

## Research Article

# Phytochemical Composition and Antibacterial Properties of *Senegalia macrostachya* Seed Extracts

Aminu Shehu Zagga<sup>1</sup>., Bala Zaki Tambuwal<sup>2</sup>., Umar Garba<sup>3</sup>., Murtala Alhaji Bello<sup>1</sup>, Bello Muhammad Achida<sup>4</sup> and <sup>5</sup>Abubakar Bashir Bande

<sup>1,4</sup>Department of Physics Shehu Shagari College of Education, Sokoto, Nigeria.

<sup>2</sup>Department of Geography Shehu Shagari College of Education, Sokoto Nigeria

<sup>3</sup>Department of Chemistry Shehu Shagari University of Education, Sokoto Nigeria

<sup>4</sup> Shehu Shagari College of Education Staff Secondary School Sokoto, Nigeria

<sup>5</sup>Department of Physics Federal College of Education Gidan Madi, Sokoto, Nigeria

\*Corresponding author's Email: [aminuzagga23@gmail.com](mailto:aminuzagga23@gmail.com), [doi.org/10.55639/607.02010014](https://doi.org/10.55639/607.02010014)

### ARTICLE INFO:

#### Keywords:

Phytochemical,  
Antibacterial,  
*Senegalia  
macrostachya*,  
Hexane,  
Ethyl acetate

### ABSTRACT

Antimicrobial resistance is a global problem which leads to fatalities worldwide, particularly in Africa. The aim of this research is to evaluate the phytochemical composition and antibacterial properties of *Senegalia macrostachya* seed extracts. Five hundred grams (500g) of the seed powder of *Senegalia macrostachya* were extracted with 2.5 liters of solvents sequentially (hexane, ethyl acetate and methanol). The solvent were evaporated at 45°C with rotary evaporator. The potential of *Senegalia macrostachya* seeds' phytochemical composition as sources of alternative medicines and for industrial uses were evaluated using the standard procedure for phytochemical assessment. Agar well diffusion methods were used for antibacterial properties evaluation. The results from this study show yields of 27.23 ± 0.05 g (5.45 ± 0.012%), 15.22 ± 0.02g (3.04 ± 0.004 %), and 99.26 ± 0.01 g (19.85 ± 0.002 %) for hexane, ethyl acetate and methanol respectively. The phytochemical composition shows tannins, Flavonoids, glycosides, Saponins, alkaloids, steroids, cardiac glycoside and saponin glycoside in both the three extracts. Extracts inhibited the growth of bacterial isolates; *Staphylococcus aureus*, *Shigella dysenteriae*, *Salmonella typhi* and *Escherichia coli* in the range (10.21 ± 0.32 - 28.25 ± 0.24 mm). The lowest MIC and MBC values were calculated for the extracts of *Senegalia macrostachya* seeds against both microorganisms tested; 0.025 mg/mL for *E. coli*, *S. typhi*, 0.05 mg/mL for *S. aureus*, *S. dysenteriae* (methanol extracts), 0.025mg/mL for *S. aureus*, *S. typhi* and *E. coli* (ethyl acetate extract), 0.025mg/mL for *E. coli*, 0.05mg/mL *S. aureus*, *S. typhi* and 0.1mg/mL *S. dysenteriae*. The *in vitro* antibacterial activities of the ethyl acetate extracts of *Senegalia macrostachya* seed were significantly higher (higher mean diameters of inhibition zones) than those of methanol and hexane ( $p < 0.05$ ), and ethyl acetate extracts gave the highest antibacterial effects. Based on the results obtained, *Senegalia macrosatchya* was seen to have an antibacterial effect against the tested bacterial isolates and therefore could be used for treatment of microorganisms to overcome the problem of antimicrobial resistance.

Corresponding author: Aminu Shehu Zagga Email: [aminuzagga23@gmail.com](mailto:aminuzagga23@gmail.com)  
Department of Physics Shehu Shagari College of Education, Sokoto, Nigeria

## INTRODUCTION

Antimicrobial resistance towards monotherapy or multiple antibiotic therapy is a spiraling problem because a growing number of infections are becoming harder to treat with current antibiotic treatments, and thereafter serious or even lethal health risks are raised. Multidrug-resistant organisms (MDROs), as reported by official organizations (WHO, ECDC), include, among others, *Mycobacterium tuberculosis*, *Enterococcus faecium*, *Enterobacter cloacae*, *Klebsiella pneumoniae*, and *Staphylococcus aureus* (Kakouri *et al.*, 2023). Bacterial infections are of global concern due to the fact that they contribute to a mortality rate of about 7.7 million deaths. These can be linked with antimicrobial resistance (AMR), which may arise as a result of indiscriminate use and misuse of antimicrobial drugs to treat infectious diseases, emergence and re-emergence of new diseases, poverty, lack of suitable vaccines, lack of access to antibiotics as well as emergence of antibiotic resistance strains (Muhammad *et al.*, 2022). Medicinal plants have been extensively used for a wide range of pharmacological properties since prehistoric times, and this trend is continuing in the modern era (Dwivedi *et al.*, 2023). Plants synthesized numerous phytochemical which are responsible for therapeutic functions. About 70-80 % of the populations of the world depend on medicinal plants for the treatment of diseases, particularly in developing countries (WHO, 2022). *Senegalia macrostachya* was belong to the plant of the family *fabaceae* (*Leguminose*), mostly found in Senegal, South Sudan and sub-Saharan African countries. The plant grows primarily in the dry season up to 15 metres tall. The plants have been used in traditional medicine practices for the treatment of varieties of infectious diseases such as diarrhea, malaria with convulsion, snake bite, old wound, prostatic enlargement etc. (Chika *et al.*, 2022; Coulibaly *et al.*, 2020). The type of solvent employed in the extraction process has a significant impact

on the effective extraction, identification, and separation of bioactive components from plant material (Muhammad *et al.*, 2022). The literature found indicates that the physiologically active components of this plant are responsible for its therapeutic qualities. Therefore, the purpose of this study was to assess the *Senegalia macrostachya* seed's phytochemical composition, as well as its antibacterial activity, which may have industrial and medical uses. *Senegalia macrostachya* seed were found to be good sources for antibacterial agents for the benefit of mankind particularly in developing and less developed countries.

## MATERIAL AND METHODS

### Sample collection and identification

The sample of *Senegalia macrostachya* seed pods were collected from Jabo town, Tambuwal local government area of Sokoto state. It was identified at the Department of Pharmacognosy and Ethnopharmacy Faculty of Pharmaceutical Sciences, Usmanu Danfodiyo University, Sokoto, Nigeria with Voucher number PCG/UDUS/Faba/0016b.

### Sample Preparation

The samples of *Senegalia macrostachya* seed pods were washed with a running tap and distilled water air dried for seven (7) days. The seeds were separated from the seedpods manually by hand. The seeds were grounded with the aid of an electrical grinder, sieved into fine powder and preserved in airtight plastic containers prior to extraction and further analysis.

### Extraction of Plant Material

Five hundred (500g) of dried plant material were extracted with sample solvents ratio (1:5, i.e 500g of sample with 2500 cm<sup>3</sup> of solvents) sequentially with (95% n-Hexane, 99.5% ethyl acetate, and 99.85% methanol). The solvent were evaporated at 45°C with the aid of rotary evaporator. After drying, the resultant crude extract were weighed to calculate the yield %, it underwent bioassay analysis (Kakuri *et al.*, 2023).

$$\text{Percentage Yield (\%)} = \frac{\text{weight of extract}}{\text{weight of plant material}} \times 100 \dots \dots \dots (1)$$

### Preliminary Phytochemical Screening

Standard procedures for phytochemical screening with little modification as reported by

Muhammad *et al.* (2022) Nortjie *et al.* (2023) and Mussa *et al.* (2024) were adopted:

**Determination Alkaloids**

Dragendorff's Test: Three (3) drops of Dragendorff's reagent were added into a test tube containing (2 cm<sup>3</sup>) of *Senegalia macrostachya* seed extracts. The formation of a reddish-brown precipitate indicates alkaloids are present (Muhammad *et al.*, 2022, Mussa *et al.*, 2024).

**Test for Cardiac glycosides (Keller Kiliani)**

A small amount of *Senegalia macrostachya* seed extracts (50 mg) were taken into test tubes, dissolved in 1 cm<sup>3</sup> of glacial acetic acid containing three (3) drops of ferric chloride solution. The solution were then transferred to a cleaned test tube and 2 cm<sup>3</sup> of sulfuric acid were added. A formation of a brown ring at the interface indicates the presence of cardiac glycoside (Muhammad *et al.*, 2022; Mussa *et al.*, 2024).

**Test for Flavonoids**

Ferric Chloride Test: Two (2 cm<sup>3</sup>) of 5% ferric chloride solution were added into test tubes containing 5 cm<sup>3</sup> *Segegalia macrostachya* seed extracts. The formation of green precipitate showed the presence of flavonoids (Muhammad *et al.*, 2022).

**Test for Saponins Frothing test**

Two centimeter cubes (2 cm<sup>3</sup>) of *Senegalia macrostachya* seed extracts were diluted with 5 cm<sup>3</sup> of distilled water in a 100 cm<sup>3</sup> measuring cylinder and shaken vigorously, then allowed to stand for 15 minutes. Persistent foaming indicated the presence of saponins (Muhammad *et al.*, 2022 Nortjie *et al.*, 2023; Mussa *et al.*, 2024).

**Test for Tannins**

Ferric Chloride Test: two centimeter cubes (2cm<sup>3</sup>) of *Senegalia macrostachya* seeds extract were diluted with five centimeter cubes (5 cm<sup>3</sup>) of distilled water. The mixtures were heated, boiled for five (5) minutes, and then two drops (2) of 5% ferric chloride were added. The formation of greenish precipitate indicated the presence of tannins (Muhammad *et al.*, 2022; Nortjie *et al.*, 2023; Mussa *et al.*, 2024).

**Test for Terpenes/steroids**

Liebermann-Buchard's Test: Small quantity (0.5g) of *Senegalia macrostachya* seed extracts were diluted in 2cm<sup>3</sup> of chloroform, Five centimeter cube (5cm<sup>3</sup>) acetic anhydride were added followed by 1cm<sup>3</sup> of concentrated sulfuric

acid were added to the solution. The formation of green colouration indicates the presence of steroids/terpene (Muhammad *et al.*, 2022; Mussa *et al.*, 2024).

**Test for Anthraquinones**

Borntrager's Test: Two centimeter cube of *Senegalia macrostachya* seed extract were added to 2 cm<sup>3</sup> of 10% ammonia solution. The formation of rose-pink color indicates the presence of anthraquinones (Muhammad *et al.*, 2022; Mussa *et al.*, 2024).

**Preparation of Extracts Concentration for Antibacterial test**

Four (4) sets of concentrations (0.2 mg/mL, 0.1 mg/mL, 0.05 mg/mL and 0.025 mg/mL) were prepared from the stock concentration of extracts (1g dissolved in 5mL Dimethyl Sulfoxide (DMSO) followed by serial dilution. For the 0.2 mg/mL solution, 2 mL, the stock concentration were mixed into a 10 mL volumetric flask and diluted with 10ml of DMSO and were mixed well. For the 0.1 mg/mL extract concentration, 1 mL of the 0.2 mg/mL solution was piped into a 10 mL volumetric flask. Solvents DMSO were added to the flask and were mixed well. For the 0.05 mg/mL concentration of the extract, 0.5 mL of the 0.1 mg/mL extract concentration were piped and transferred into a 10 mL volumetric flask. The solvent DMSO was added to the flask and were mixed well. Also, for the 0.025 mg/mL extract concentration, 0.25 mL of the 0.1 mg/mL extract concentration were piped and transferred into a 10 mL volumetric flask. The solvent DMSO was added to the flask up to the mark.

**Antibacterial assessment of *S. macrostachya* seed extracts**

The bacterial isolates used for this study were obtained from department of microbiology Usmanu Danfodiyo University, Sokoto, Nigeria. The four (4) bacterial isolates are; *Staphylococcus aureus*, *Shigella dysenteriae*, *Salmonella typhi* and *Escherichia coli*.

**Preparation of inoculum**

Inoculum preparation both strains of bacteria were left overnight for culture in Mueller–Hinton agar medium at 35°C. Using a spectrophotometer, the growth of bacteria was harvested in 5 mL of sterile saline water, and the cell count was diluted to 10<sup>7</sup> CFU/mL at 580 nm (Kakour *et al.*, 2023).

**Antibacterial activity of *Senegalia macrostachya* seed extract**

The antibacterial activity of *Senegalia macrosatachya* seeds extract were determined via a agar well diffusion method. 0.2 mg/mL (stock concentration) was prepared by dissolving 1g of the extracts in 5 cm<sup>3</sup> dimethyl sulfoxide (DMSO). Muller Hinton Agar were prepared according to manufacturer's instructions and were sterilized for 15 minutes at 121°C, poured into sterile petri dishes and allowed to cool and solidified, inoculated and incubated for 24 hours. The solidified sterile mediums were seeded with 0.1mL standard inocula of the test bacteria; the inoculums were spread over the surface of the medium with the aid of a sterile swab stick. Wells were bored into the solidified inoculated nutrient agar plate using a cork borer of 6 mm diameter. The wells were filled with 0.1 ml DMSO solution of the extract and allowed to diffuse for 1 h. Incubation of the inoculated medium was made at 37°C for 24. The Ciprofloxacin disc was used as a positive control for antibiotics. The zone of inhibition around the wells was recorded in millimeters (mm) and used as antibacterial activity of *Senegalia macrostachya* seeds extracts (Muhammad *et al.*, 2022; Kakour *et al.*, 2023; Asaolu *et al.*, 2024).

**Determination of minimum inhibitory concentrations of the effective *Senegalia macrostachya* seed extracts**

After 24 h of incubation, the MIC was characterized by a low concentration of antibacterial agents that prevent microbial growth. By using the method of disc diffusion, the most effective extracts of plants, having strong antimicrobial activities at 0.2 mg/mL, were modified to calculate their MIC by dissolving 1g of the extracts in 5 cm<sup>3</sup> dimethyl sulfoxide (DMSO), filtering it with a Millipore filter and transferring the required

amount to sterile discs, effective plant extracts with different concentrations (0.2 mg/mL, 0.1 mg/mL, 0.5 mg/mL, 0.025 mg/mL,) were produced (the discs had 8 mm in diameter). Pathogenic strains of cultured bacteria were infused using Mueller–Hinton agar into sterile Petri dishes. Various amounts of extracts were obtained and loaded onto filter paper discs; Mueller–Hinton agar plates were later covered. The plates were then kept at 5°C in the fridge for 2 h and then incubated for 24 h at 35°C. By the help of Vernier caliper inhibition zones were determined and compared to the concentration of the effective extract of the plant (Imran *et al.*, 2021; Muhammad *et al.*, 2022; Kakour *et al.*, 2023).

**Determination of minimum bactericidal concentrations of the effective *Senegalia macrostachya* seeds extract**

Two streaks of plates bearing MIC inhibitory zones with little concentration were collected and cultivated in tryptone soya agar (TSA) plates that displayed limited growth. Next, the plates were put for incubation at 35°C for 24 h. The growth of bacteria was observed in different plant extract concentrations. On freshly infected agar plates, MBC was defined as the extract of plant concentration that did not show any bacterial growth (Imran *et al.*, 2021; Muhammad *et al.*, 2023; Kakour *et al.*, 2023).

**Statistical Analysis**

All experiments were performed in triplicates. The results were presented as the mean value  $\pm$  the estimated SD. Significance differences between extracts means were determined by a student's t test using minitab-17 statistical software. The significance level was set to 0.05, and the confidence intervals were at  $\pm 95\%$  CI. The data were presented as mean  $\pm$  standard deviation (SD).

## RESULTS AND DISCUSSION

Table 1 Yield of *Senegalia macrostachya* seed obtained using various solvents

Extracts	Yield (g)	Yield % (W/W)	Color
Hexane	27.23 ± 0.05*	5.45 ± 0.012	Golden-yellow
Ethyl acetate	15.22 ± 0.02*	3.04 ± 0.004	Green
Methanol	99.26 ± 0.01*	19.85 ± 0.002	Brown

\* Results are presented as mean ± standard deviation (SD) (n = 3) (p < 0.05).

Extraction yield is affected by the solvent and extraction process (Jisieike *et al.*, 2020). The extraction process used must allow for full extraction of the chemicals of interest while avoiding chemical alteration (Dwived *et al.*, 2023). In this study, extraction of *Senegalia macroactahya* seeds was achieved by macerating dry powder with solvents. To acquire the true extraction yield, extracts were further concentrated on a water bath by completely evaporating the solvents. Determining the extraction percentage yield is an important phenomenon in phytochemical extraction to evaluate the standard extraction efficiency for a particular solvent (Dwive *et al.*, 2023). Table 1 shows yields of extraction obtained from *Senegalia macrostachya* seeds using hexane, ethyl acetate and methanol as solvents. The yield of plant extracts varies substantially depending on the solvent, hexane extract were found to be golden yellow in colour and have yields of (27.23 ± 0.05g; 5.45 ± 0.012 %), ethyl acetate greenish in color

(15.22 ± 0.02g, 3.04 ± 0.004 %) while methanol extracts brown in color (99.26 ± 0.01g, 19.85 ± 0.002%). From Table 1 above, methanol extract have high yield compared to the other extracts, followed by hexane and ethyl acetate respectively. In order to identify the bioactive chemicals of the plants used for extractions, the choice of solvent is essential. Low toxicity, easy evaporation at low temperatures, good solubility of the target molecule, and adequate volatility are characteristics of the ideal extraction solvent (Nortjie *et al.*, 2023). The results of extract yield obtained for methanol extract was found to be higher than (57.46 g, 5.75 %) as reported by Muhammad *et al.* (2022) and lower than 113.12g (22.624 %) for methanol extract *Acacia macrostachya* leave as reported by Garba *et al.* (2024) This indicates that the seed from *Senegalia macrostachy* plant have appreciable % yield, and also shows high amount of polar compounds.

Table 2: Results of Phytochemical Composition of *Senegalia macrostachya* seed extracts

Composition	Test	Inference		
		Hexane	Ethyl acetate	Ethanol
Flavonoids	Ferric Chloride	+	+++	+
Alkaloids	Dragendoff	+	+++	++
Saponins	Frothing	+	++	++
Glycosides	Killer kilani	+	++	+
Steroids/terpenes	Lieberman Bu	+	+++	++
Tannins	Ferric Chloride	+	+++	++
Cardiac glycoside	Killer kilani	++	+++	+
Anthraquinones	Borntrager	ND	ND	ND

Key: Trace Amount = +, Moderate Amount = ++, Large Amount = +++, Not Detected (ND)

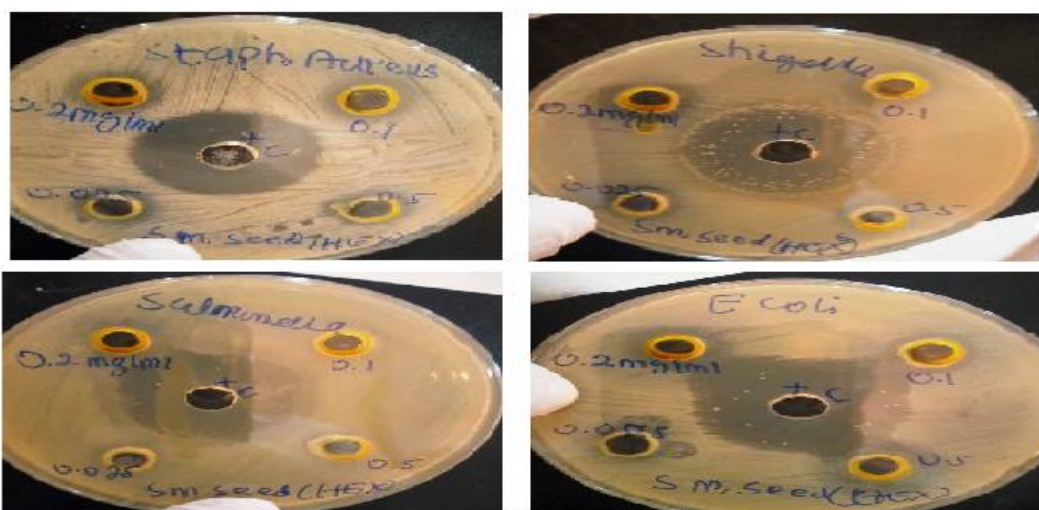
The results of phytochemical composition of *Senegalia macrostachya* seeds extracts showed the presence flavonoids, tannins, saponins, steroid, alkaloids and cardiac glycosides from both extracts. Flavonoids, tannins, steroids, alkaloids and cardiac glycoside are found in large amount in ethyl acetate extracts followed by methanol and hexane, while anthraquinones were not detected as presented in Table 2 above. This indicated that the *Senegalia macrostachya* seeds have vast amount of secondary metabolite. These secondary metabolite are of pharmacological importance, for instance, plants that are rich in tannins exhibit some activity

such as anti-diarrhea, anti-inflammatory and antioxidant activity (Khalid *et al.*, 2022). Saponins, phenols and flavonoids are known to have antimicrobial activities; such as antifungal, antibacterial, anti-allergenic, antispasmodic and anti-inflammatory (Khalid *et al.*, 2022; Rodríguez-Negrete *et al.*, 2024). Likewise Alkaloids have been reported to aid in anti-diuretic activity of medicinal plants (Khalid *et al.*, 2022 Muhammad *et al.*, 2023). The seeds from *Senegalia macrostachya* have similar phytochemical with that of *Rothmania longiflora* seeds as reported by Muhammad *et al.* (2022)

**Table 3a:** Results for Antibacterial Properties of *Senegalia macrostachya* seeds hexane extracts

Organism	Extract concentration / Zone of inhibition				Standard
	0.2mg/mL	0.1 mg/mL	0.05mg/mL	0.025mg/mL	
<i>Staphylococcus aureus</i>	15.20 ± 0.23 <sup>a</sup> mm	14.04 ± 0.04 <sup>a</sup> mm	11.26 ± 0.26 <sup>b</sup> mm	0 mm	31.35 ± 0.24 mm
<i>Shigella dysenteriea</i>	11.24 ± 0.22 <sup>b</sup> mm	10.23 ± 0.12 <sup>c</sup> mm	0 mm	0 mm	40.27 ± 0.24 mm
<i>Salmonella typhi.</i>	15.08 ± 0.25 <sup>a</sup> mm	11.12 ± 0.17 <sup>b</sup> mm	10.21 ± 0.32 <sup>a</sup> mm	0 mm	35.26 ± 0.33 mm
<i>Escherichia coli</i>	17.26 ± 0.16 <sup>b</sup> mm	14.07 ± 0.06 <sup>a</sup> mm	12.12 ± 0.24 <sup>d</sup> mm	10.23 ± 0.21 <sup>c</sup> mm	33.05 ± 0.09 mm

Results are presented as mean ± standard deviation (SD) (n = 3) (p < 0.05) a–d and values with the same letter are non-significantly different (p < 0.05).

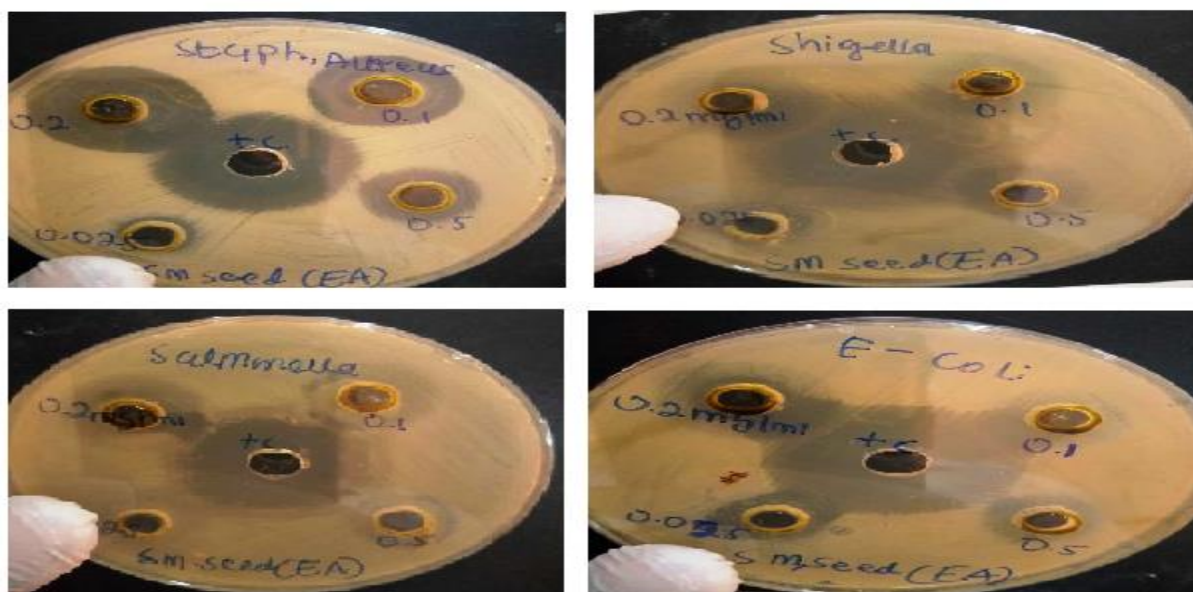


**Plate 1:** Antibacterial Disc for Hexane *Senegalia macrostachya* (Sm) seed (HE) Extract

**Table 3b:** Results of Antibacterial properties of *Senegalia macrostachya* seeds Ethyl Acetate Extracts

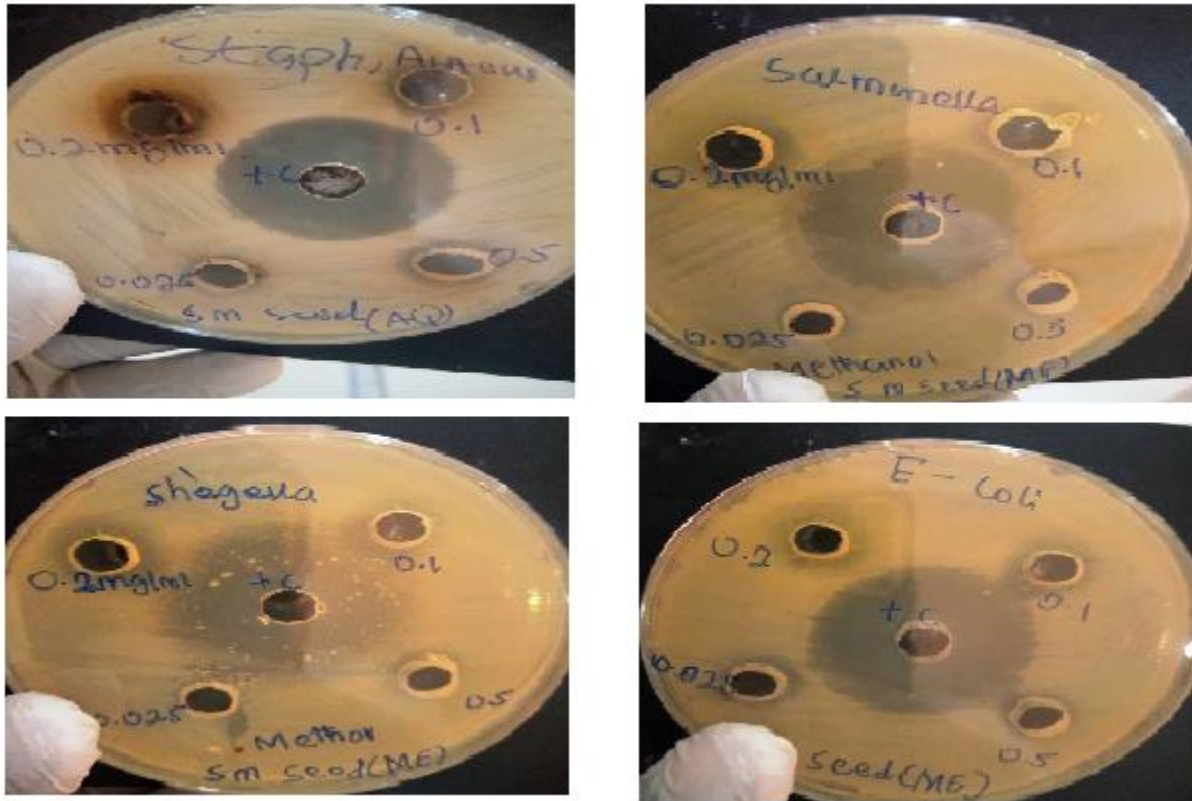
Organism	Extract conc. / zone of inhibition				Standard
	0.2mg/mL	0.1mg/mL	0.05mg/mL	0.025mg/mL	
<i>Staphylococcus aureus</i>	28.25 ± 0.24 <sup>a</sup> mm	22.23 ± 0.22 <sup>b</sup> mm	18.12 ± 0.09 <sup>b</sup> mm	12.02 ± 0.23 <sup>c</sup> mm	31.23 ± 0.27mm
<i>Shigella dysenteriea</i>	12.06 ± 0.16 <sup>c</sup> mm	10.02 ± 0.21 <sup>c</sup> mm	0 mm	0 mm	40.27 ± 0.24 mm
<i>Salmonella typhi.</i>	22.28 ± 0.19 <sup>b</sup> mm	20.27 ± 0.65 <sup>b</sup> mm	18.23 ± 0.23 <sup>b</sup> mm	14.08 ± 0.23 <sup>c</sup> mm	35.02 ± 0.23mm
<i>Escherichia coli</i>	21.22 ± 0.19 <sup>b</sup> mm	16.03 ± 0.26 <sup>b</sup> mm	14.06 ± 0.09 <sup>c</sup> mm	11.21 ± 0.05 <sup>c</sup> mm	33.05 ± 0.92mm

Results are presented as mean ± standard deviation (SD) (n = 3) (p < 0.05). a–c and values with the same letter are non-significantly different (p < 0.05).

**Plate 2:** Antibacterial Discs for Ethyl Acetate (EA) Extracts**Table 3c:** Antibacterial of *S. macrostachya* seeds methanol extracts

Organism	Extract conc. / zone of inhibition				Standard
	0.2mg/mL	0.1mg/mL	0.05mg/mL	0.025mg/mL	
<i>Staphylococcus aureus</i>	19.23 ± 0.26 <sup>a</sup> mm	17.06 ± 0.16 <sup>a</sup> mm	10.45 ± 0.25 <sup>b</sup> mm	0 mm	31.23 ± 0.47mm
<i>Shigella dysenteriea</i>	15.02 ± 0.11 <sup>a</sup> mm	13.02 ± 0.33 <sup>b</sup> mm	11.21 ± 0.23 <sup>b</sup> mm	0 mm	40.25 ± 0.26 mm
<i>Salmonella typhi.</i>	20.21 ± 0.23 <sup>a</sup> mm	18.32 ± 0.17 <sup>a</sup> mm	16.08 ± 0.22 <sup>a</sup> mm	15.09 ± 0.32 <sup>a</sup> mm	35.05 ± 0.26 mm
<i>Escherichia coli</i>	17.02 ± 0.34 <sup>a</sup> mm	15.02 ± 0.90 <sup>a</sup> mm	12.23 ± 0.19 <sup>b</sup> mm	11.29 ± 0.31 <sup>b</sup> mm	33.08 ± 0.02 mm

Results are presented as mean ± standard deviation (SD) (n = 3) (p < 0.05). a–d and values with the same letter are non-significantly different (p < 0.05).



**Plate 3:** Antibacterial disc for methanol (ME) extracts

Resistance to antibiotics is a spiraling health problem. Current antibiotic therapies gradually become ineffective or are sometimes inadequate to treat infections, an issue that, according to the WHO, prolongs hospitalization and increases costs and mortality rates. In this regard, the discovery of new antibiotics is urgent. Auspicious solutions against antibiotic resistance are naturally derived products (Kakuri *et al.*, 2023). The antibacterial properties of *Senegalia macrostachya* seed extracts were evaluated against four (4) bacterial isolates; *Staphylococcus aureus*, *Shigella dysenterea* and *Samonella typhi* and *Escherichia coli*, at various concentration of 0.2mg/mL, 0.1 mg/mL, 0.5mg/mL and 0.025 mg/mL respectively. Antibacterial properties for hexane extract, *Staphylococcus aureus* (0.2mg/mL; 15.20 ± 0.23mm; 0.1 mg/mL; 14.04 ± 0.04mm; 0.05 mg/mL; 11.26 ± 0.26 mm, and for standard ciprofloxacin, 0.5mg/mL; 31.35 ± 0.24 mm) This results were found to be little bit high than (10±1.3mm) as reported by Dwivedi *et al.*

(2023) for leaf extract of *Plumbago zeylanica* and also were found to be lower (27±2.3mm) for root of *Plumbago zeylanica* as reported by Dwivedi *et al.* (2023). This show that the extracts (hexane) form *Senegalia macrostachya* possess antibacterial properties. For *Shigella dysenteriea*; (0.2 mg/mL; 11.24 ± 0.22 mm, 0.1 mg/mL; 10.23 ± 0.12 mm standard 40.27 ± 0.24 mm), for *Salmonella typhi*; (0.2 mg/mL; 15.08 ± 0.25 mm, 0.1 mg/mL; 11.12 ± 0.17 mm, 0.05 mg/mL 10.21 ± 0.32 mm for standard 35.26 ± 0.33mm). For *Escherichia coli* (0.2 mg/mL ; 17.26 ± 0.16 mm, 0.1 mg/mL; 14.07 ± 0.06 mm, 0.05 mg/mL; 12.12 ± 0.24mm, 0.025 mg/mL; 10.23 ± 0.21 mm for the standard 33.05 ± 0.09 mm) This results were found to be lower than (16 mm) for *A. indicum* seed extract as reported by Selvara *et al.* (2021) . The highest zone of inhibition recorded in hexane extract was 17.26 ± 0.16 mm in *Escherichia coli* at 0.2mg/ml. Nevertheless, for ethyl acetate extract, the following zone of inhibition was recorded; *Staphylococcus aureus* (0.2mg/mL; 28.25 ± 0.24



mm, 0.1 mg/mL;  $22.23 \pm 0.22$  mm, 0.05 mg/mL;  $18.12 \pm 0.09$  mm, 0.025 mg/mL;  $12.02 \pm 0.23$  mm and for standard ciprofloxacin 0.5mg/mL;  $31.23 \pm 0.27$  mm). For *Shigella dysenteriae*; (0.2 mg/mL;  $12.06 \pm 0.16$  mm, 0.1 mg/mL;  $10.02 \pm 0.21$  mm standard  $40.27 \pm 0.24$  mm), for *Salmonella typhi*; (0.2 mg/mL;  $22.28 \pm 0.19$  mm, 0.1 mg/mL;  $20.27 \pm 0.65$  mm, 0.05 mg/mL;  $18.23 \pm 0.23$  mm, 0.025 mg/mL;  $14.08 \pm 0.23$  mm for standard  $35.02 \pm 0.23$  mm). For the *Escherichia coli* (0.2 mg/mL ;  $21.22 \pm 0.19$  mm, 0.1 mg/mL;  $16.03 \pm 0.26$  mm, 0.05mg/mL;  $14.06 \pm 0.09$  mm, 0.025 mg/mL for the standard  $33.05 \pm 0.92$  mm), the was found to be higher than  $13.1 \pm 0.27$ mm as reported by Imran *et al.* (2021) for *Acacia catechu* leaf extracts. This also shows an implication that the plant (*Senegalia macrostachya* seed) have good activity against the tested microbes. The highest zone of inhibition for ethyl acetate extracts was found to be  $28.25 \pm 0.24$  mm at 0.2mg/mL in *Staphylococcus aureus*. For the methanol extract; *Staphylococcus aureus* (0.2mg/mL;  $19.23 \pm 0.26$  mm, 0.1 mg/mL;  $17.06 \pm 0.16$  mm, 0.05 mg/mL;  $10.45 \pm 0.25$  mm, and for standard ciprofloxacin 0.5mg/ml;  $31.23 \pm 0.47$ mm). This results were found to be comparable with  $17.9 \pm 0.10$  mm for *Punica granatum* extracts and higher than  $8.6 \pm 0.67$  mm for *Quercus infectoria* extracts as pointed out by Imran *et al.* (2021). For *Shigella dysenteriae*; (0.2 mg/mL;  $15.02 \pm 0.11$  mm, 0.1 mg/mL;  $13.02 \pm 0.33$  mm, 0.05 mg/mL;  $11.21 \pm 0.23$  mm, standard ciprofloxacin  $40.25 \pm 0.26$  mm). this results were found to be high than  $11.11 \pm 2.65$  mm as reported by Obeng-Boateng *et al.* (2024) for *M. citrifolia*. Extract. for *Salmonella typhi*; (0.2 mg/mL;  $20.21 \pm 0.23$  mm, 0.1 mg/mL;  $18.32 \pm 0.17$  mm, 0.05 mg/mL;  $16.08 \pm 0.22$  mm, 0.025;  $15.09 \pm 0.32$  mm for standard  $35.05 \pm 0.26$  mm). For *Escherichia coli* (0.2 mg/mL ;  $17.02 \pm 0.34$  mm, 0.1 mg/mL;  $15.02 \pm 0.90$  mm, 0.05mg/mL;  $12.23 \pm 0.19$  mm, 0.025 mg/mL;  $11.29 \pm 0.31$  mm for the standard  $33.08 \pm 0.02$  mm). The highest zone of inhibition for methanol extracts was found to be  $20.21 \pm 0.23$  mm for *Salmonella typhi* at 0.2mg/ml. From the overall results, the highest zone of inhibition was obtained from ethyl acetate ( $28.25 \pm 0.24$  mm) against *Staphylococcus aureus* In all doses, ciprofloxacin showed noticeably greater activity

than the plant extracts ( $p < 0.05$ ). On comparison, the value obtained from *Senegalia macrostachya* seed ethyl acetate for *Staphylococcus aureus* ( $28.25 \pm 0.24$  mm) is higher than (25 mm) as reported by Alex-Asaolu *et al.* (2024), for *Escherichia coli* (21 mm) obtained were found to comparable with ( $21.33 \pm 1.80$  mm.) for *M. citrifolia* as reported by Obeng-Boateng *et al.* (2024) Likewise for the methanol extracts (15 mm) zone of inhibition were seen to have higher zone of inhibition (12 mm) as reported by Muhammad *et al.* (2022) for *Indigofera hirsute* lin extracts. Compared to traditional antibacterial medicines, herbal plants are known to contain secondary metabolites that have less negative effects and known effects against bacterial infections. Many plants have been utilized historically as antibacterial agents, but their use has not been scientifically validated or documented (Obeng-Boateng *et al.*, 2024). Therefore, the extracts can be said have good broad spectrum of activity considering the mean zone of inhibition diameter greater than 18 (Muhammad *et al.*, 2022). The minimum inhibitoroy Centration and minimum bactericidal concentration for the extracts of *Senegalia macrostachya* seeds against both microorganisms tested were found to be 0.025 mg/mL for *Escherichia coli*, *Samonella typhi*, 0.05 mg/mL for *S.aureus*, *S. dysenteriae* (methanol extracts), 0.025mg/mL for *Staphylococcus aureus*, *Salmonella typhi* and *Escherichia coli* (ethyl acetate extract), 0.025mg/mL for *Escherichia coli*, 0.05mg/mL *Staphylococcus aureus*, *S. typhi* and 0.1mg/mL *S. dysenteriae* for hexane extract respectively.

## CONCLUSION

This study shows that *Senegalia macrostachya* seed have moderate % yield extracts. Methanol have high extracts yield followed by hexane and ethyl acetate. Also the *Senegalia macrostachya* seeds contains significant amount of secondary metabolites such as flavonoid, steroid, saponins, cardiac glycoside among others. The pharmacological properties of this plant seed could be attributed to this phytochemical presence. The plants extract also shows significant antibacterial activity on the targeted and tested bacterial isolates with ethyl acetate had high activity followed by methanol and hexane. Based on the above finding, the plant

(*Senegalia macrosatachya* seeds) could be used as sources of medicinal plant for the treatment microbial infection as well as for industrial application for the benefit of mankind and the ethno medicinal uses of the plant were also validated. Further researches should be conducted on the remaining pathogen so as to access its potential on other microorganism such as fungi, helminthes algae, and plasmodium.

#### DECLARATIONS

All author declared there is no competing interest.

#### ACKNOWLEDGEMENT

The researchers acknowledge the support and funding from Tetfund under Institution based research (IBR) with research code TETF/DR&D/CE/COE/SOKOTO/IBR/2024/VOL1 BATCH 10:S/NO. 15 via Tetfund committee Shehu Shagari College of Education Sokoto.

#### REFERENCES

- Alex-Asaolu, A., Uba, A., Birnin-Yauri, U.A., Yusuf, A.J (2024). Isolation and Characterization of antimicrobial constituents from the stem of *Cissus populnea* Guill. & Perr. *Drugs and Drug candidates* 3:172-183.
- Chika, A., Bello, S.O., Yunusa, A., Yahaya, A.B. and Sadiq, A (2022). Ethnobotanical survey of medicinal plants used as remedies for benign prostatic hyperplasia in Sokoto North western Nigeria. *National Journal of Physiology, Pharmacy and Pharmacology*. **12**(4):511-518
- Coulibaly, A.C., Esther, W.L.M., Kabre, B., Traore, T.K., Achatde, C., Boly, G.L., Nebie, M.T., Ouedraogo, N., Kiendrebeogo, M. and Sawadogo, R.W (2020). Phytochemical screening, anti-inflammatory and Analgesic activities of Root barks from *Acacia macrostachya* Reichenb. Ex DC. (Fabaceae). *Annual Research and Review in Biology* **35**(7):76-83
- Kakouri, E.; Daferera, D.; Trigas, P.; Charalambous, D.; Pantelidou, M.; Tarantilis, P.A.; Kanakis, C.D. (2023). Comparative Study of the Antibacterial Activity, Total Phenolic and Total Flavonoid Content of Nine Hypericum Species Grown in Greece. *Appl. Sci.* **13** (3305): 1-12
- Dwivedi, S., Singh, S and Singh, J. (2023). Effect of extraction solvent and plant part on the yield of phenolic compounds, plumbagin and biological activity of *Plumbago zeylanica*. *Journal of Pharmacognosy and Phytochemistry* **12**(6): 05-10
- Garba, U., Farouk, U.Z., Uba, A., Nasir, I., Yusuf, A.J. and Kwazo, H.A. Phytochemical and In vitro Antibacterial Studies of Methanolic extract from *A. macrostachya* Reichenb. (*Leguminosae*) Leaves. A Paper Presented at 1<sup>st</sup> International conference on advancement in research, innovation, scholarship and enterprises at Topaith university Mkpatak from 3<sup>rd</sup> - 6<sup>th</sup> December, (2024) : 101
- Imran M, Khan AS, Khan MA, (2021). Antimicrobial activity of different plants extracts against *Staphylococcus aureus* and *Escherichia coli*. *Polim Med.* **51**(2):69–75.
- Khalid, S., Shahzad, A., Basharat , N., Abubakar , M., Anwar, P. (2022). Phytochemical Screening and Analysis of Selected Medicinal Plants in Gujrat. *J Phytochemistry and Biochemistry* **2**(1): 108.
- Muhammad, M.U., Gayari, M.S., Idris, B., Garba, U. and Bello, I (2022) Evaluation of Phytochemical Composition and Antibacterial Activity of *Indigofera hirsuta* Linn *Arid Zone Journal of basic and Applied Research*. **1**(5):192-203
- Mussa, E.N., Mganga, N.D., and Nchimbi, H.D (2023). Phytochemical screening of selected medicinal plants of the West Usambara Mountains in Tanzania. *Tanzania Journal of Health Research* **25**(3):1120-1131
- Nortjie, E.; Basitere, M.; Moyo, D.; Nyamukamba, P. (2023) Extraction Methods, Quantitative and Qualitative Phytochemical Screening of Medicinal

- Plants for Antimicrobial Textiles: A Review. *Plants* . **11**(2011): 1-17
- Nyalo, P.O., Omwenga, G.I., and Ngugi, M.P (2023). Antibacterial properties and GC-MS analysis of ethyl acetate extracts of *Xerophyta spekei* (Baker) and *Grewia tembensis* (Fresen). *Heliyon* **9**(3):223-228
- Obeng-Boateng F, Kpordze SW, Addy F (2024) In vitro antibacterial activity of *Morinda citrifolia* extracts against eight pathogenic bacteria species. *PLoS ONE* **19**(10): e0313003.
- Selvaraj, S., Prashanth, C., Ponraj, G., and Rameshkumar, K. (2021). Antibacterial Activities of Medicinal Plant Leaves Extract Against Isolated *Escherichia coli* Bacteria from Different Water Sources. *Research & Reviews: A Journal of Microbiology & Virology* **11**(3):34-40
- World Health Organization, WHO (2022) Global Centre for Traditional Medicine. Retrieve on 15 October, 2022 from <https://www.who.int/initiatives/who-global-centre-for-traditional-medicine>
- Rodríguez-Negrete, E.V., Morales-González, A., Madrigal-Santillán, E.O., Sánchez-Reyes, K., Álvarez-González, I., Madrigal-Bujaidar, E., Valadez-Vega, C., Chamorro-Cevallos, G., Garcia-Melo, L.F and Morales-González, J. A. (2024). Phytochemicals and Their Usefulness in the Maintenance of Health, *Plant* **13**(4): 523