Research Article / Review Article FUPRE JOURNAL 9(3):317-329(2025)

FUPRE Journal

of

Scientific and Industrial Research

ISSN: 2579-1184(Print) ISSN: 2578-1129 (Online)

http://fupre.edu.ng/journal

Phytochemical Screening, GC Analysis and Antimicrobial Activity of N-Haxane Extract of Cissus arguta Hook.f. (Sunset bell)

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ARTICLE INFO

Received: 23/04/2025
Accepted: 10/09/2025

Keywords

Antimicrobial, Cissus arguta, Medicinal Plants, n-hexane extracts, Phytochemical Screening

ABSTRACT

This study focused on determining the phytochemicals and the antimicrobial efficacy of the non-polar extract of the fresh stem of Cissus arguta using n-hexane. The phytochemical classes were determined by standard methods followed by Gas Chromatography – Mass Spectroscopic (GC-MS) analysis. Disc diffusion (Agar) method was used to determine the microbial sensitivity of extract against selected strains of micro-organisms, while broth dilution was used to determine the Minimum inhibitory concentration (MIC). The percentage yield of the extract was 1.03 %, revealing alkaloids, glycosides, saponins, steroids, tannins, and terpenoids via phytochemical studies. GC-MS results indicated free fatty acids as the major constituents (54.24 %) of the C. arguta n-hexane extract, closely followed by esters and terpenoids (41.50 %). The hydrocarbons were of alicyclic derivatives, with the least percentage composition (4.25 %). The extract showed antimicrobial potency against Escherichia coli (MIC:12.5 mg/mL; MBC: 25 mg/mL), Pseudomonas aeruginosa (MIC: 25; MBC: 25), Staphylococcus aureus (MIC: 25 mg/mL; MBC: 50 mg/mL), Bacillus subtlis (MIC:50 mg/mL; MBC: 100 mg/mL), Asperigillus niger (MIC: 25 mg/mL; MFC: 50 mg/mL). and Candida albicans (MIC:50 mg/mL; MFC: 100 mg/mL). The extract of C. arguta shows antimicrobial activity against all class of microbes, with the highest zones of inhibition against P. aeruginosa and S. aureus, but least active against the fungi strains. Specifically, C albicans show the highest resistance against the extract. The microbial activity and phytochemicals justify its folkloric usage.

1. INTRODUCTION

Plants are reliable source of medicine, and have been found to contain most biologically active phytochemicals (Ngo *et al.*, 2013) which are sometimes used in the manufacture of newly synthesized drugs. These products, namely glycosides, carotenoids, steroids, tannins, flavonoids and terpenoids, are derived from various parts of plants' roots and shoots, suggesting the usefulness of almost all parts of plants (Ajibesin, 2011). Though these and many other biologically active phytochemicals are found in many

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plants, the compounds are not well established due to limited knowledge of the chemistry and techniques in extracting them. Interestingly these vast range of chemical compounds were generated by plants to help them perform critical biological tasks and defend themselves against predators like insects, fungus, and herbivorous animals (Sandhya *et al.*, 2006). There are still many different plant species that contain therapeutic compounds that have not yet been discovered, despite numerous exploration of the plant kingdom for pharmacological and phytochemical potentials (Trease and Evans, 1996). The main essence of phytochemical screening in addition to revealing the components of plant extracts, is finding bioactive compounds for therapeutic medications (Sheel *et al.*, 2014).

Cissus are evergreen plants that can be perennials, shrubs, or climbers. They occasionally have succulent stems or rootstocks, simple or palmately lobed leaves, and clusters of inconsequential flowers followed by tiny berries. The larvae of several *Lepidoptera* species, such as *Hypercompeeridanus* and *Hypercompeicasia*, consume *Cissus* species as food plants. Chimpanzees consume them as well (Rex and Ravi, 2020). *Cissus arguta* plant, classified under the Vitaceae family, is a crawling plant most seen in the swampy areas of the southern part of Nigeria, precisely the Niger Delta. It is an herbaceous climber with internodes and leaves attached to petiole, the leaves are typically dark green in colour. Its known as "Humbudi" in Ijaw language and "Oshimere" by the Itsekiris of Delta State.

Phytochemical research of *Cissus* plants have revealed several bioactive compounds, including alkaloids, cardiac glycosides, flavonoids, saponins, steroids, tannins, and terpenes. Phytochemical studies reveal the existence of other compounds such as δ amyrin, δ amyrone, friedelan-3-one, glycerin, isopentacosanoic acid, nonanol, pallidol, perthenocissine, phytol, phytosterols, piceatannol, resveratrol, taraxerol, and taraxeryl acetate (Sudmoon *et al.*, 2016). The root, leaves, stem, and ash of the *Cissus* plant contain high concentrations of mineral elements, vitamins, and other substances (Omotayo and Borokini, 2012).

Cissus arguta as previously investigated showed it has medicinal value having phytochemicals which have curative properties. Hence, further investigation of the phytochemical contents could be a panacea to novel drug discovery or the use of *Cissus arguta* to enhance orthodox treatment. The health benefits of *Cissus arguta*, are attributed to phytochemical constituents that have physiological actions on the human body. These compounds possess various antimicrobial and antibacterial activities. *Cissus arguta* locally is used for the treatment of certain diseases such as blockage of blood vessels, body pains, boils, bone related diseases and disorders, chest pain, cough, intense fever, inflammation of the lymphatic nodes, piles, peptic ulcers, rashes, skin and sexually transmitted infections, as well as wounds. This plant helps against muscle and bone pains, as well as gout, leucorrhoea, and tumours (Sarkar *et al.*, 2016).

The screening of plant extracts has had an impressive history of identifying active agents. The choice of the stem part of *Cissus arguta* of interest in this work was based on its vast medicinal importance in West Africa. Therefore, there is reason for a scientific study to ascertain the medicinal potentials of this plant. The rising rate of mutation, especially in dangerous microorganisms, is one of today's biggest problems. With regard to these evolving strains, the majority of well-known, once reliable and efficient drugs appear to be losing their potency. This puts strain on currently available

chemotherapeutic agents (synthetic drugs) and asks for expanded and coordinated chemotherapy research. Drugs have historically been mostly sourced from medicinal plants. Utilizing a medicinal chemistry strategy, contemporary research initiatives to find and create new drugs are based on compounds obtained from plants.

The validation of the traditional usage of medicinal plants will ultimately provide scientific backing for the development of plants' bioactive constituents, which inturn, could provide novel compounds or precursors for the pharmaceutical industry. This study was therefore aimed at determining the phytochemicals, GC-MS profiling, and antimicrobial activity of *Cissus arguta* to verify its use in folkloric medicine.

2. MATERIALS AND METHODS

2.1 Extraction, Purification and isolation of Cissus arguta extract

Fresh stem of *Cissus arguta* samples were collected from Sapele Delta state. The plant was identified by Prof. B.Y. Abubakar of the Department of Botany, Faculty of Life sciences, Ahmadu Bello University, Zaria, Nigeria, with voucher number #ABU0291. Fresh samples of *Cissus arguta* were pulverized and extracted using soxhlet extractor. 50 g of sample was packed in a 500 mL soxhlet extractor. 300 mL of n-hexane was introduced to the extraction flask and was extracted for 3 hours. 20 g of anhydrous magnesium sulphate was then introduced to the flask containing extract in n-hexane and then swirled in order to remove any trace of water. This was then filtered, and the residue was washed thrice with n-hexane solvent into the flask containing the filtrate. The resulting filtrate was concentrated to a minimal volume using the Soxhlet extractor. The extract was poured into a weighed dish and allowed the rest of the hexane to evaporate and then weighed. Percentage yield of n-hexane extracts of *Cissus arguta* was then determined.

2.2 Phytochemical Analysis of Cissus arguta extract

The n-hexane extract obtained was screened for its photochemical constituents using standard procedures according to Sapunyo *et al.,* (2023). Phytochemical studies conducted include tannins (Ferric chloride test), saponins (Frothing test), alkaloids (Wagner's test), cardiac glycosides (*Keller- Killan test*), steroids, flavonoids, terpenes (Salkowsiac test), and anthraquinones (Borntrager's reaction for free anthraquinones).

2.3 Gas Chromatography Mass Spectroscopic Analysis of Cissus arguta extract

The bioactive chemical constituents of n-hexane extract of fresh *Cissus arguta* was subjected to GC analysis using an Agilent 7809A GC connected to Agilent MS detector. The MS detector was equipped with split/splitless injector which is interfaced with a selective detector that operated at exactly 70 eV. The source temperature set at 200 °C upon an MS range of m/z 50–700 at 1428 amu/sec scan rate. The GC column model was HP-5MS with 30 m length, internal diameter 0.25 mm and a film thickness of 0.25 μm. The oven temperature was programmed as follows: initial temperature of 80 °C for 2 min, increased at 10 °C/min to a temperature of 240 °C for 6 mins. Helium was used as the carrier gas at a flow rate of 1 mL/min. Injection volume, linear velocity and pressure were adjusted at 1.0 μL, 362 cm/s and 56.2 KPa, respectively. The oven temperature was set at an initial temperature of 60 °C, and the final temperature of 280 °C with a gradual increase of 10 °C/min within 3 mins. Both the injector and detector temperatures were fixed at 250

°C. The relative percentages of the essential oil components were obtained by FID peak-area normalisation, all relative response factors being taken as 1.

2.4 Antimicrobial Analysis of Cissus arguta extract

Antimicrobial sensitivity was determined by the use of Kirby-Bauer disc diffusion method as reported by Hudzicki (2009) with some adjustments. Six (6) microbes consisting of two Gram-negative bacteria (that is, *Escherichia coli* (*E. coli*) and *Pseudomonas aeruginosa* (*P. aeruginosa*)) and two Gram-positive bacteria (that is, *Staphylococcus aureus* (*S. aureus*) and *Bacillus subtilis* (*B. subtilis*)), with two fungi (that is, *Candida albicans*, and *Aspergillus niger*) were used in this study. All microbes were clinical isolates obtained from, and identified in the Department of Microbiology, University of Benin, Edo State, Nigeria.

Antimicrobial susceptibility Test: 15 mLs of freshly prepared Mueller Hinton agar was aseptically transferred into thirty-six (36) properly labelled sterile petri dishes (three plates per microorganism), and then allowed to cool and solidify. 0.1 mL of standard inoculum of each microbe was then transferred into, and evenly distributed on surfaces of sterilized medium contained in the plates. For each microorganism, three (3) petri dishes were used in order to have triplicate result for each organism. Seven (7) wells were then drilled on each plate, representing each concentration of the extracts as well as standard antibiotics as positive control (10 µg/mL gentamicin for bacteria, and 30% tioconazole for fungi) and Dimethyl sulfoxide (DMSO) as negative control. 0.1 mL of each concentration of the extracts of extracts and standards were then introduced respectively into separate wells on the medium, and incubated at 37 °C for 24 hours. Zone of inhibitions was then measured and the average of triplicate values calculated and recorded (in millimeters).

Determination of minimum inhibitory concentration: The minimum inhibitory concentration of the extract was determined using the broth double dilution method. 10 mLs of previously prepared Mueller Hinton broth was dispensed into test tubes. This was then sterilized at 121 °C for 15 mins, and then allowed to cool. The initial test solution of 10 mg/mL of extract was doubly diluted serially in sterile broth to achieve concentrations of 10 mg/mL, 5 mg/mL, 2.5 mg/mL, 1.25 mg/mL, and 0.63 mg/mL. 0.1 mL of inoculum of each micro organism previously standardized with McFarland Turbidity Standard was then inoculated aseptically into all test tubes containing the different concentrations of extracts. This was followed by incubation at 37 °C for 24 hours. The lowest concentration of the extract in the sterile broth that shows no turbidity after incubation was noted as the minimum inhibitory concentration.

Determination of minimum bactericidal (MBC) and minimum fungicidal concentrations (MIC): To determine the minimum concentration that is growth inhibitor or lethal to test microbes, MBC and MFC were carried out against bacteria and fungi respectively. Freshly prepared Mueller Hinton agar was poured into sterile petri dishes and were allowed to solidify. The contents of the MIC (sterile broth that shows no turbidity after incubation) in the serial dilutions were then inoculated onto the prepared medium. Incubation was then made at 37 °C for 24 hours, after which the plates of the medium was observed for growth. Concentration of the extract in plates where no colony growth was observed after incubation was recorded as the MBC/MFC.

3. RESULTS

Table 1 presents the physical properties as well as the percentage yield of *C. arguta*. The extraction of fresh stem of *C. arguta* using n-hexane yielded 1.03% of an amber colored extract.

Table 1: Percentage Yield and Appearance of n-hexane extract of *C. arguta*

Weight of Sample packed for Extraction (g)	50
Weight of extract (g)	0.515
Percentage yield (%)	1.03
Colour	Amber

Phytochemical analysis of n-hexane extract of *C. arguta* is represented in Table 2. Phytochemical screening of the n-hexane extract revealed alkaloids, glycosides, saponins, steroids, tannins, and terpenoids, while flavonoids, anthraquinones and phlobotanins were absent.

Table 2: Phytochemical Screening of n-hexane extracts of *C. arguta*

Phytochemical	**Test**	**Result**
Tannins	Ferric Chloride	+
Saponins	Frothing Test	+
Alkaloids	Wagner Test	+
Cardiac Glycosides	Keller-Killan Test	+
Steroids	Liebermann-Buchard Test	+
Flavonoids	Alkaline Reagent Test	-
Terpenes	Salkowsiac Test	+
Anthraquinones	Borntrager's Reaction	-

Key: + = present; - = absent

A total of fourteen (14) active components were determined from the GC-MS analysis containing three (3) carboxylic acids (54.24 %), seven (7) esters and terpenoids (41.50 %) and three (3) hydrocarbons (4.25 %). Tables 3, 4 and 5 shows the three class of compounds identified by the GC analysis.

Esters found in the extract were: 9-Octadecenoic acid (Z)-, methyl ester, Pentadecanoic acid, 14-methyl-, methyl ester, Methyl stearate, 9-Octadecenoic acid (Z)-, methyl ester, Methyl 10-trans,12-cis-octadecadienoate, 8,11-Octadecadienoic acid, methyl ester, Undec-10-ynoic acid, undec-2-en-1-yl ester, 15-Octadecenoic acid, methyl ester. Free acids were oleic acid, n-hexadecanoic acid and cis-vaccenic acid. The hydrocarbons were cyclododecane, bicyclo [3.1.1] heptane, 2,6,6-trimethyl and octahydro- 4,7-Methano-1H-indene.

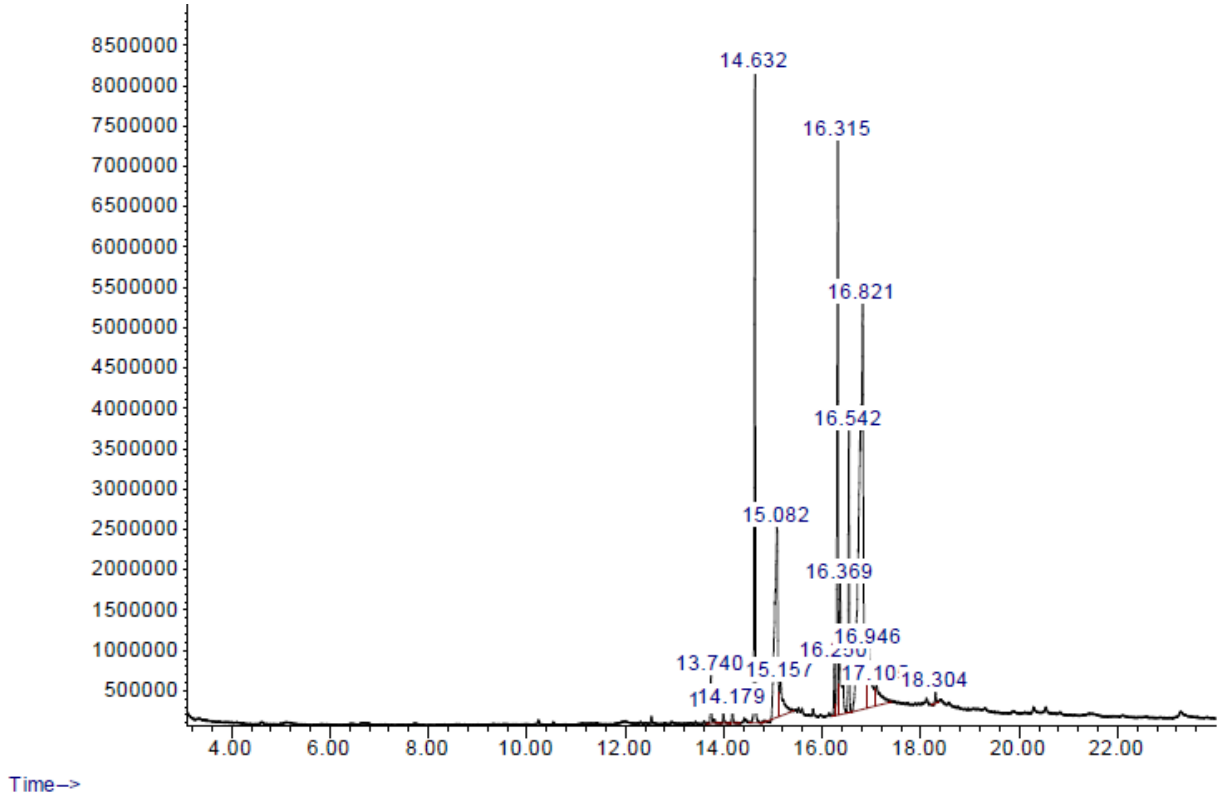
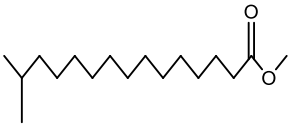
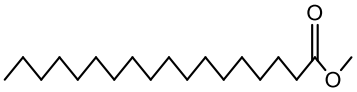
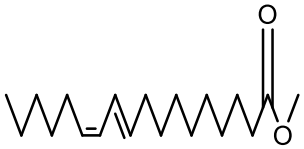


Figure 1: Gas Chromatogram of n-hexane Extracts of *C. arguta*

Table 3: Esters and terpenoids identified in the n-hexane extracts of *C. arguta*

Compounds	Structure	Retention time	Percentage composition (% area)
9-Octadecenoic acid (Z)-, methyl ester		16.313	18.32
Pentadecanoic acid, 14-methyl-, methyl ester		14.632	13.09
Methyl stearate		16.541	6.02
Methyl 10-trans,12-cis-octadecadienoate		17.107	2.29
8,11-Octadecadienoic acid, methyl ester		16.251	1.22

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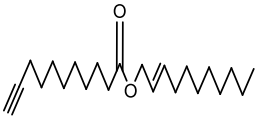
Undec-10-ynoic acid, undec-2-en-1-yl ester		13.993	0.31
15-Octadecenoic acid, methyl ester		18.305	0.25
Total			**41.50**

Table 4: Carboxylic acids identified in the n-hexane extracts of *C. arguta*

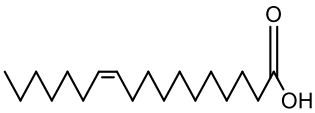
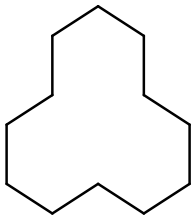
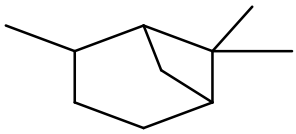
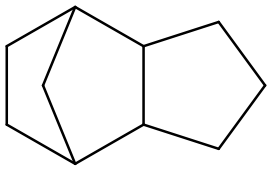
S/no	Compounds	Structure	Retention time	Percentage composition (% area)
1.	Oleic Acid		16.821	37.05
2	n-Hexadecanoic acid		15.083	12.71
3	cis-Vaccenic acid		16.946	4.48
	Total			**54.24**

Table 5: Hydrocarbons identified in the n-hexane extracts of *C. arguta*

s/no	Compounds	Structure	Retention time	Percentage composition (% area)
1	Cyclododecane		15.156	2.60
2	Bicyclo[3.1.1]heptane, 2,6,6-trimethyl		13.739	1.19
3	Octahydro- 4,7-Methano-1H-indene		14.180	0.46
	Total			**4.25**

Results for the antimicrobial analysis of n-hexane extracts of *C. arguta* are presented in Tables 6, 7 and 8. Accordingly, the n-hexane extracts of *C. arguta* shows antimicrobial activity against all class of microbes, with the highest zones of inhibition against *P. aeruginosa* and *S. aureus,* but least active against the fungi strains. Specifically, *C albicans* show the highest resistance against the *C. arguta* extract.

Table 6: Zones of Inhibition of Different Isolates at Different Concentrations of n-hexane extracts of *C. arguta*

Concentration of extract (mg/ml)	**Inhibition* (mm)**					
	Gram negative bacteria		**Gram negative bacteria**		**Fungi isolates**	
	E. coli	***Pseudomonas aeruginosa***	***S. aureus***	***Bacillus subtilis***	***Asperigillus niger***	***Candida albicans***
12.5	0±0.0	0±0.0	0±0.0	0±0.0	0±0.0	3.0±0.0
25	0.0±0.0	11.0±0.1	0.0±0.0	10.0±0.3	2.0±0.0	3.0±0.0
50	15.0±0.4	17.0±0.3	6.0±0.4	14.0±0.1	8.0±0.3	9.0±0.4
100	16.0±0.0	14.0±0.1	11.0±0.4	17.0±0.1	8.0±0.0	7.0±0.0
200	17.0±0.1	18.0±0.3	18.0±0.1	15.0±0.2	8.0±0.2	7.0±0.3
Negative control**	0	0	0	0	0	0
Positive control***	37.0	38.0	39.0	37.0	-	-
Positive control***	-	-	-	-	28.0	28.0

**Values are mean ± standard deviation of triplicate determinations **Negative control: DMSO (for Bacteria and fungi); ***Positive Control: Gentamicin (10 µg/mL) for bacteria, Tioconazole (30%) for fungi.*

The Minimum Inhibitory Concentration (MIC) of n-hexane extracts of *C. arguta* are shown in Table 7. The MIC results revealed variation in the MICs of the extract for given micro-organisms. As observed, the extract exhibit appreciable MICs for bacteria (especially *E. coli*), but lower inhibitory values for fungi. The lowest inhibition was 12.5 mg/mL (against *E. coli*). This was followed by an MIC of 25 mg/mL observed against *P. aeruginosa, S. aureus* and *A. niger.* Like *C. albicans*, *B. subtilis* gave the highest MIC values.

Table 7: Minimum Inhibitory concentration (MIC) of n-hexane extracts of *C. arguta*

Concentration of extract (mg/ml)	**Potency**					
	Gram negative bacteria		**Gram negative bacteria**		**Fungi isolates**	
	E. coli	***Pseudomonas aeruginosa***	***S. aureus***	***Bacillus subtilis***	***Asperigillus niger***	***Candida albicans***

0 (DMSO-control)	-	-	-	-	-	-
100	-	-	-	-	-	-
50.0	-	-	-	-	-	-
25.0	-	-	-	+	-	+
12.5	-	+	+	+	+	+
6.25	+	+	+	+	+	+

Key: + = Presence of Turbidity; - = Absence of Turbidity

The Minimum Bactericidal concentration (MBC) and minimum fungicidal concentration (MFC) of n-hexane extracts of *C. arguta* are shown in Table 8. Again, the extract shows the least MFC against *C. albicans* and *B. subtilis*, with an MFC and MBC values respectively of 100 mg/mL. This is followed by *S. aureus* and *A. niger*, having 50 mg/mL MBC and MFC respectively. The extract was most potent against *E. coli*, and *P. aeruginosa*, with an MBC of 25 mg/mL.

Table 8: Minimum bactericidal concentration (MBC) and minimum fungicidal concentration (MFC) of n-hexane extracts of *C. arguta*

Concentration of extract (mg/ml)	**Potency**					
	Gram negative bacteria		**Gram negative bacteria**		**Fungi isolates**	
	E. coli	***Pseudomonas aeruginosa***	***S. aureus***	***Bacillus subtilis***	***Asperigillus niger***	***Candida albicans***
0 (DMSO-control)	-	-	-	-	-	-
100	-	-	-	-	-	-
50.0	-	-	-	+	-	+
25.0	-	-	+	+	+	+
12.5	+	+	+	+	+	+

Key: + = Presence of Turbidity; - = Absence of Turbidity

4. DISCUSSION OF RESULTS

Percentage Yield

Extraction from plants is empirical since various solvents are utilized at different conditions such as duration, method of extraction and temperature (Krishnananda *et al.*, 2017), and the percentage yield of extract is a function of the nature of plant and solvent, temperature of extraction, and extraction methods. The percentage yield of the n-hexane extract of fresh *C. arguta* was 1.03 %, a far cry from the yield of *C. arguta* from recorded literature, which ranged from 4 to 15 % (Kumar and Patel, 2021). The observed low yield may be as a result of the nature of plant materials. Dried plant materials often have higher concentration of extractable compounds because moisture can dilute the active ingredients (Santos and Silva, 2018). Further, presence of moisture may interact with the hydrophilic components of the plant, making the matrix non-penetrable by the hydrophilic n-hexane.

Phytochemical Analysis of n-hexane extracts of C. arguta

Phytochemicals studies of medicinal plants have shown the presence of these compounds, most of which have been linked to anti-microbial, and other biomedical properties. Terpenoids have exhibited several medicinal properties like antimicrobial, anti-parasitic, antiviral, ant allergic, anti-inflammatory, chemotherapeutic, ant hyperglycemic and antispasmodic properties (Prakash and Gupta, 2009). Similarly, tannins and saponins have been reported to have exhibited protections against pathogens in addition to their antimicrobial, anti-inflammatory and antiulcer effects (Mert-Turk (2006). A review by Srivastava, *et al.*, (2020), discussed the antimicrobial effects of alkaloids, highlighting their potential as natural antimicrobial agents. Alkaloids extracted from plants have been found to possess antimicrobial properties, inhibiting the growth of certain microorganisms (Kumar *et al.*, 2018). Specifically, alkaloids isolated from *Berberis aristata* showed remarkable antimicrobial potency against *S. aureus*, *E. coli*, and *C. albicans* (Singh *et al.*, 2019). The antimicrobial effects of glycosides, as reviewed by Sharma *et al.*, (2020), highlighted their potential as natural antimicrobial agents. Glycosides extracted from *Vitis vinifera* (grape) exhibit antibacterial potency against *S. aureus, E. coli*, and antifungal potency against *C. albicans*. (Kim *et al.*, 2018). Similarly, glycosides isolated from *Terminalia chebula* exhibited antimicrobial effects against certain bacteria and fungi (Dey *et al.*, 2019). Steroids have proven to be natural and synthetic antimicrobial agents (Patel *et al.*, 2020). Natural steroids, such as cholesterol and ergosterol, showed remarkable antimicrobial potency against *S. aureus* and *C. albicans* (Liu *et al.*, 2018). Further, synthetic steroids, such as prednisolone and dexamethasone, exhibited antimicrobial effects against certain bacteria and fungi (Rajput *et al.*, 2019).

GC Analysis of n-hexane extracts of C. arguta

Presence of these phytochemicals in the extracts validates their usage for therapeutic purposes. Jain *et al.*, (2010) had reported the presence of heptacosane, tentatriacontane and hexatriacontane from *Cissus quadrangularis.*

Antimicrobial analysis of n-hexane extracts of C. arguta

The antimicrobial results obtained in this study is consistent with those in literature where Cissus species have been found to exhibit antimicrobial effects against various microorganisms, including bacteria, fungi, and viruses. Dickson *et al.*, (2012) had reported antibacterial and antifungal activity against *Aspergillus flarus, B. subtilis, C. albicans, Enterobacter spp, Enterococcus feacalis, E. coli, Klebsiella pneumonia, Microsporuim camb, Proteus mirabilis, S. aureus, Streptococcus pneumonia, Tenea pedis* as well as *Trichophyton*. Activity of *C. arguta* against *A. niger* as well and *P. aeruginosa* have not been previously reported. *C. quadrangularis* was reported to have exhibited remarkable antimicrobial activity against *S. aureus, E. coli*, and *C. albicans* (Jain *et al.*, 2018), *Cissus sicyoides* according to de Souza *et al.*, (2019), exhibited antimicrobial effects against certain bacteria and fungi, including methicillin-resistant *S. aureus* (MRSA). Similarly, the antimicrobial effects of various *Cissus species*, was discussed in a review by Ojewole *et al.*, (2020), highlighting their potential as natural antimicrobial agents. The antimicrobial efficacy of *Cissus arguta*, as revealed in this study, may not be unconnected to the phytochemicals present in them. Results from this study reveal the presence of alkaloids, glycosides and

steroids, among other phytochemicals. These plant chemicals have been found to exhibit antimicrobial effects against various microorganisms, including bacteria, fungi, and viruses.

5. CONCLUSION AND RECOMMENDATION

Phytochemical screening of the n-hexane extract of *C. arguta* revealed various bioactive metabolites which have shown antimicrobial, antiparasitic, antiviral, antiallergic, anti-inflammatory, chemotherapeutic, antihyperglycemic, antispasmodic and antiulcer effects. Presence of these compounds were confirmed by Gas chromatography (GC) analysis, and presence of these components in the extracts validated the usage of *C. arguta* for therapeutic purposes. The extract exhibited significant antimicrobial activity against a range of Gram-positive and Gram-negative bacterial strains, as well as some fungal strains. Overall, these findings suggest that the n-hexane extract of *C. arguta* has potential therapeutic properties that can be explored for the development of novel drugs or natural remedies. However, further studies are needed to determine the safety, efficacy, and mode of action of the extract.

STATEMENTS and DECLARATIONS

FUNDING

The authors declare that no funds, grants, or other support were received during the preparation of this manuscript.

COMPETING INTERESTS

The authors have no relevant financial or non-financial interests to disclose.

CONFLICT OF INTEREST

The author declares that there is no conflict of interests regarding the publication of this manuscript.

AUTHOR CONTRIBUTIONS

All authors contributed to the study conception, preparation, and design. Material preparation, data collection and analysis were performed by Mary Elire Edema and Hamzah Audu Bawa. Statistical analysis was performed by all authors. The first draft of the manuscript was written by Hamzah Audu Bawa and all authors commented on previous versions of the manuscript. The authors read and approved the final manuscript.

REFERENCE

Ajibesin, K. K. (2011). *Dacryodes edulis* (G. Don) HJ Lam: a review on its medicinal, phytochemical and economical properties. *Research Journal of Medicinal Plant*, *5*(1), 32-41.

Busson, F. (1965). Edible Plants of West Africa: A Botanical, Biological and Chemical Study. Marseille. Leconte.

Catalogue of Life (2007). Species 2000 and ITIS Catalogue of Life: 2007 Annual Checklist. Retrieved from: https://catalogueoflife.org on November 25th, 2023.

de Souza, R., de Souza, T., and Silva, M. (2019). Antimicrobial activity of Cissus sicyoides against certain bacteria and fungi, including MRSA. *Journal of Medicinal Food*, 22(10), 1039-1046.

Dey, P., Dey, J., and Ghosh, S. (2019). Antimicrobial activity of glycosides from Terminalia chebula. *Journal of Ethnopharmacology*, 231, 145-153.

Dickson, Udeme John; Igbe, Igbodaro and **Edema, Mary Olire** (2012) Antibacterial and antifungal activity and Bone healing Potency of methanol extract of *Cissus arguta* Hook F.Nig. J. Chem Research 17: 1 - 11

Ebido, C. J. (2000). Traditional Medicine and Superstition in Nigeria. *Journal of Herbal Medicine*, 1(1), 33-38.

Ingle, K. P., Deshmukh, A. G., Padole, D. A., Dudhare, M. S., Moharil, M. P., and Khelurkar, V. C. (2017). Phytochemicals: Extraction methods, identification and detection of bioactive compounds from plant extracts. *Journal of Pharmacognosy and Phytochemistry*, 6(1), 32-36.

Jain V., Thakur, R. S., and Laddha, K. (2010). Long chain aliphatic hydrocarbons from *Cissus quadrangularis*. *Indian Drugs*, 47 (5): 52 – 54

Jain, P., Jain, A., and Sharma, S. (2018). Antimicrobial activity of Cissus quadrangularis against certain microorganisms. *Journal of Ethnopharmacology*, 211, 241-248.

Kim, J., Kim, B., and Lee, S. (2018). Antimicrobial activity of glycosides from Vitis vinifera. *Journal of Medicinal Food*, 21(10), 1039-1046.

Kumar, R., and Patel, N. (2021). Extraction and Yield of Bioactive Compounds from *Cissus arguta*: A Comparative Study. *Journal of Herbal Medicine*, 15(4), 345-359.

Kumar, V., Kumar, V., and Singh, B. (2018). Antimicrobial activity of alkaloids from plant sources. *Journal of Ethnopharmacology*, 211, 241-253.

Liu, Y., Liu, X., and Jiang, Y. (2018). Antimicrobial activity of cholesterol and ergosterol against Staphylococcus aureus and Candida albicans. *Journal of Steroid Biochemistry and Molecular Biology*, 183, 145-153.

Ngo, L. T., Okogun, J. I., and Folk, W. R. (2013). 21st century natural product research and drug development and traditional medicines. *Natural product reports*, *30*(4), 584-592.

Ojewole, J., Ojewole, A., and Adeyemi, O. (2020). Cissus species as natural antimicrobial agents. *Journal of Pharmacy and Pharmacology*, 72(10), 1431-1442.

Omotayo, F. O., and Borokini, T. I. (2012). Comparative phytochemical and ethnomedicinal survey of selected medicinal plants in Nigeria. *Scientific Research and Essays*, *7*(9), 989-999.

Patel, H., Patel, S., and Shrivastava, S. (2020). Steroids as natural and synthetic antimicrobial agents. *Journal of Pharmacy and Pharmacology*, 72(12), 1731-1742.

Prakash, D., and Gupta, K. R. (2009). The antioxidant phytochemicals of nutraceutical importance. *The Open Nutraceuticals Journal*, *2*(1).

Rajput, S., Rajput, M., and Kumar, V. (2019). Antimicrobial activity of synthetic steroids against certain bacteria and fungi. *European Journal of Medicinal Chemistry*, 176, 241-248.

Rex, M., C., and Ravi, L. (2020). A review on *Cissus quadrangularis* L. as herbal medicine. *Indian Journal of Natural Products and Resources (IJNPR) [Formerly Natural Product Radiance (NPR)]*, 11(3), 155-164.

Sandhya, B., Thomas, S., Isabel, W., and Shenbagarathai, R. (2006). Ethnomedical plants used by the Valaiyan community of Piranmalai Hills (reserved forest),

Tamilnadu, India – A pilot study. *African Journal of Traditional, Complementary and Alternative Medicines, 3(1), 101-114.*

Santos, J. C., and Silva, T. S. (2018). *Principles and Techniques of Plant Extraction*. Academic Press.

Sapunyo, W. L., Mbaria, J. M., Kanja, L. W., Omolo, M. J., and Onyancha, J. M. (2023). Phytochemical Screening, Toxic Effects, and Antimicrobial Activity Studies of *Digitaria abyssinica* (Hochst. ex A. Rich.) Stapf (Poaceae) Rhizome Extracts against Selected Uropathogenic Microorganisms. *Evidence-Based Complementary and Alternative Medicine, 2023*.

Sarkar, B. K., Kumar, R., Kumar, P., Mandal, P. and Bhusan, V. (2016). Formulation and evaluation of anti-inflammatory herbal topical formulation of *Cissus quadrangularis* L., World Journal of Pharmaceutical Research, 5(3), 681–689.

Sharma, P., Sharma, A., and Shrivastava, P. (2020). Glycosides as natural antimicrobial agents. *Journal of Pharmacy and Pharmacology*, 72(10), 1431-1442.

Sheel, R., Nisha, K., and Kumar, J. (2014). Preliminary Phytochemical Screening of n-hexaneic Extract of *Clerodendron infortunatum*. *IOSR-Journal of Applied Chemistry*, 7(1), 10-13.

Singh, B., Singh, J., and Singh, S. (2019). Antimicrobial activity of alkaloids from Berberis aristata. *Journal of Pharmaceutical Sciences*, 108(1), 341-348.

Sofowora, A. (2008). Medicinal Plants and Traditional Medicine in Africa. Spectrum Books Limited.

Srivastava, S., Srivastava, S. K., and Mishra, J. (2020). Alkaloids as natural antimicrobial agents. *Journal of Pharmacy and Pharmacology*, 72(8), 1131-1144.

Sudmoon, R., Chaveerach, A., and Tanee, T. (2016). Analysis of genetics and chemical contents relation compared to commonly used *Cissus quadrangularis* L. and barcode markers of some Thailand Cissus species, *Pakistan Journal of Pharmaceutical Science,* 29(1), 65–75

Trease, G. E., and Evans, W. C. (1996). Phytochemical methods: a guide to modern techniques of plant analysis Pharmacognosy. *London: Bailliere Tindall*, 89-122.