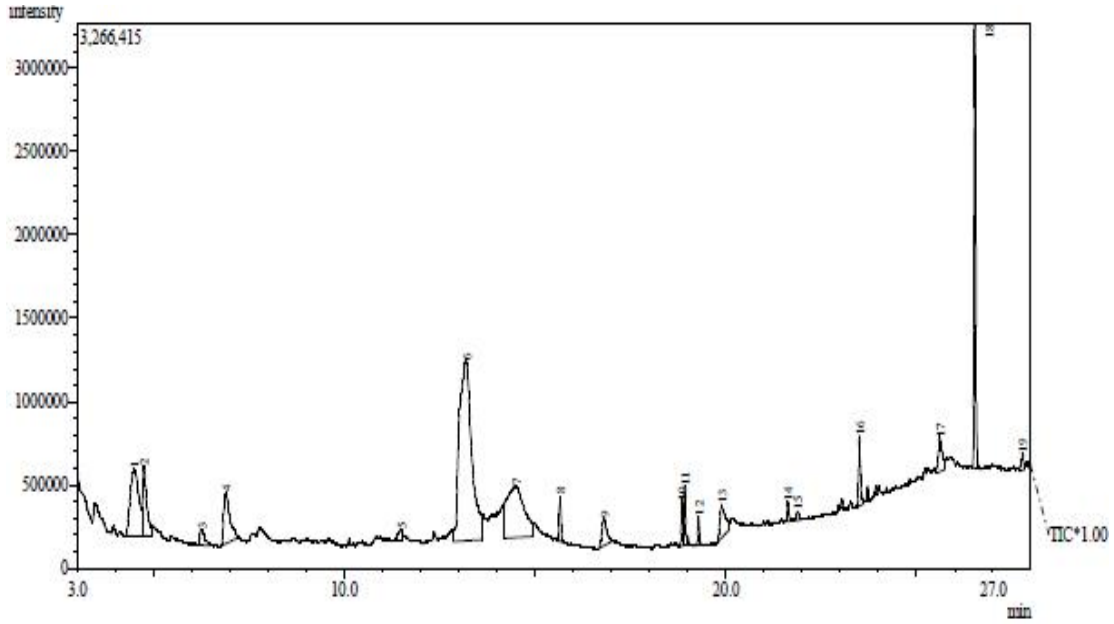

Fig. 1a. Base peak chromatogram of compounds from leaf extract

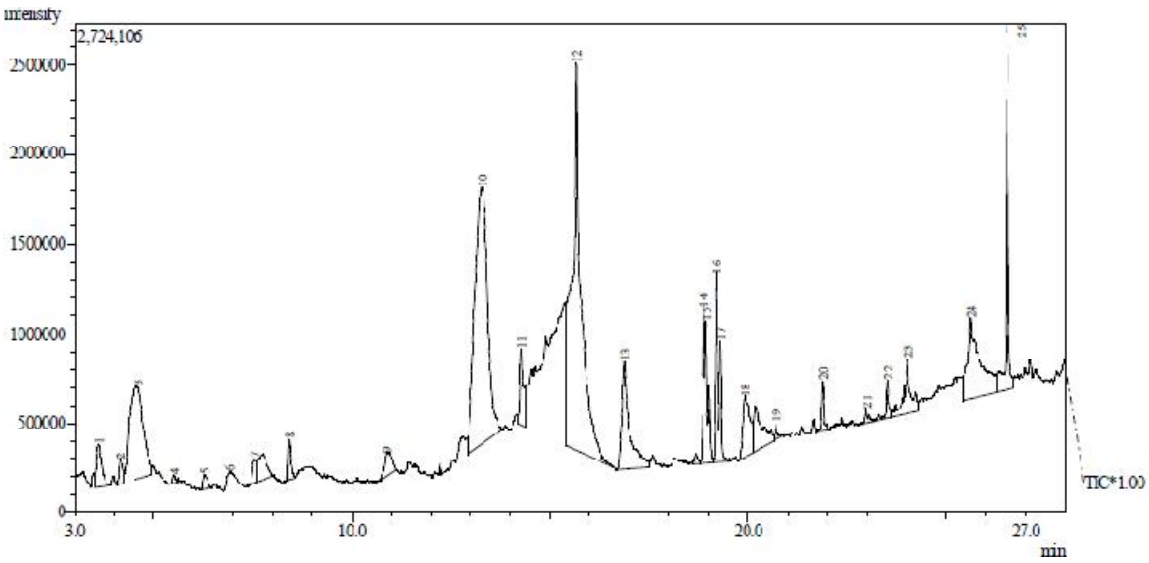

Fig. 1b. Base peak chromatogram of compounds from stem bark extract

Table 2a. Compounds identified in leaf extract using negative ions in GC-MS

Peak	Retention time (min)	% Area	m/z (M-H)	Molecular formula	Proposed compound
1	4.497	9.54	92	$C_3H_8O_3$	1,2,3- Propanetriol
2	4.764	4.57	108	C_7H_8O	α-Hydroxytoluene
3	6.273	1.24	144	$C_6H_8O_4$	3,5-Dihydroxy-6-methyl-2,3-dihydro 4H-pyran-4-one
4	6.907	5.09	122	$C_7H_6O_2$	Benzenecarboxylic acid
5	11.487	0.73	151	$C_8H_9NO_2$	1-Ethyl-2-nitrobenzene
6	13.191	36.25	162	$C_6H_{10}O_5$	Levoglucosan (β-D-glucopyranose)
7	14.502	14.91	194	$C_7H_{14}O_6$	α-Methylmannofuranoside
8	15.662	1.30	270	$C_{17}H_{34}O_6$	Methylene (Methyl hexadecanoate)
9	16.810	2.12	256	$C_{16}H_{32}O_2$	n-Hexadecanoic acid
10	18.866	1.23	266	$C_{17}H_{30}O_2$	7,10-Hexadecenoic acid methyl ester
11	18.929	1.72	296	$C_{19}H_{36}O_2$	10-Octadecenoic acid methyl ester
12	19.293	0.79	354	$C_{23}H_{46}O_2$	Methyl decanoate
13	19.902	2.99	338	$C_{22}H_{42}O_2$	13-Decosenoic acid
14	21.636	0.56	170	$C_{10}H_{18}O_2$	3-Decanoic acid
15	21.886	0.36	326	$C_{21}H_{42}O_2$	Methyl eicosanoate
16	23.510	1.91	182	$C_{12}H_{22}O$	Cyclododecene epoxide
17	25.607	2.17	210	$C_{14}H_{26}O$	3,11-Tetradecadien-1-ol
18	26.538	11.84	410	$C_{30}H_{50}$	Squalene
19	27.785	0.69	264	$C_{17}H_{28}O_2$	Farnesyl acetate

Table 2b. Compounds identified in stem extract using negative ions in GC-MS

Peak	Retention time (min)	% Area	m/z (M-H)	Molecular formula	Proposed compound
1	3.612	1.52	98	C_6H_6O	2-Methylcyclopentanone
2	4.170	0.75	116	$C_6H_{12}O_2$	Hexanoic acid
3	4.599	5.54	92	$C_3H_8O_3$	Glycerol
4	5.501	0.22	126	$C_8H_{14}O$	3-Ethyl-4-Methyl-3-Penten-2-one
5	6.283	0.44	144	$C_6H_8O_4$	3,5-Dihydroxy-6-Methyl-2,3-dihydro-4H-Pyran-4-one
6	7.543	0.62	120	C_8H_8O	2-Methylbenzaldehyde
8	8.417	1.60	150	$C_9H_{10}O_2$	4-(1-Hydroxyethyl) benzaldehyde
9	10.927	0.75	136	$C_8H_8O_2$	2-Hydroxy-4-Methylbenzaldehyde
10	13.269	1.13	171	$C_8H_{13}NO_3$	N-(5-Hydroxy-7-oxacyclohept-2-yl) acetamide
11	14.272	22.88	212	$C_{14}H_{28}O$	2-Tetradecen-1-ol
12	15.671	1.57	270	$C_{17}H_{34}O_2$	Methyl hexadecanoate
13	16.887	24.27	256	$C_{16}H_{32}O_2$	Hexadecanoic acid
14	18.700	5.62	266	$C_{17}H_{30}O_2$	Methyl(7E,10E)-7,10-Hexadecadienenoate
15	18.881	0.24	296	$C_{19}H_{36}O_2$	Methyl (10E)-10-octadecenoate
16	19.201	4.79	296	$C_{20}H_{40}O$	Phytol
17	19.927	4.48	254	$C_{16}H_{30}O_2$	9-Hexadecenoic acid
19	20.700	3.21	368	$C_{24}H_{48}O_2$	Methyl tricosanoate
20	21.900	2.72	270	$C_{17}H_{34}O_2$	Methyl-14-methylpentadecanoate
21	22.983	0.28	198	$C_{13}H_{26}O$	Tridecane aldehyde
22	23.524	0.71	182	$C_{12}H_{22}O$	Cyclododecene epoxide
23	24.023	0.32	330	$C_{19}H_{38}O_4$	Glycerol-1-palmitate
24	25.625	0.70	268	$C_{17}H_{32}O_2$	Methyl (7E)-7-hexadecanoate
25	26.548	2.64	410	$C_{30}H_{50}$	Trans-squalene

3.3 Antimicrobial Screening of *Sarcocephalus latifolius* Extracts

The antimicrobial susceptibility of test organisms to leaf and stem extracts of *Sarcocephalus latifolius* was determined using a hole-in-plate method and the result is shown in Table 3. The mean zones of inhibition ranged between 11.0±0.71 mm at 12.5 mg/ml to 16.0±0.71 mm at 50 mg/ml. The highest sensitivity with zone of

Table 3. The Antimicrobial screening of *Sarcocephalus latifolius* extracts

Strains/ concentration (mg/ml)	Zone of inhibition (mm)							
	Leaf				Stem			
	50	25	12.5	G	50	25	12.5	G
S. typhi UCH01	15.5±0.71	15.0±0.71	12.5±0.00	14.0±0.71	14.5±1.41	13.5±1.41	13.0±0.71	14.0±0.71
S. typhi UCH02	15.5±1.41	15.0±0.71	14.0±0.71	17.0±1.41	15.5±0.71	15.0±0.00	15.0±0.71	17.0±1.41
S. typhi UCH03	13.5±0.71	13.0±0.71	11.5±1.41	14.0±1.41	13.0±0.71	12.5±1.41	12.0±0.00	14.0±1.41
Lactobacillus spp.	16.0±0.71	15.0±1.41	13.0±0.71	12.0±0.71	13.0±1.41	12.0±0.71	11.0±0.71	12.0±0.71
S. enteric Typhimurium ATCC 14028	16.0±0.71	15.0±0.71	12.0±1.41	15.5±1.41	13.0±0.00	12.0±0.00	11.0±0.71	15.5±1.41
E. coli ATCC 11175	15.0±0.71	15.0±0.00	13.0±0.71	18.0±0.71	13.0±0.00	13.0±0.71	12.0±0.71	18.0±0.71

key: G: Gentamicin (10 µg/ml) M: Methanol=7.0±00 mm

Table 4. Minimum Inhibitory Concentration (MIC) of leaves and stem bark extract

Test organisms	MIC (mg/ml)	
	Leaves	Stem
S. Typhi UCH01	1.563	1.563
S. Typhi UCH02	0.782	1.563
S. Typhi UCH03	3.125	3.125
Lactobacillus spp	1.563	1.563
S. enterica Typhimurium ATCC 14028	3.125	3.125
E. coli ATCC 11175	3.125	3.125

inhibition of 16.0±0.71 mm was observed at 50 mg/ml against *Lactobacillus spp* and *Salmonella ecterica* Typhimurium ATCC 14028. At the lowest concentration (12.5 mg/ml) the extracts inhibited the growth of laboratory strains, *S. typhi* with mean zones of inhibition ranging from 11.5±1.41-15.00±0.00 mm. The mean zones of inhibition of bacterial growth by gentamicin (10 µg/ml) in test organisms ranged from 12.0 ± 0.71 mm to 18.0 ± 0.71 mm. There was no inhibition of bacterial growth in wells that contained the solvent methanol which served as the negative control.

3.4 Minimum Inhibitory Concentration (MIC) of the Extracts

The result of determination of MIC of leaf extract of *Sarcocephalus latifolius* showed that the MIC value for *S. Typhi* UCH02 was the lowest (0.782mg/ml), while *S. Typhi* UCH03 and *S. enterica typhimurium* ATCC 14028 exhibited the highest MIC values of 3.125 mg/ml. MICs of *S. Typhi* UCH01, *E. coli* ATCC 11175 and *lactobacillus spp.* was 1.563 mg/ml. For stem bark extract, the MIC values obtained was (1.56mg/ml) for *S. typhi* UCH01, *S. typhi* UCH02, *E. coli* ATCC 11175 and *lactobacillus spp.* While for *S. typhi* UCH03 and *S. enterica Typhimurium* ATCC 14028 the MIC was 3.125 mg/ml. This is shown in Table 4.

4. DISCUSSION

Medicinal plants have served as the models for many clinically proven drugs, and are now being reassessed as sources of antimicrobial agents [21-23]. However, most of the uses have been on an empirical basis. It is, therefore, necessary to scientifically evaluate the activity of plant extracts before considering them as useful antimicrobial agents.

This research evaluated the phytochemical compounds and the antimicrobial properties of leaf and stem bark extracts of *Sarcocephalus latifolius*. The results of the phytochemical screening of the plant extracts showed that the leaves and stems were rich in alkaloids, flavonoids, tannins and saponins. This result agrees with the previous findings of [14] on the presence of alkaloids, flavonoids, tannins and saponins in methanolic root extracts of *Sarcocephalus latifolius*. The composition of the phytochemical compounds obtained by GC QP-MS analysis revealed 18 compounds from the leaf extract, while 23 compounds were identified from the stem bark extract. The predominant constituents of the extracts were terpenoids, alkaloids, flavonoids, tannins and anthraquinones.

The result of the antimicrobial screening showed that all the tested strains were sensitive to both leaf and stem bark extracts of *Sarcocephalus latifolius* in a manner that indicates a significant antimicrobial activity comparable to that of standard antibiotic. At concentration >50 mg/ml, the extracts produced clear zones of inhibition of bacterial growth equivalent to that of the standard antimicrobial ($p<0.05$) on the tested bacterial strains. For bacterial strains, *S. enterica* Typhimurium 14028 and *E. coli* 11175 a significant difference ($p>0.05$) was observed between the mean zones of inhibition of growth with both the leaf and stem extracts at 12.5 mg/ml. The antimicrobial activity of the extracts may not be unconnected with the predominant chemical constituents notably; decanoic acid, decanoic acid, benzene carboxylic acid, their derivatives and terpenes (phytol and farnesyl acetate). [24] reported the inhibition of growth and biofilm formation of *Staphylococcus aureus* by *Cis*-2-decanoic acid. Phytol a compound identified in both leaf and stem bark extracts *Sarcocephalus latifolius* was shown to have excellent antimicrobial activity against *Escherichia coli*, *Candida Africans* and *Aspergillus niger* [25,26]. Similarly, [27] evaluated the antimicrobial activity of farnesol acetate which inhibited the growth of *S. aureus* and *Pseudomonas aeruginosa* [28]. Furthermore, 2,4-Dihydroxybenzoic acid and the sugars were found to exhibit excellent antimicrobial activity against some selected strains Gram negative and Gram-positive bacteria [29-31].

The minimum inhibitory concentrations of the leaf and stem bark extracts on all the tested bacterial strains followed a similar trend as the zones of inhibition of bacterial growth except for the strain *Salmonella typhi* UCH02 in which the MIC of the leaf extract was found to be half that of the stem bark extract. The low MIC of the leaf extract against the strain may be connected with strain variability.

5. CONCLUSION

The antimicrobial activity of leaf and stem extracts of *Sarcocephalus latifolius* against Gram-positive and Gram-negative bacteria appear to be a result of the synergistic effect of the mixture of bioactive compounds present in

the extract. This study, therefore, strengthens the use of the plant extracts for treatment of infections in traditional medicine.

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COMPETING INTEREST

Authors have declared that no competing interests exist.

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