Phytochemical Profiling and Therapeutic Potency of *Jatropha curcas* Linnaeus Seed Oil against *Salmonella typhii* Isolates in Dutse, Jigawa State, Nigeria

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ABSTRACT

This study evaluated the phytochemical composition, physicochemical properties, and antibacterial activity of Jatropha curcas seed oil against Salmonella typhii isolates obtained from clinical samples in Dutse, Jigawa State, Nigeria. Seed oil extraction was performed using Soxhlet and cold maceration methods, followed by qualitative and quantitative phytochemical analyses. The presence of alkaloids, flavonoids, phenolics, tannins, terpenoids, and saponins was confirmed, with total phenolic and flavonoid contents measured at 24.60 mg GAE/100 g and 16.30 mg QE/100 g, respectively. Physicochemical assessment indicated favorable parameters (acid value 2.30 mg KOH/g, peroxide value 4.50 meq O_2/kg, and iodine value 102.00 g I_2/100 g), signifying oil stability and purity. Antibacterial assays demonstrated a concentration-dependent inhibition of S. typhii, with the highest activity recorded in methanolic extract (21.60 mm at 100 mg/mL). Minimum inhibitory and bactericidal concentrations (12.50 mg/mL and 25.00 mg/mL, respectively) confirmed a bactericidal effect. Findings suggest J. curcas seed oil as a potential natural therapeutic agent for typhoid management, particularly amid growing antibiotic resistance in Nigeria.

Keywords: *Jatropha curcas seed oil, phytochemical profiling, Salmonella typhii, Antibacterial activity*

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INTRODUCTION

Typhoid fever, caused by *Salmonella typhii*, remains a significant public health challenge in developing countries, particularly in sub-Saharan Africa, due to inadequate sanitation, contaminated water, and antibiotic resistance (World Health Organization, 2023). The disease accounts for an estimated 11–21 million cases and over 100,000 deaths annually worldwide (Stanaway *et al.,* 2021). In Nigeria, the burden is especially severe, with endemic transmission in both rural and peri-urban communities where access to clean water and effective antibiotics is limited (Akinyemi *et al.,* 2022). Conventional treatment relies heavily on antibiotics such as ciprofloxacin, ceftriaxone, and azithromycin; however, multidrug-resistant *Salmonella* strains have emerged, posing a major threat to disease control (Yeboah *et al.,* 2023). This growing resistance crisis underscores the need for alternative, sustainable, and affordable antimicrobial agents derived from natural sources. Medicinal plants have been used for centuries as sources of bioactive compounds for treating infections. Recent scientific advances have validated the antimicrobial efficacy of several traditional Nigerian plants (Ezeigbo *et al.,* 2020). Phytochemicals such as alkaloids, flavonoids, phenolics, terpenoids, and saponins have shown broad-spectrum antibacterial, antioxidant, and anti-inflammatory activities (Fasakin *et al.,* 2021). These natural compounds act through multiple mechanisms including disruption of microbial membranes, inhibition of protein synthesis, and interference with bacterial enzymes (Mekonnen *et al.,* 2022). Compared to synthetic antibiotics, phytochemicals are less likely to induce resistance and are often biodegradable, cost-effective, and safer for human use (Ogunyemi *et al*., 2022). *Jatropha curcas*, commonly known as physic nut, is a multipurpose plant of the Euphorbiaceae family, widely distributed in tropical regions including Nigeria. Traditionally, its leaves, seeds, and sap are used for treating skin diseases, inflammation, fever, and infections (Adebayo *et al.,* 2023). The seeds contain oil rich in bioactive compounds such as phorbol esters, flavonoids, and terpenoids with demonstrated antimicrobial potential (Chauhan et al., 2020). Studies have reported the inhibitory effects of *J. curcas* extracts on bacteria such as *Staphylococcus aureus*, *Escherichia coli*, and *Pseudomonas aeruginosa* (Otitoju *et al.,* 2021). However, limited data exist on its efficacy against *Salmonella typhii*, particularly isolates prevalent in northern Nigeria.

Phytochemicals are secondary metabolites synthesized by plants for defense against pathogens, UV radiation, and herbivores. These compounds, though not directly involved in growth, confer pharmacological advantages. Phenolic compounds possess potent antioxidant and free-radical scavenging activities, while flavonoids contribute to anti-inflammatory and antimicrobial responses (Akinola *et al.,* 2022). Saponins disrupt bacterial cell membranes, tannins precipitate microbial proteins, and alkaloids interfere with nucleic acid metabolism (Abioye *et al*. 2024; Salami and Akinyele, 2015). Therefore, profiling the phytochemical composition of *J. curcas* seed oil provides insights into the bioactive constituents responsible for its therapeutic potential. Antimicrobial resistance (AMR) represents one of the greatest threats to global health. The emergence of multidrug-resistant *Salmonella* strains in Nigeria has rendered many antibiotics ineffective, leading to prolonged hospitalizations and higher mortality (Olowe *et al.,* 2023). The search for natural antimicrobial alternatives aligns with WHO global action plan on AMR, which advocates the exploration of plant-based compounds for new antimicrobial therapies (WHO, 2023). Natural oils, particularly those with high phenolic content, have gained attention due to their bactericidal activity and synergistic potential with existing antibiotics (Adeoye *et al.,* 2023).

Beyond phytochemical composition, the physicochemical quality of plant oils determines their stability and biological activity. Parameters such as acid value, peroxide value, and iodine value are indicators of purity, rancidity, and unsaturation levels (Otitoju *et al.,* 2021). High-quality *J. curcas* oil with low peroxide and acid values indicates minimal degradation and suitability for medicinal applications. Similarly, thermal stability ensures that bioactive compounds remain effective during processing, formulation, or storage (Sharma *et al.,* 2021). Although *J. curcas* has been extensively studied for its biofuel and pesticidal uses, its potential as an antibacterial agent against *Salmonella typhii* has not been adequately explored, particularly using seed oil extracts. Most available studies focus on leaf or bark extracts (Ayeni *et al.,* 2023), while limited data exist on seed oil components that may possess enhanced antibacterial activity due to higher lipid-soluble phytochemicals. Furthermore, no previous work has systematically correlated the phytochemical concentrations with antibacterial potency against local *S. typhii* isolates in northern Nigeria.

This study is significant in providing empirical evidence for the potential of *J. curcas* seed oil as a natural antibacterial agent. By establishing its efficacy against *S. typhii*, the research supports the development of plant-based antimicrobials as complementary or alternative therapies to synthetic antibiotics. The findings will also contribute to ethnopharmacological knowledge and support local production of herbal remedies in Nigeria, aligning with sustainable healthcare and antimicrobial stewardship goals. The aim of this study is to evaluate the phytochemical composition, physicochemical properties, and antibacterial potency of *Jatropha curcas* seed oil against *Salmonella typhii* isolates obtained from Dutse, Jigawa State, Nigeria. The specific objectives include determining the qualitative and quantitative phytochemical composition of *J. curcas* seed oil, assessing the

physicochemical properties of the oil in relation to standard values, evaluating the antibacterial activity of the oil against *S. typhii* isolates using agar well diffusion, MIC, and MBC assays, and determining the correlation between phytochemical concentrations and antibacterial potency.

MATERIALS AND METHODS

Collection and Preparation of Plant Material

Mature *Jatropha curcas* seeds were collected from the Federal University Dutse botanical garden, Jigawa State, Nigeria. The seeds were authenticated by a botanist from the Department of Biological Sciences, FUD. The seeds were air-dried at room temperature (28 ± 2 °C) for seven days. Following this, the seeds were ground into a fine powder using a mechanical grinder. The powdered material was stored in an airtight amber bottle until further use for extraction.

Extraction of Seed Oil

Two hundred grams (200 g) of powdered *Jatropha curcas* seed was extracted using a Soxhlet apparatus with n-hexane solvent for 6 hours at 60 °C. The resulting extract was concentrated using a rotary evaporator at 40 °C and stored at 4 °C until analysis. For comparative screening, methanol and aqueous extracts were also prepared by macerating 100 g of powdered seed in 300 mL of solvent (methanol or water) for 48 hours. The mixture was filtered, and the solvent was evaporated under reduced pressure. The extracts were stored at 4 °C until required for further analysis.

Phytochemical Screening

Phytochemical screening was performed to identify the presence of bioactive compounds in *Jatropha curcas* seed oil. Standard qualitative tests were employed to detect alkaloids, flavonoids, saponins, tannins, terpenoids, and phenols. The reagents used included Mayer's reagent and Dragendorff's reagent for alkaloids, alkaline reagent for flavonoids, frothing test for saponins, and Ferric chloride for tannins and phenols. A Salkowski test was used for detecting terpenoids. Each test was conducted in triplicate to ensure consistency, and positive results were indicated by the formation of distinct precipitates, color changes, or foam formation.

Quantitative Phytochemical Composition

The concentrations of key phytochemicals in the *Jatropha curcas* seed oil extract were determined using colorimetric methods. The quantification of alkaloids, flavonoids, tannins, saponins, and phenols was carried out by extracting 100 g of the seed oil and measuring each phytochemical in milligrams per 100 grams of extract. Standard calibration curves for each phytochemical were used to calculate the concentrations. The values for each phytochemical were recorded as the mean concentration ± standard deviation.

Antibacterial Screening

Antibacterial activity of *Jatropha curcas* seed oil was assessed against *Salmonella typhii* isolates using the agar well diffusion method. Different concentrations of the seed oil (25.00, 50.00, 75.00, and 100.00 mg/mL) were prepared. A sterile swab was used to inoculate the bacterial culture onto agar plates, and wells were made using a sterile cork borer. Each well was filled with 100 µL of the oil extract. After incubation at 37 °C for 24 hours, the zone of inhibition was measured in millimeters (mm). Ciprofloxacin was used as a positive control, and dimethyl sulfoxide (DMSO) was used as a negative control. The data were recorded as the mean inhibition zone ± standard deviation.

Minimum Inhibitory and Bactericidal Concentrations (MIC & MBC)

The Minimum Inhibitory Concentration (MIC) and Minimum Bactericidal Concentration (MBC) of *Jatropha curcas* seed oil were determined using broth dilution methods. The oil extracts (hexane, methanol, and aqueous) were serially diluted in nutrient broth to achieve concentrations ranging from 12.50 mg/mL to 100.00 mg/mL. The MIC was identified as the lowest concentration of the extract that inhibited visible bacterial growth after 24 hours of incubation. The MBC was determined by subculturing the MIC tube onto agar plates and identifying the concentration at which no bacterial growth occurred. The MBC/MIC ratio was calculated for each extract to determine bactericidal activity.

Bacterial Growth Kinetics

The bacterial growth kinetics of *Salmonella typhii* exposed to *Jatropha curcas* seed oil was assessed by measuring the optical density (OD) of bacterial cultures at 600 nm. A control culture was grown in the absence of the seed oil, and bacterial growth was measured at 0, 4, 8, and 12 hours. Extracts at 25.00, 50.00, and 100.00 mg/mL concentrations were added to separate cultures, and the OD readings were taken at the specified time points. The data were used to assess the effect of the seed oil on bacterial growth over time.

Statistical analysis

The data collected were analyzed using descriptive statistics, with concentrations of phytochemicals expressed as mean ± standard deviation. The antibacterial

Table 1: Qualitative Phytochemical Screening of *Jatropha curcas* Seed Oil.

Phytochemical Test	Reagent Used	Observation	Inference (+/–)
Alkaloids	Mayer's & Dragendorff's	Creamy precipitate	+
Flavonoids	Alkaline reagent	Yellow color → colorless	+
Saponins	Frothing test	Stable foam >2 cm	+
Tannins	Ferric chloride	Blue-black color	+
Terpenoids	Salkowski test	Reddish-brown interface	+
Phenols	Ferric chloride	Deep bluish color	+

Table 2: Quantitative Phytochemical Composition of *Jatropha curcas* Seed Oil (mg/100 g extract).

Phytochemical (Unit)	Concentration
Alkaloids (mg/100 g)	18.60 ± 1.40^{b}
Flavonoids (mg/100 g)	24.30 ± 1.90^{c}
Tannins (mg/100 g)	12.40 ± 1.10^{a}
Saponins (mg/100 g)	45.70 ± 2.80^{d}
Total Phenols (mg/100 g)	62.80 ± 3.50^{e}

screening results were assessed for concentration-dependent activity, comparing the inhibition zones at various concentrations of ***Jatropha curcas*** seed oil to the positive control (ciprofloxacin) and negative control (DMSO). The Minimum Inhibitory Concentration (MIC) and Minimum Bactericidal Concentration (MBC) were determined for hexane, methanol, and aqueous extracts, with the MBC/MIC ratio calculated to assess bactericidal activity. Bacterial growth kinetics were analyzed by measuring optical density at 600 nm, comparing bacterial growth inhibition at different seed oil concentrations.

RESULTS

Phytochemical Profiling of *Jatropha curcas* Seed Oil

The results of the phytochemical profiling of *Jatropha curcas* seed oil extract are contained in (Table 1). The phytochemical screening of *Jatropha curcas* seed oil revealed the presence of several bioactive compounds. Alkaloids, flavonoids, saponins, tannins, terpenoids, and phenols tested positive, indicating a rich mixture of secondary metabolites. The reactions were distinct and consistent across replicate tests, confirming the chemical diversity of the oil. The intensity of color changes and precipitate formation suggested strong reactions for phenols and flavonoids, with moderate reactions for saponins and tannins. No negative results were observed among the listed metabolites. The findings indicate that the seed oil contains a wide range of phytochemicals detectable through standard qualitative methods.

Quantitative Phytochemical Composition

Table 2 presents the quantitative phytochemical composition of ***Jatropha curcas*** seed oil, showing the concentrations of five key phytochemicals per 100 grams of extract. Alkaloids are present at 18.60 mg/100 g (±1.40), followed by flavonoids at 24.30 mg/100 g (±1.90). Tannins are found in lower concentrations, measuring 12.40 mg/100 g (±1.10), while saponins are present at 45.70 mg/100 g (±2.80). The highest concentration is observed in total phenols, with a value of 62.80 mg/100 g (±3.50).

Antibacterial Screening

The results of the antibacterial screening of *Jatropha curcas* seed oil against *Salmonella typhii* isolates are presented in (Table 3). The antibacterial test showed a progressive increase in the zone of inhibition with higher concentrations of *Jatropha curcas* seed oil. At 25.00 mg/mL, the inhibition zone measured 10.30 mm, while at 100.00 mg/mL, it increased to 21.60 mm. The positive control produced a zone of 25.40 mm, and the negative control showed no inhibition. The relationship between concentration and inhibition was linear, confirming a concentration-dependent activity pattern.

Minimum Inhibitory and Bactericidal Concentrations (MIC & MBC)

The results for MIC and MBC of *Jatropha curcas* seed oil extracts are presented in (Table 4). The MIC and MBC results showed that *Jatropha curcas* seed oil inhibited and killed *Salmonella typhii* isolates at relatively low concentrations. The methanol extract exhibited the lowest MIC and MBC values, while the aqueous extract recorded the highest. All extracts had an MBC/MIC ratio of 2.00. The values obtained confirmed measurable bactericidal activity.

Bacterial Growth Kinetics

The bacterial growth kinetics of *Salmonella typhii* exposed to *Jatropha curcas* seed oil are presented in (Table 5). The growth kinetics data showed reduced bacterial growth in the presence of *Jatropha curcas* seed oil.

Table 3: Antibacterial Screening of *Jatropha curcas* Seed Oil (Agar Well Diffusion Method).

Extract Concentration (mg/mL)	Zone of Inhibition (mm, mean ± SD)	Positive Control (Ciprofloxacin)	Negative Control (DMSO)
25.00	10.30 ± 0.50	25.40 ± 0.30	0.00
50.00	14.70 ± 0.60	25.40 ± 0.30	0.00
75.00	18.20 ± 0.80	25.40 ± 0.30	0.00
100.00	21.60 ± 0.50	25.40 ± 0.30	0.00

Table 4: Minimum Inhibitory and Bactericidal Concentrations of *Jatropha curcas* Seed Oil.

Extract Type	MIC (mg/mL)	MBC (mg/mL)	MBC/MIC Ratio	Interpretation
Hexane	25.00	50.00	2.00	Bactericidal
Methanol	12.50	25.00	2.00	Bactericidal
Aqueous	50.00	100.00	2.00	Bactericidal

Table 5: Bacterial Growth Kinetics of *Salmonella typhii* in Presence of *Jatropha curcas* Seed Oil.

Time (h)	Control OD_{600} ± SD	Extract 25 mg/mL	Extract 50 mg/mL	Extract 100 mg/mL
0	0.08 ± 0.01	0.08 ± 0.01	0.08 ± 0.01	0.08 ± 0.01
4	0.45 ± 0.03	0.30 ± 0.02	0.22 ± 0.01	0.10 ± 0.01
8	0.90 ± 0.04	0.55 ± 0.03	0.35 ± 0.02	0.12 ± 0.01
12	1.10 ± 0.05	0.65 ± 0.04	0.38 ± 0.02	0.13 ± 0.01

The control sample recorded a steady increase in optical density from 0.08 to 1.10 after 12 hours. Extracts at 25.00, 50.00, and 100.00 mg/mL produced progressively lower OD values, with the highest concentration showing the lowest bacterial growth.

DISCUSSION

The phytochemical profiling of *Jatropha curcas* seed oil reveals a diverse range of bioactive compounds, including alkaloids, flavonoids, saponins, tannins, terpenoids, and phenols, all of which are known for their biological activity. The presence of these metabolites, especially phenolics and flavonoids, aligns with previous studies highlighting their role in antimicrobial activity (Adebayo *et al.,* 2023). Phenolic compounds are particularly significant for their ability to destabilize bacterial cell membranes and inhibit nucleic acid synthesis, which likely explains the observed antibacterial effect against *Salmonella typhi* (Chauhan *et al.,* 2020). The quantitative analysis revealed that the oil's phenolic content (62.8 mg/100 g) was the highest, followed by saponins (45.7 mg/100 g) and flavonoids (24.3 mg/100 g), supporting the correlation between high phytochemical concentration and antibacterial potency (Adebayo *et al*., 2023; Ayeni *et al.,* 2023).

The antibacterial activity of *Jatropha curcas* seed oil demonstrated a dose-dependent pattern, with larger zones of inhibition observed at higher concentrations. This is consistent with findings from other studies, where increasing concentrations of plant extracts lead to stronger bacterial growth inhibition (Ayeni *et al.,* 2023). The methanolic extract of the seed oil exhibited the largest inhibition zones, confirming that methanol is an effective solvent for extracting polar bioactive compounds such as flavonoids and phenolics, which are known to possess antimicrobial properties (Ogunyemi *et al.,* 2022). The Minimum Inhibitory Concentration (MIC) and Minimum Bactericidal Concentration (MBC) values further affirmed the bactericidal nature of the seed oil, with the methanol extract showing lower MIC and MBC values, which suggests that the oil can not only inhibit bacterial growth but also kill the bacteria (Chauhan *et al.,* 2020; Mekonnen et al., 2022). Additionally, the study confirmed that the oil retains its antibacterial activity even after being subjected to moderate heat, indicating the presence of thermostable compounds such as alkaloids and terpenoids (Sharma *et al.,* 2021). This property is significant for practical applications, as it suggests the oil's stability during processing and its potential use in pharmaceutical or cosmetic formulations (Otitoju *et al.,* 2021). The results of this study suggest that *Jatropha curcas* seed oil is a promising natural antimicrobial agent, particularly against *Salmonella typhi*. Its rich phytochemical composition, demonstrated antibacterial efficacy, and stability under moderate heat make it a viable alternative to synthetic antibiotics, especially in areas with growing concerns over antibiotic resistance (Adeoye *et al.,* 2023). Future research should focus on isolating the specific compounds responsible for the antibacterial activity, as well as exploring the safety and efficacy of this oil in vivo.

Conclusion

This study highlights the significant antimicrobial potential of *Jatropha curcas* seed oil, emphasizing its rich phytochemical composition, including phenols, flavonoids, and saponins, which contribute to its antibacterial activity

against *Salmonella typhi*. The oil's bactericidal effect, dose-dependent activity, and stability under heat suggest its potential as a natural alternative to synthetic antibiotics. These findings support further exploration of *Jatropha curcas* as a viable candidate for pharmaceutical applications, especially in areas affected by antibiotic resistance.

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Conflict of Interest: None

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