Antibacterial Activity of Stem Bark Extract of *Boswellia Odorata* Against Some Isolates of Wound Among Patients Attending Selected Hospitals in Kano Metropolis

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Abstract

Infection of wounds by pathogenic bacteria continues to be an important health problem owing to the growing bacterial resistance to common antimicrobial drugs. Medicinal plants are therefore being explored for alternative antibacterial substances. The current research was carried out in order to examine the phytochemicals present and antibacterial properties of Boswellia odorata stem bark extract towards selected bacterial strains linked with wound infection in hospitals in the Kano Metropolis. The stem bark of Boswellia odorata was harvested from Shanono Local Government Area of Kano State, authenticated, shade dried, milled and subjected to cold maceration with 95% ethanol to water for 72 hours. Phytochemical analysis both qualitative and quantitative was done, but the antibacterial activity of the extract was carried out at concentrations of 25, 50, 100, and 200 mg/mL using the agar well diffusion technique. The minimum inhibitory concentration (MIC) and minimum bactericidal concentration (MBC) were also determined. The phytochemical analysis showed that there were alkaloids, flavonoids, tannins, saponins, and phenolic compounds. The phenolic compounds were found to have the highest concentration of 21.8 ± 0.5 mg/g while the flavonoids had 20.2 ± 0.6 mg/g. There was antibacterial activity exhibited by the extract against the all test organisms, where the higher the concentrations of the extract were the higher was the inhibition exhibited. Staphylococcus aureus was the most susceptible organism, having an inhibition zone of 20 mm at 200 mg/mL, while Pseudomonas aeruginosa was the least susceptible, with inhibition zone of 17 mm. Escherichia

coli and P. aeruginosa had high resistance level of 50%, while S. aureus and Klebsiella pneumoniae had 25% resistance level. S. aureus, K. pneumoniae, and P. aeruginosa had a minimum inhibitory concentration (MIC) of 25 mg/mL and minimum bactericidal concentration (MBC) of 50 mg/mL, while E. coli had MIC of 50 mg/mL and MBC of 75 mg/mL. The study illustrates that the extract of Boswellia odorata stem bark has valuable bioactive phytochemicals and has wide range of antibacterial activity against some wound related bacteria. Therefore, the extract can be used as a potential source of antibacterial agents, but more research is required for this purpose.

Keywords: *Boswellia odorata, stem bark extract, phytochemicals, antibacterial activity, wound pathogens.*

Introduction

Medicinal plants have played a central role in primary healthcare delivery across Africa for centuries, particularly in rural and semi-urban communities where access to modern healthcare is limited. In Northern Nigeria, including Kano State, traditional medicine remains deeply embedded in cultural practices, with plant-based remedies widely used for treating wounds, skin infections, and inflammatory conditions. Ethnobotanical surveys conducted in Kano and neighboring states have consistently identified members of the genus *Boswellia* as important medicinal plants employed in wound care, often through topical application of bark or resin preparations (Sadiq and Lawal, 2021a). Plants such as *Boswellia odorata* are traditionally used for treating wounds and infections. Understanding the epidemiology and pathophysiology of wound infections therefore provides a strong scientific basis for investigating the antibacterial activity of *Boswellia odorata* stem bark extract against wound-associated bacterial isolates (Ibrahim and Bello, 2024).

Boswellia odorata, a member of the family Burseraceae, is traditionally valued for its aromatic resin and medicinal stem bark. Among Hausa-speaking communities in Northern Nigeria, the stem bark is commonly harvested, dried, and processed into powders or decoctions used to clean wounds, stop bleeding, and prevent infection. Traditional healers often combine *Boswellia odorata* bark with water or oils to produce topical formulations believed to accelerate wound healing and reduce pus formation (Abubakar *et al*., 2022). Such practices reflect long-standing indigenous knowledge passed across generations.

Due to rising resistance and the high cost of synthetic drugs, medicinal plants have become a focal point for alternative and complementary medicine. In traditional African medicine, plants like *Boswellia odorata* have been used for treating infections and inflammation. This plant, a member of the Burseraceae family, is known for producing aromatic resin and bark extracts that possess antimicrobial and anti-inflammatory properties (Aliyu and Garba, 2021). Phytochemical investigations have shown that the stem bark of *Boswellia odorata* contains bioactive compounds such as boswellic acids, flavonoids, tannins, alkaloids, and saponins (Nuhu *et al*., 2023). These compounds act through different mechanisms, including disruption of bacterial membranes, inhibition of nucleic acid synthesis, and impairment of bacterial enzyme systems. Such actions are vital in combating Gram-positive and Gram-negative pathogens. Preliminary in vitro studies have indicated that *Boswellia odorata* extracts exhibit significant antibacterial activity against clinical strains of *S. aureus* and *P. aeruginosa*, with inhibition zones comparable to standard antibiotics at certain concentrations (Bello *et al*., 2022). These findings justify further investigation, particularly against clinical isolates directly obtained from infected wounds.

Therefore, this study is designed to evaluate the antibacterial activity and Phytochemical screening of the stem bark extract of *Boswellia odorata* against bacterial isolates from wounds in selected hospitals in Kano Metropolis. The stem bark of *Boswellia odorata*, like other species within the *Boswellia* genus, is believed to contain a wide array of secondary metabolites that contribute to its biological properties. Preliminary phytochemical screenings of related *Boswellia* species conducted in Northern Nigeria have revealed the presence of flavonoids, tannins, saponins, alkaloids, phenolic compounds, terpenoids, and glycosides, all of which are known to exhibit antimicrobial effects (Abubakar and Sadiq, 2022). These compounds often function synergistically to enhance antibacterial potency. In Kano State, traditional healers prefer the stem bark of *Boswellia odorata* over leaves or roots, attributing greater medicinal strength to it. This preference is supported by phytochemical studies conducted on stem bark extracts of *Boswellia dalzielii* and other closely related species, which showed higher concentrations of phenolic compounds and tannins in bark tissues compared to other plant parts (Ibrahim *et al*., 2021). Phenolic compounds are widely recognized for their ability to denature bacterial proteins and disrupt cell membranes, making them effective against a broad spectrum of wound pathogens.

Material and Methods

Study Area

The study was conducted in selected hospitals within Kano State, these hospitals include Murtala Mohammed Specialist Hospital (11.9946°N, 8.5162°E), Muhammad Abdullahi Wase Teaching Hospital (11.9910°N, 8.5115°E), and Khalifa Isyaka Rabiu Pediatrics Hospital (11.9982°N, 8.5168°E). These hospitals are major healthcare providers in the region, offering specialized wound management and serving as referral centers for both urban and rural populations. They are well-equipped for diagnosing and managing wounded patients, making them ideal settings for this research. It was estimated that about 53,899 patients are visiting these hospitals annually which shows how large numbers of wound patients they contained, and this may help in providing a reliable sample pool (Mohammed and Tijjani, 2020).

Research Design

This study adopts an experimental research design involving laboratory-based analysis. The approach includes isolation and identification of wound pathogens, extraction of phytochemicals from *Boswellia odorata* stem bark, and evaluation of antibacterial activity using both microbiological and molecular techniques (Ibrahim and Bello, 2024).

Ethical Considerations

Ethical clearance was obtained from the Kano State Ministry of Health Ethical Review Board. Written informed consent was obtained from mothers or guardians of wound patients. All data were kept confidential and used solely for academic purposes.

Sample Size Determination

Using the formula *(Ibrahim and Bello, 2024)*:

$$n = \frac{Z^2 x\ pq}{d^2}$$

Where:

n = Number of samples

Z = Statistic for a level of confidence at 95% = 1.96

p = 22% previous prevalence were used (Mohammed and Tijjani, 2020).
d = Allowable error (5% = 0.05)

$$n = \frac{(1.96)^2 \text{x } 0.25(1-0.25)}{(0.05)^2} = 288$$

Adding 10% for Std. error

$$n = 288 + 29 = 317 \text{ samples}$$

Thus, exactly 317 patients were recruited (Ibrahim and Bello, 2024).

Sample collection

Plant Material

Fresh stem bark of *Boswellia odorata* was collected from Shanono local government Kano Nigeria and authenticated by a plant taxonomist at the Department of Botany, Bayero University, Kano. A voucher specimen was deposited for future reference (Akinyemi *et al.,* 2019).

Extraction of plant bark

The bark was washed, shade-dried for 10 days, and ground into powder using a mechanical grinder. Cold maceration was employed. A 200g of powdered bark was soaked in 1L of 95% ethanol to water (% V/V) for 72 hours with periodic stirring for 2 minutes in every one hour. The extract was filtered using Whatman No. 1 filter paper and concentrated with a rotary evaporator at 40°C (Aliyu and Garba, 2021). The crude extract was stored in airtight containers at 4°C until use.

Qualitative and Quantitative phytochemical Screening

The phytochemical analysis of *Boswellia odorata* stem bark extract was carried out to determine the presence and concentration of bioactive secondary metabolites responsible for its antibacterial activity. Both qualitative and quantitative phytochemical screenings were performed using standard analytical procedures as described by Harborne (1973) and further modified by Yusuf *et al*. (2023).

Susceptibility of Bacterial Isolates to Crude Extract

Mueller-Hinton agar was inoculated with 0.5 McFarland-standardized bacterial suspension. Wells (6 mm diameter) were punched into the agar, and 100 µL of varying concentrations (25, 50, 100, and 200mg/mL) of the plant extract were added. Plates were incubated at 37°C for 24 hours, and zones of inhibition were measured in millimeters (Bello *et al*., 2022). Ciprofloxacin (5 µg) serve as a positive control, while 10% Dimethyl Sulphuroxide (DMSO) serve as a negative control *(*Ibrahim and Bello, 2024*)*.

Determination of MIC and MBC

MIC was determined by the broth dilution method using 6 set of test tubes. Tubes were observed for turbidity after 24 hours of incubation. MBC was determined by sub-culturing from MIC tubes onto agar plates and checking for bacterial growth (Oyetunji and Hassan, 2023).

Result and Discussion

Qualitative and Quantitative Phytochemical Constituent of *Boswellia odorata* Stem Bark Extract

The qualitative and quantitative phytochemical constituents of the stem bark extract of *Boswellia odorata*. The qualitative screening revealed the presence of all the phytochemicals tested,

including alkaloids, flavonoids, tannins, saponins, and phenolic compounds, as indicated by positive (+) reactions. Quantitative analysis showed that phenolic compounds were the most abundant constituent with a concentration of 21.8 ± 0.5 mg/g, followed closely by flavonoids at 20.2 ± 0.6 mg/g. Alkaloids were also present in relatively high concentration (18.6 ± 0.4 mg/g), while tannins recorded a moderate concentration of 14.1 ± 0.3 mg/g. Saponins were the least abundant phytochemical constituent with a concentration of 9.4 ± 0.2 mg/g Table 1.

Table 1: Qualitative and Quantitative Phytochemical Constituent of *Boswellia odorata* Stem Bark Extract

Phytochemical	Qualitative	Quantitative (mg/g)
Alkaloids	+	18.6 ± 0.4
Flavonoids	++	20.2 ± 0.6
Tannins	+	14.1 ± 0.3
Saponins	+	9.4 ± 0.2
Phenols	++	21.8 ± 0.5

Key: + signifies the presence of the phytochemical in the samples and ++ shows how abundance it is based on color inference. The disc is 6mm and the quantitative results is the average triplicates reading of the sample.

Zone of Inhibition (mm) of *Boswellia odorata* Extract at Different Concentrations

The antibacterial activity of *Boswellia odorata* stem bark extract against selected bacterial isolates at varying concentrations (25, 50, 100 and 200 mg/ml). The extract demonstrated inhibitory effects on all the tested organisms, indicating broad-spectrum antibacterial activity. A concentration-dependent increase in the zone of inhibition was observed for all organisms. At the lowest concentration (25 mg/ml), relatively small inhibition zones ranging from 5–8 mm were recorded. However, at higher concentrations (100 and 200 mg/ml), larger zones of inhibition were produced, with values ranging from 13–20 mm. This trend suggests that the antibacterial activity of the extract increases with increasing concentration. Among the isolates, *Staphylococcus aureus* showed the highest susceptibility to the extract, recording the largest zones of inhibition at all concentrations, with a maximum inhibition zone of 20 mm at 200 mg/ml. In contrast, *Pseudomonas aeruginosa* exhibited the lowest susceptibility, producing the smallest zones of inhibition across the concentrations tested, which indicates a relatively higher resistance to the extract. The activity observed against both Gram-positive (*Staphylococcus aureus*) and Gram-negative bacteria (*Escherichia coli*, *Pseudomonas aeruginosa* and *Klebsiella pneumoniae*) demonstrates that *Boswellia odorata* extract possesses broad-spectrum antibacterial potential. These findings support the traditional medicinal use of *Boswellia odorata* in the treatment of wound infections and suggest that the plant extract contains bioactive compounds with significant antibacterial properties Table 2.

Table 2: Zone of Inhibition (mm) of *Boswellia odorata* Extract at Different Concentrations

Test Organism	Concentration (mg/mL)				
	25	50	100	200	Positive Control (Ciprofloxacin 5 µg)
Staphylococcus aureus	8	12	16	20	30
Escherichia coli	6	10	14	18	28
Pseudomonas aeruginosa	6	9	13	17	26
Klebsiella pneumonia	7	11	15	19	29

Key: Values represent the mean diameter of zones of inhibition (mm) measured in millimeters and the disc diameter is 6mm

3.3 Percentage Resistance of Test Isolates to *Boswellia odorata* Extract

The percentage resistance of the test isolates to *Boswellia odorata* extract based on inhibition zones ≤10 mm. The results indicate that *Escherichia coli* and *Pseudomonas aeruginosa* had the highest resistance (50%), while *Staphylococcus aureus* and *Klebsiella pneumoniae* showed lower resistance (25%). This suggests that Gram-negative bacteria generally exhibited greater resistance to the extract compared to Gram-positive bacteria Table 3.

Table 3 Percentage Resistance of Test Isolates to *Boswellia odorata* Extract

Isolates	Total Tests	Number of Resistant Isolates (%)
Staphylococcus aureus	4	1 (25)
Escherichia coli	4	2 (50)
Pseudomonas aeruginosa	4	2 (50)
Klebsiella pneumoniae	4	1 (25)

3.4 Minimum Inhibitory Concentration (MIC and MBC) of *Boswellia odorata* Stem Bark Crude Extract

The Minimum Inhibitory Concentration (MIC) and Minimum Bactericidal Concentration (MBC) of the crude stem bark extract of *Boswellia odorata* against selected bacterial isolates. The results revealed that the extract exhibited antibacterial activity against all the tested organisms, with MIC values of 25 mg/mL and MBC values of 50 mg/mL across all isolates with exception of *E. coli* with 50mg/mL as MIC and 75mg/mL as MBC. The negative control (DMSO) showed no inhibitory or bactericidal activity, confirming that the observed antibacterial effects were solely due to the plant extract and not the solvent. On the other hand, Ciprofloxacin (5 µg), used as a positive control, demonstrated strong antibacterial activity against all the test isolates Tables 4.

Table 4: Minimum Inhibitory Concentration (MIC) and Minimum Bactericidal Concentration (MBC) of *Boswellia odorata* Stem Bark Extract against Test Isolates

Test Organism	MIC (mg/mL) Extract	MBC (mg/mL) Extract
Staphylococcus aureus	25	50
Escherichia coli	50	75
Klebsiella pneumoniae.	25	50
Pseudomonas aeruginosa.	25	50

Discussion

The presence of the preliminary phytochemicals tested in the study. Phenols and flavonoids were found in higher concentrations than other compounds, followed by alkaloids. The high concentration of phenolic compounds observed in *Boswellia odorata* aligns with earlier Nigerian studies reporting phenols as major antimicrobial agents in medicinal plants used for wound treatment (Nuhu *et al.,* 2023; Bello *et al.,* 2023). Phenolic compounds exert bactericidal effects by disrupting bacterial cell membranes and precipitating proteins, particularly in Gram-positive organisms such as *Staphylococcus aureus*. Flavonoids, which were the second most abundant constituents, have been widely reported to inhibit nucleic acid synthesis and interfere with bacterial energy metabolism (Aliyu and Garba, 2021). Similar flavonoid levels have been reported in *Boswellia* species studied in Northern Nigeria and Sudan, where significant antibacterial activity was demonstrated against *Pseudomonas aeruginosa* and *E. coli* (Sule *et al.,* 2022). The presence of tannins at appreciable concentrations further supports the wound-healing potential of the extract. Tannins promote wound contraction and form protective layers over damaged tissue, thereby reducing microbial invasion (Chukwu *et al.,* 2021). Studies from Ghana and Kenya have shown strong correlations between tannin concentration and inhibition zones in wound pathogens (Mensah *et al.,* 2020). Alkaloids and saponins, though present in moderate quantities, contribute synergistically to antibacterial activity by interfering with DNA replication and increasing membrane permeability respectively (Yakubu *et al.*, 2022). The phytochemical richness observed validates the traditional use of *Boswellia odorata* in wound management. The findings of this study demonstrate that *Boswellia odorata* stem bark extract possesses significant antibacterial activity against the selected wound-associated bacterial isolates. The extract produced measurable zones of inhibition against all tested organisms, indicating a broad-spectrum antibacterial effect. This supports the ethnomedicinal use of *Boswellia odorata* in the treatment of wound infections and other microbial-related ailments. The zone of inhibition (mm) of *Boswellia odorata* stem bark extract against selected bacterial isolates at varying concentrations. The results show a concentration-dependent increase in antibacterial activity, with zones of inhibition increasing from 25 mg/ml to 200 mg/ml across all tested organisms. *Staphylococcus aureus* exhibited the highest susceptibility with a maximum inhibition zone of 20 mm, while *Pseudomonas aeruginosa* showed the least susceptibility with a maximum of 17 mm. The positive control (ciprofloxacin) demonstrated significantly higher inhibition zones (26–30 mm), confirming the effectiveness of the standard antibiotic compared to the plant extract. A clear concentration-dependent pattern was observed, as the diameter of the zones of inhibition increased with increasing extract concentration. At 25 mg/ml, the extract exhibited relatively low antibacterial activity, while at higher concentrations (100 and 200 mg/ml), pronounced inhibitory effects were recorded. This suggests that the antibacterial constituents of the extract are more effective at higher doses, which is consistent with previous reports on plant-derived antimicrobial agents. Among the tested organisms, *Staphylococcus aureus* showed the highest susceptibility to the extract, producing the largest zones of inhibition at all concentrations. This may be attributed to the structural characteristics of Gram-positive bacteria, which lack the outer membrane present in Gram-negative bacteria, thereby allowing easier penetration of bioactive compounds. In contrast, *Pseudomonas aeruginosa* exhibited the least susceptibility, possibly due to its intrinsic resistance mechanisms, including efflux pumps and reduced membrane permeability. The observed activity of the extract against Gram-negative bacteria such as *Escherichia coli* and *Klebsiella pneumoniae* further confirms the broad-spectrum nature of the extract. This suggests that the phytochemical constituents of *Boswellia odorata*, such as flavonoids, tannins, terpenoids, and saponins, may act

through multiple mechanisms including disruption of cell walls, inhibition of protein synthesis, and interference with essential metabolic pathways in bacterial cells. The antibacterial potential demonstrated in this study is particularly important in the context of increasing antimicrobial resistance among wound pathogens. The effectiveness of *Boswellia odorata* extract against both Gram-positive and Gram-negative isolates suggests that it could serve as a potential source of novel antimicrobial compounds. However, further studies involving purification of active compounds, toxicity evaluation, and in vivo testing are necessary before clinical application can be considered. The observed increase in zone of inhibition with increasing concentration of *Boswellia odorata* extract confirms its dose-dependent antibacterial activity.

This trend is consistent with findings by Attallah *et al*. (2021), who reported that *Boswellia* extracts demonstrated enhanced antimicrobial effects at higher concentrations due to increased availability of active phytochemicals such as boswellic acids and flavonoids. The higher susceptibility observed in *Staphylococcus aureus* (20 mm at 200 mg/ml) compared to Gram-negative bacteria aligns with previous studies indicating that Gram-positive bacteria are more vulnerable, often showing inhibition rates of 80–95%, due to the absence of an outer membrane barrier (Jaroš *et al*., 2022). Conversely, the relatively lower inhibition zones recorded for *Pseudomonas aeruginosa* reflect its intrinsic resistance mechanisms, including efflux pumps and biofilm formation. The percentage resistance of the test isolates to *Boswellia odorata* extract based on inhibition zones ≤10 mm. The results indicate that *Escherichia coli* and *Pseudomonas aeruginosa* had the highest resistance (50%), while *Staphylococcus aureus* and *Klebsiella pneumoniae* showed lower resistance (25%). This suggests that Gram-negative bacteria generally exhibited greater resistance to the extract compared to Gram-positive bacteria. Furthermore, the resistance pattern observed in Table 4.5 supports existing literature on the reduced susceptibility of Gram-negative bacteria to plant-derived antimicrobials. Studies have shown that *Escherichia coli* and *Pseudomonas aeruginosa* often exhibit resistance levels ranging from 40–60%, primarily due to the protective lipopolysaccharide layer in their cell walls (Almutairi *et al*., 2022). The moderate resistance observed in *Klebsiella pneumoniae* (25%) may be attributed to its polysaccharide capsule, which limits penetration of antimicrobial agents. Despite this, the extract still demonstrated appreciable antibacterial activity, indicating its potential as an alternative or complementary antimicrobial agent. The significantly higher inhibition zones produced by ciprofloxacin (>95% effectiveness) further validate the assay and highlight the need for optimization of plant extract potency for clinical applications. The Minimum Inhibitory Concentration (MIC) and Minimum Bactericidal Concentration (MBC) of the crude stem bark extract of *Boswellia odorata* against selected bacterial isolates. The MIC values for all tested organisms were 25 mg/mL, while the MBC values were 50 mg/mL, indicating that the extract exhibited both inhibitory and bactericidal effects across all tested bacteria. The similarity in MIC and MBC values among *Staphylococcus aureus*, *Escherichia coli*, *Klebsiella pneumoniae*, and *Pseudomonas aeruginosa* suggests that the crude extract possesses broad-spectrum antibacterial activity. The relatively low MIC and MBC values indicate that the extract is capable of effectively inhibiting and killing these organisms at moderate concentrations. The relationship MBC = 2 × MIC further suggests bactericidal potential, as only a small increase beyond the inhibitory concentration was sufficient to achieve bacterial killing. The negative control (DMSO) showed no inhibitory or bactericidal activity, confirming that the antimicrobial effects observed were due solely to the plant extract. Ciprofloxacin (5 µg), used as a positive control, demonstrated effective bactericidal activity against all tested organisms, validating the reliability of the assay. The results are consistent with previous reports indicating that *Boswellia odorata* extracts possess antibacterial activity against both Gram-positive and

Gram-negative pathogens. The activity against *Staphylococcus aureus* aligns with studies from Nigeria, where this organism is a predominant cause of wound infections (Bello *et al.,* 2022; Yakubu *et al.,* 2022). The susceptibility of Gram-negative bacteria (*Escherichia coli*, *Klebsiella pneumoniae*, and *Pseudomonas aeruginosa*) also supports reports from Africa and Asia showing that *Boswellia* species contain bioactive compounds capable of penetrating the protective outer membrane of Gram-negative organisms (Abdullahi *et al.,* 2022; Tenover, 2006).

Conclusion

The results suggest the suitability of the stem bark of *Boswellia odorata* as a potential resource for antibacterial components against selected wound pathogens. Nevertheless, the use of the extract cannot be regarded as an alternative to existing antibiotics just from the findings above. Further research is needed in order to isolate and identify the bioactive components, conduct toxicity testing, formulation studies, and animal studies.

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