AN INVESTIGATION OF THE PHYTOCHEMICAL COMPOSITION AND ANTIMICROBIAL ACTIVITIES OF COMMIPHORA AFRICANA STEM BARK EXTRACT

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An Investigation of the Phytochemical Composition and Antimicrobial Activities of Commiphora Africana Stem Bark Extract

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Abstract— *Commiphora africana*, a traditional African medicinal plant, has long been utilized for treating diverse ailments. This study provides a novel exploration of the phytochemical composition, antibacterial activity, and antioxidant properties of its stem bark extract, aiming to bridge the gap between traditional knowledge and scientific validation. Phytochemical analysis revealed the presence of bioactive compounds such as alkaloids, flavonoids, glycosides, and terpenoids. The extract exhibited significant antibacterial activity against *Staphylococcus aureus*, *Escherichia coli*, and *Salmonella typhi*, with minimum inhibitory concentrations (MIC) ranging from 0.5 to 2.5 mg/mL, surpassing some previously studied natural extracts in potency. Additionally, the antioxidant evaluation demonstrated a robust free radical scavenging capacity, suggesting potential for therapeutic applications. These findings not only validate the traditional use of *Commiphora africana* but also position its stem bark extract as a promising candidate for developing natural antibacterial and antioxidant agents. To the best of our knowledge, this is the first comprehensive report detailing the bioactivities of *Commiphora africana* stem bark extract, emphasizing the need for further studies to isolate and characterize its bioactive constituents.

Keywords— Commiphora Africana, Phytochemicals, Antibacterial Activity, Antioxidant Activity, Traditional Medicine.

I. INTRODUCTION

Commiphora africana, commonly referred to as African myrrh, is a shrub belonging to the family Burseraceae, characterized by short lateral branches and clusters of leaves at the apex [1]. It is geographically widespread across Africa, Asia, and the Middle East and is predominantly found in northern Nigeria, where it is traditionally used to treat a wide variety of disorders [1]. Phytochemical investigations have linked the pharmacological activities of *C. africana* to the presence of secondary metabolites such as flavonoids, coumarins, triterpenoids, saponins, and alkaloids [2].

The genus Commiphora, commonly known as myrrh, has garnered recognition in numerous cultures for its medicinal properties, particularly for treating infectious diseases. Its applications span a wide range of conditions, including pain, skin infections, inflammation, diarrhea, periodontal diseases, and wound healing. Islamic traditions have highlighted its efficacy in addressing intestinal parasites, diarrhea, wounds, and chronic chest ailments [3]. Various parts of the plant—roots, leaves, stem bark, flowers, and essential oils—are used across regions to treat infections affecting the respiratory, urinary, gastrointestinal, and biliary systems, as well as skin ailments [4].

Across West African nations, *C. africana* has been traditionally valued for its rich bioactive compounds, including methylisopropenyl furan, sesquiterpenes, and commiphoric acid. In Côte d'Ivoire and Burkina Faso, crushed leaves macerated in oil are consumed as sedatives and sleep-inducing remedies [5]. Its bark extracts have been traditionally used as antiseptic solutions, skin infection washes, and even insect repellents. The seed contains tannins, dihydroflavonol glucoside, Z-guggulsterone, and stable oils with potential bioactivities [5].

While previous studies have explored the traditional uses and some pharmacological properties of *C. africana*, limited research has specifically focused on its stem bark, particularly regarding its phytochemical composition and antibacterial potential. This study aims to bridge this gap by providing the first comprehensive analysis of the stem bark extract, emphasizing its antibacterial and antioxidant activities. By focusing on these aspects, the research not only validates traditional claims but also identifies the stem bark of *C. africana* as a promising source of natural bioactive agents.

II. MATERIALS AND METHOD

A. Materials

1) Plant Material Collection and Preparation: *Commiphora africana* stem bark was collected from Malammadori Local Government Area, Jigawa State, Nigeria. The plant material was washed with water to remove debris and air-dried in the laboratory at ambient temperature (25–30°C) for 25 days to minimize the risk of thermal degradation of bioactive compounds. The dried material was pulverized using a mortar and pestle, followed by grinding into a coarse powder to increase the surface area for efficient extraction.

2) Solvent Selection for Extraction: Ethanol was selected as the primary solvent for extraction due to its ability to dissolve a wide range of polar and moderately non-polar compounds. This ensures comprehensive extraction of phytochemicals such as alkaloids, flavonoids, and phenolic compounds. The use of gradient

extraction allowed optimal separation of components with varying polarities. Ethanol is also safe, readily available, and widely used in pharmaceutical research [6, 7, 8, 9, 10].

B. Methodology

1) Extraction Process: Cold ethanol extraction was performed to avoid thermal degradation of heat-sensitive bioactive compounds. Each powdered sample was soaked in ethanol for 48 hours, allowing sufficient time for solubilization of phytochemicals. The extract was then evaporated in a water bath at 60°C to obtain a concentrated residue, which was chilled and stored in sterile containers for subsequent analyses. The percentage yield was calculated using the Remaderin equation [11, 12].

2) Phytochemical Screening: The extract was subjected to phytochemical screening using standard protocols [11, 13]. The screening tested for the presence of alkaloids, carbohydrates, phenolics, tannins, flavonoids, saponins, steroids, glycosides, and other secondary metabolites. Each test involved well-documented chemical reactions, ensuring specificity [14].

3) Microbiological Media Preparation and Rationale for Controls: Nutrient agar was used as the growth medium, prepared following the manufacturer's instructions. Media sterility was confirmed by incubating plates at 37°C for 24 hours before use. Erythromycin, a broad-spectrum antibiotic, served as a positive control to benchmark the antibacterial activity of the extracts. Sterile distilled water was used as a negative control to ensure no contamination or activity interference [15, 16, 17].

4) Antibacterial Activity Testing: The agar well diffusion method [18] was employed to evaluate antibacterial activity against *Escherichia coli*, *Salmonella typhi*, and *Staphylococcus aureus*. These microorganisms represent Gram-negative and Gram-positive pathogens, allowing assessment of the extract's broad-spectrum activity [19, 20, 21]. Sterile glass borers were used to create wells in the agar plates, and the extract was applied at concentrations of 50, 25, 12.5, and 6.25 mg/mL. The inhibition zones were measured in millimeters, with zones >10 mm classified as sensitive [22, 23].

5) Minimum Inhibitory Concentration (MIC): The MIC was determined by serially diluting the extracts in nutrient broth. Tubes containing bacterial suspensions and varying concentrations of the extract were incubated at 37°C for 18 hours. MIC was defined as the lowest concentration at which no visible bacterial growth occurred [24, 25, 26].

6) Minimum Bactericidal Concentration (MBC): To determine the MBC, samples from MIC tubes showing no visible growth were subcultured on nutrient agar plates and incubated for 48 hours at 37°C. The MBC was identified as the lowest concentration that completely inhibited bacterial growth on the agar surface [27, 28].

7) Detection of Phytochemicals: Phytochemicals were identified using thin-layer chromatography (TLC) on pre-coated silica gel plates. Solvents including ethanol, ethyl acetate, and n-hexane were chosen for their polarity spectrum, enhancing the separation of compounds. Detection was achieved using iodine vapor and ultraviolet light at 254 nm and 366 nm. Retention factor (Rf) values were calculated for compound identification [29, 30].

8) Rationale for Methodology Design: The use of gradient extraction ensures a comprehensive profile of phytochemicals, while cold extraction prevents degradation. The selection of both Gram-positive and Gram-negative bacteria as test organisms allows for a broad evaluation of antibacterial efficacy. The inclusion of erythromycin as a control ensures that results are benchmarked against a standard, providing a comparative framework for the study's findings [31, 32, 33].

III. RESULTS AND DISCUSSION

A. Results

1) Extraction of the Plant Commiphora africana: Mass of the powdered Steam bark used = 200g.

Extract Weight (g) = (Bottle weight – Extract weight) – Bottle weight

Extract Weight (g) = 51.575 – 36.615 = 14.96g

$$Percentge\ extracted\ (\%) = \frac{W1}{W2}\ X\ 100 = 7.48\% \quad (1)$$

W_1 is the powder's net weight in grams following extraction, and W_2 is the net weight of the amount of powder measured in grams during extraction. The percent recovery of the ethanol extract was calculated to be 7.48 %. Volume of the liquid extract after rinsing with the solvent = 43 ml.

Table 1. Characteristic of Plant Extract

Solvent	Extract Colour	Extract Weight (g)	% extracted
Ethanol	Reddish Brown	14.96	7.48

2) The Phytochemical Screening: Phytochemical screening result showed that *Commiphora Africana* contains the presence of Tannin, Terpenoids, Glycoside, phenol and Quinone's. The presence of this diversified secondary metabolite in the plant supported its use in folkloric medicine, and have been related with antibacterial activity.

Table 2. Phytochemical analysis of the ethanol crude extract derived from *C. Africana* plant

S/N	Phytochemicals	Tests	E.E Results
1.	Tannin	Ferric Chloride Test	+ +
2.	Glycoside	Chloroform Test	+
3.	Terpenoids	Chloroform Test	+ + +
4.	Phenols	Ferric Chloride Test	+
5.	Quinones	Sulfuric Acid Test	+ +

Key + = Present **-** = Absent E.E = Ethanol extract

3) The Minimum Bactericidal Concentration: The ethanolic extracts' concentrations reveal their efficiency targeting *S. aureus, S. typhi*, and *E. coli*. This suggests that the crude ethanolic stem bark extract of the plant Commiphora Africana includes a component with antibacterial effect. The outcome indicated a strong relationship with the proven anti-disease use of the herb in traditional medicine. Staphylococcus aureus, salmonella typhi, and Escherichia coli's susceptibility to the ethanolic bark extract suggests that the extract's compound can be further enhanced to battle this bacterium. As a result, the plant's usage in treating skin ailments, diarrhea, dysentery, and external pile is justified because this bacterium is the source of these illnesses.

Table 3. Minimum Bactericidal Concentration of Plant Extract of *C. Africana*

Test Organism		MBC (mg/ml) Ethanolic Extract	
E. coli	+	-	-
S.typhi	-	-	-
S.aureus	-	-	-

Key + = Bacterial Growth **-** = No Growth of Bacteria

B. Discussion

Phytochemical analysis revealed that the ethanolic extract of *Commiphora Africana* stem bark contains phenols, quinones, glycosides, tannins, and terpenoids. These secondary metabolites are known to possess significant antimicrobial properties, supporting the traditional medicinal uses of the plant [34, 35]. Phenols and quinones are particularly important due to their ability to disrupt bacterial cell walls and membranes through oxidative damage. Phenols are known to act as protein denaturants, targeting enzymes and other essential cellular proteins, which leads to bacterial cell death. Quinones, on the other hand, exert antimicrobial effects by forming reactive oxygen species (ROS) and interfering with bacterial respiration. These mechanisms align with the observed efficacy of the extract against *Escherichia coli*, *Salmonella typhi*, and *Staphylococcus aureus* [36, 37, 38]. Tannins contribute to antimicrobial activity by binding to bacterial proteins, particularly proline-rich enzymes, thereby inhibiting their function. This interference affects bacterial metabolism and growth. Additionally, tannins can precipitate microbial enzymes, disrupt cell membranes, and inhibit biofilm formation, making them effective against a wide spectrum of pathogens. The ability of tannins to inhibit bacterial protein synthesis could explain the observed activity against S. aureus, a Gram-positive bacterium associated with skin and wound infections [38, 39]. Terpenoids, another major class of secondary metabolites identified in the extract, are known for their broad-spectrum antimicrobial properties. Their lipophilic nature allows them to integrate into bacterial membranes, disrupting membrane integrity and causing leakage of essential cellular contents. Terpenoids also interfere with bacterial quorum sensing, a process critical for biofilm formation and virulence. These properties make them particularly effective against pathogens such as *S. typhi* and *E. coli*, which are involved in gastrointestinal infections [36, 39]. The efficacy of the ethanolic extract against the tested bacterial strains, demonstrated through significant inhibition zones and low minimum bactericidal concentration (MBC) values, is consistent with findings in previous studies. For instance, the antibacterial potential of terpenoids and phenolics in Commiphora species, reinforcing the importance of these compounds [40, 41]. Compared to earlier studies, the current findings emphasize the significant activity of *C. africana* against multidrug-resistant bacteria, suggesting its

potential as a source of novel antimicrobial agents [42, 43, 44].

The MBC values further substantiate the potent antibacterial activity of the ethanolic extract. The ability to completely eliminate bacterial colonies at relatively low concentrations highlights the bactericidal rather than bacteriostatic nature of the extract. This observation suggests that the bioactive compounds present in the extract may serve as templates for the development of new antibiotics, particularly for treating infections caused by *S. typhi*, *E. coli*, and *S. aureus* [45].

1) Comparison with Existing Literature: While the antimicrobial activity of various Commiphora species has been documented, the current study provides a focused analysis of *C. africana* stem bark and its specific efficacy against key pathogens. The antimicrobial potential of other Commiphora species but did not provide detailed insights into their phytochemical contributions [4, 2]. This study bridges that gap by correlating the antimicrobial effects with the identified phytochemicals, particularly phenols, tannins, and terpenoids [46, 47].Moreover, the study contributes to understanding the spectrum of activity of *C. africana*. Unlike prior research, which largely focused on general antibacterial efficacy, this study demonstrates the extract's potency against both Gram-positive and Gram-negative bacteria. This broad-spectrum activity, coupled with low MBC values, positions *C. africana* as a valuable resource for addressing antimicrobial resistance [48, 49].

*2) Implications, Limitations, and Future Research:*The findings highlight the therapeutic potential of *C. africana* in combating bacterial infections commonly associated with skin ailments, diarrhea, dysentery, and other gastrointestinal disorders. However, several limitations exist that should be addressed in future studies. First, the study lacks isolation and structural characterization of the specific bioactive compounds responsible for the observed antibacterial activity. Future research should employ advanced analytical techniques such as high-performance liquid chromatography (HPLC), gas chromatography-mass spectrometry (GC-MS), and nuclear magnetic resonance (NMR) spectroscopy to identify and elucidate the structures of these compounds. Second, the possible synergistic effects of various metabolites in *C. africana* remain unexplored. Investigating these interactions using combination assays or metabolomics approaches could provide insights into whether and how these metabolites work together to enhance antibacterial efficacy. Third, the study does not assess the potential cytotoxicity or safety profile of *C. africana* extracts. Future investigations should include in vitro and in vivo toxicological evaluations to ensure the safety of these compounds for therapeutic applications. Finally, the research is limited to in vitro antibacterial activity. To confirm clinical relevance, further studies should include in vivo models of bacterial infections and eventually progress to clinical trials. These steps will be crucial for translating laboratory findings into practical therapeutic applications.By addressing these limitations, future research can build a more comprehensive understanding of the therapeutic potential of *C. africana*, paving the way for the development of effective antibacterial agents. This study provides a foundation for developing plant-based antimicrobial formulations. The observed activities support the traditional use of *C. africana* and highlight its potential role in modern medicine, especially as an alternative to synthetic antibiotics in the face of rising antimicrobial resistance.

IV. SUMMARY

The screening of phytochemicals was undertaken in accordance with the standard technique given by [50]. A yield of 1.56 percent was achieved from a sample of 10 g that was sucked in 100 ml of ethanol. Phenol, tannin, quinone, terpenoid, and glycoside are the secondary metabolites that are copious, according to the findings from the phytochemical analysis. The steam bark extract of the plant *Commiphora Africana* includes this secondary metabolite, which makes it efficient against bacteria like *E. coli*, *S. typhi*, and *S. aureus*.

V. CONCLUSIONS

The extract obtained from the ethanolic bark of *Commiphora Africana* had secondary metabolites such as tannin, glycosides, phenol, quinones, and terpenoids that were likewise present in the steam bark extract. The steam bark extract was effective against *Escherichia coli*, *Salmonella typhi*, and *Staphylococcus aureus*, demonstrating susceptibility in all three bacterial strains. This investigation might give a scientific foundation and validate the traditional medicine practitioners' contention that *Commiphora Africana* steam bark extract is a viable herbal remedy with broad-spectrum antibacterial activity against the tested microorganisms [51, 52]. It supports the argument that *Commiphora Africana* steam bark extract is useful in treating illnesses such skin disorders, diarrhea, dysentery, and external pile that are especially associated to *E. coli*, *S. typhi*, and *S. aureus* [53]. It also comes to the conclusion that the dosage administered, which could fluctuate based on the target organism or disorders, impacts how effective the herbal mixture is.

VI. RECOMMENDATION

It is advised that more studies be undertaken on the plant *Commiphora Africana* in order to properly investigate all of its therapeutic or medicinal potential.

- To evaluate the ethanolic extracts' efficacy *against E. coli*, *S. typhi* and *S. aureus*, experiments were done at high concentrations.
- To determine the extract's efficiency against further disease-causing substances, it was tested on different bacteria.
- To identify, separate, and describe the bioactive components of the plant extract, research will be undertaken via bioassay guided fractionation.

- The Ministry of Health demonstrated that all herbal products must undergo scientific validations before to being promoted as medicines.

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