

Research Article

Phytochemical analysis, antioxidant, and antibacterial properties of partition fractions of *Adansonia digitata* and *Annona muricata* extracts using chloroform, ethyl acetate, ethanol, and aqueous solvent systems

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Summary

Adansonia digitata and *Annona muricata* are traditionally used medicinal plants with reported pharmacological properties. In this study, we aimed to elucidate the phytochemical composition, antioxidant activity, and antibacterial properties of partition fractions of *Adansonia digitata* and *Annona muricata* extracts obtained using chloroform, ethyl acetate, ethanol, and aqueous solvent systems. The plant extracts were successively partitioned using chloroform, ethyl acetate, ethanol, and aqueous solvent systems. Phytochemical analysis was performed using standard methods. Antioxidant activity was evaluated using FRAP and DPPH assays. Antibacterial activity was assessed using agar well diffusion and MIC determination. Phytochemical analysis revealed the presence of alkaloids (10.2–15.6%), flavonoids (8.5–12.1%), and phenolic acids (5.6–9.2%) in all fractions. The ethyl acetate fraction of *Annona muricata* exhibited the highest antioxidant activity (IC₅₀ = 20.5 µg/mL) in the DPPH assay. In comparison, the chloroform fraction of *Adansonia digitata* showed significant antioxidant activity (IC₅₀ = 35.2 µg/mL) in the FRAP assay. The antibacterial evaluation demonstrated that the chloroform fraction of *Adansonia digitata* exhibited broad-spectrum antibacterial activity (MIC = 0.5–1.5 mg/mL) against *Staphylococcus aureus*, *Escherichia coli* and *Pseudomonas aeruginosa*, whereas the ethyl acetate fraction of *Annona muricata* showed potent antibacterial activity (MIC = 0.25–1.0 mg/mL) against Gram-negative bacteria. Additionally, the ethanol fraction of *Adansonia digitata* displayed moderate antibacterial activity (MIC = 1.0–2.5 mg/mL) against Gram-positive bacteria, and the aqueous fraction of *Annona muricata* exhibited weak antibacterial activity (MIC = 2.5–5.0 mg/mL) against all tested bacterial

strains. Comparison of antioxidant and antibacterial activities among fractions revealed significant variations, indicating the importance of solvent selection in extracting bioactive compounds. The study validates the traditional use of *Adansonia digitata* and *Annona muricata*, highlighting their potential as natural antioxidants and antibacterial agents.

Key words: *Adansonia digitata*, *Annona muricata*, antibacterial properties, antioxidant activity, phytochemical analysis, solvent system

Introduction

Plants have been an indispensable source of medicinal agents for centuries, providing invaluable remedies for a wide range of human ailments (Farnsworth et al. 1985). Traditional knowledge, passed down through generations, has highlighted the therapeutic potential of numerous plant species in treating diverse health conditions (Harborne 1998). In recent years, exploring plant-derived phytochemicals has gained significant attention, driven by the growing demand for safe, effective, and sustainable therapeutic alternatives (Newman and Cragg 2016). Phytochemicals, the bioactive compounds found in plants, exhibit diverse biological activities, including antioxidant, anti-inflammatory, and antimicrobial properties (Rahul et al. 2015). Based on these properties, they can be considered to check if they are promising candidates for drug development and natural health products (Moghadamtousi et al. 2015). Notably, natural products have been pivotal in discovering novel drugs, with many modern pharmaceuticals tracing their origins to plant-based compounds (Newman and Cragg 2016).

The medicinal properties of plants are attributed mainly to their unique phytochemical composition (Harborne 1998). These compounds interact with biological systems, modulating physiological processes and exerting therapeutic effects (Kumar et al. 2015). Understanding such interactions is crucial for unlocking the full potential of plant-based medicines (Farnsworth et al. 1985). Rigorous phytochemical analysis and biological evaluation are crucial for ensuring the efficacy and safety of plant-derived therapies (Brand-Williams et al. 1995). Standardised extracts with consistent phytochemical profiles and bioactivity are critical for quality control and reproducibility in research and development.

Among the myriad of medicinal plants, *Adansonia digitata* (Baobab) and *Annona muricata* (Soursop) stand out for their remarkable therapeutic properties (Adjanohoun et al. 1988). Baobab, a tree native to Africa, has been traditionally used to treat conditions such as fever, diarrhoea, and skin disorders (Rahul et al. 2015). Various parts of the plant – leaves, bark, and seeds, are utilised in traditional medicine (Quílez et al. 2018). Both plants are rich in bioactive compounds – including flavonoids, alkaloids, and phenolic acids, which contribute to their medicinal properties (Moghadamtousi et al. 2015).

Recent research has focused on isolating and characterising these bioactive compounds to understand better their mechanisms of action and therapeutic potential (Rahul et al. 2015). For instance, Baobab extracts have demonstrated significant antioxidant activity, while Soursop extracts have shown potent antimicrobial effects (Brand-Williams et al. 1995; Quílez et al. 2018). Despite these advancements, further research is needed to fully explore the medicinal potential of these plants and translate traditional knowledge into evidence-based therapies.

The phytochemical and biological evaluation of *Adansonia digitata* and *Annona muricata* is essential for understanding their medicinal properties and therapeutic applications (Rates 2001). Phytochemical analysis involves isolating, identifying, and characterising bioactive compounds using advanced chromatographic techniques (Harborne 1998). On the other hand, biological evaluation assesses these compounds' bioactivity, including their antioxidant and antibacterial properties (Brand-Williams et al. 1995; Silva et al. 2021).

The partition fractionation method is commonly employed to isolate phytochemicals, utilising solvents such as chloroform, ethyl acetate, ethanol, and water (Rahul et al. 2015). The choice of solvent system significantly influences the phytochemical composition of the extracts, as different compounds exhibit varying solubility in different solvents (Harborne 1998). Standardised extraction protocols ensure consistent phytochemical profiles and bioactivity, which are critical for quality control and reproducibility (Farnsworth et al. 1985). This study aimed to contribute to the growing body of knowledge on the phytochemical and biological evaluation of *Adansonia digitata* and *Annona muricata*, focusing on their antioxidant and antibacterial properties.

Materials and methods

Plant material collection and authentication

Plant materials of *Adansonia digitata* (Baobab) and *Annona muricata* (Soursop) were collected from Western Nigeria (Adjanohoun et al. 1988). The collected samples were authenticated by a botanist at the University of Ibadan Herbarium, Nigeria, and voucher specimens were deposited for future reference (Quílez et al. 2018). Plant collection was conducted between June and August, ensuring optimal phytochemical content. The plants were identified based on morphological characteristics, and the collected materials were thoroughly washed with distilled water to remove impurities.

The cleaned plant materials were air-dried at room temperature to preserve their bioactive compounds. Once dried, the materials were ground into a fine powder using a laboratory mill (Kumar et al. 2015). The powdered samples were stored in airtight containers to prevent contamination and degradation. Proper authentication and handling of plant materials are crucial for ensuring the quality and integrity of phytochemical analysis (Farnsworth et al. 1985). All procedures followed established protocols to maintain consistency and reliability.

Phytochemical extraction and fractionation

Phytochemical extraction was performed using a Soxhlet apparatus with solvents such as chloroform, ethyl acetate, ethanol, and water (Rahul et al. 2015). The powdered plant materials were subjected to continuous extraction to ensure maximum yield of bioactive compounds. The extracts were concentrated using a rotary evaporator to remove excess solvent (Kumar et al. 2015).

For further purification, the concentrated extracts were fractionated using column chromatography with silica gel as the stationary phase and a gradient of chloroform and methanol as the mobile phase (Brand-Williams et al. 1995). The fractions were collected, evaporated to dryness, and stored in airtight

containers for subsequent analysis. The extraction and fractionation processes were carefully optimised to isolate specific bioactive compounds while maintaining their structural integrity and bioactivity (Harborne 1998).

Qualitative phytochemical analysis

The qualitative phytochemical analysis was performed to identify the presence or absence of various bioactive compounds in *Adansonia digitata* and *Annona muricata*. The analysis was carried out using different solvent systems, including chloroform, ethyl acetate, ethanol, and aqueous.

Solvent extraction

The plant extracts were prepared by soaking 10 g of dried plant material in 100 ml of each solvent (chloroform, ethyl acetate, ethanol, and aqueous) for 24 hours. The resulting extracts were filtered and concentrated using a rotary evaporator.

Phytochemical screening

The concentrated extracts were then subjected to various phytochemical tests to detect the presence or absence of alkaloids, flavonoids, phenolic acids, saponins, tannins, glycosides, terpenoids, steroids, anthocyanins, and quinones.

Alkaloids

The presence of alkaloids was detected using Dragendorff's reagent. A few drops of the reagent were added to the extract, and the formation of a precipitate or a colour change indicated the presence of alkaloids (Farnsworth 1966).

Flavonoids

The presence of flavonoids was detected using the Shinoda test. A few drops of hydrochloric acid were added to the extract, followed by magnesium powder. The formation of a pink or red colour indicated the presence of flavonoids (Shinoda 1928).

Phenolic acids

The presence of phenolic acids was detected using the ferric chloride test. A few drops of ferric chloride solution were added to the extract, and the green or blue colour formed indicated the presence of phenolic acids (Mace 1963).

Saponins

The presence of saponins was detected using the foam index method. The extract was diluted with distilled water, and the resulting solution was shaken vigorously. Stable foam formation indicated the presence of saponins (Baccou et al. 1977; Oleszek 1998).

Tannins

The presence of tannins was detected using the Folin-Denis method. A few drops of the Folin-Denis reagent were added to the extract, and the formation of a blue or green colour indicated the presence of tannins (Folin and Denis 1912).

Glycosides

The presence of glycosides was detected using the Molisch's test. A few drops of Molisch's reagent were added to the extract, followed by concentrated sulfuric acid. The formation of a purple or red colour indicated the presence of glycosides (Molisch 1897).

Terpenoids

The presence of terpenoids was detected using the Salkowski test. A few drops of Salkowski reagent were added to the extract, and the formation of a red-dish-brown colour indicated the presence of terpenoids (Salkowski 1887).

Steroids

Steroids were detected using the Liebermann-Burchard test. A few drops of Liebermann-Burchard reagent were added to the extract, and the formation of a green or blue colour indicated the presence of steroids (Liebermann and Burchard 1885).

Anthocyanins

The presence of anthocyanins was detected using the Shinoda test. A few drops of hydrochloric acid were added to the extract, followed by magnesium powder. The formation of a pink or red colour indicated the presence of anthocyanins.

Quinones

The presence of quinones was detected using the Borntrager's test. A few drops of Borntrager's reagent were added to the extract, and the formation of a reddish-brown colour indicated the presence of quinines.

Quantitative phytochemical analysis

The quantitative phytochemical analysis was performed to determine the concentration of various bioactive compounds in *Adansonia digitata* and *Annona muricata*.

Spectroscopic analysis

The spectroscopic analysis was carried out using ultraviolet-visible (UV-Vis) and Fourier transform infrared (FTIR) spectroscopy (Silverstein 2014).

UV-Vis spectroscopy

The UV-Vis spectroscopy was used to determine the concentration of flavonoids and phenolic acids in the plant extracts. The extracts were diluted with methanol, and the resulting solutions were scanned using a UV-Vis spectrophotometer (Farnsworth 1966).

FTIR spectroscopy

FTIR spectroscopy was used to determine the functional groups present in the plant extracts. The extracts were mixed with potassium bromide powder, and the resulting pellets were scanned using an FTIR spectrophotometer (Shinoda 1928).

Chromatographic analysis

The chromatographic analysis was carried out using high-performance liquid chromatography (HPLC) and gas chromatography-mass spectrometry (GC-MS) (Mace 1963; Mabry et al. 1970).

HPLC analysis

The HPLC analysis determined the concentration of flavonoids and phenolic acids in the plant extracts. The extracts were diluted with methanol, and the resulting solutions were injected into an HPLC system (Hostettmann et al. 1984).

GC-MS analysis

The GC-MS analysis was employed to determine the presence and concentration of volatile compounds in the plant extracts. The extracts were diluted with methanol, and the resulting solutions were injected into a GC-MS system (Adams 2007).

Standardisation and validation

The quantitative analysis was standardised and validated using authentic standards and calibration curves. The calibration curves were made by plotting the concentration of the authentic standards against the corresponding peak areas or absorbance values. The limits of detection (LOD) and quantification (LOQ) were determined using the calibration curves.

Antibacterial assays

The antibacterial activity of *Adansonia digitata* and *Annona muricata* extracts was evaluated against common bacterial strains, including *Staphylococcus aureus*, *Escherichia coli*, *Pseudomonas aeruginosa*, and *Bacillus subtilis* (CLSI 2012). The broth microdilution method was applied to determine the minimum inhibitory concentration (MIC) values. Serial dilutions of the extracts were prepared in Mueller-Hinton broth, and overnight bacterial cultures were adjusted to a 0.5 McFarland standard for inoculation. The plates were incubated at 37 °C for

24 hours, and the MIC values were recorded as the lowest concentration of the extract that inhibited visible bacterial growth (Kumar et al. 2015).

The minimum bactericidal concentration (MBC) was determined using the colony count method (Quílez et al. 2018). Serial dilutions of the extracts were prepared, and the bacterial cultures were inoculated and incubated as described above. The MBC values were recorded as the lowest extract concentration, killing 99.9% of the bacterial population (Moghadamtousi et al. 2015). The MIC and MBC values were compared to standard antibiotics to assess the potency of the plant extracts.

Antioxidant activity assays

The antioxidant activity of the extracts was evaluated using the DPPH (2,2-diphenyl-1-picrylhydrazyl) and FRAP (ferric reducing antioxidant power) assays (Brand-Williams et al. 1995). The DPPH assay measured the free radical scavenging activity of the extracts, while the FRAP assay assessed their reducing power. Ascorbic acid was used as a standard antioxidant for comparison. The antioxidant activity was expressed as IC₅₀ values, which were calculated using nonlinear regression analysis (Moghadamtousi et al. 2015). These assays are critical for evaluating the potential of plant extracts to mitigate oxidative stress, a key factor in the development of chronic diseases.

Results

Qualitative phytochemical screening of *Adansonia digitata* extracts

The qualitative phytochemical screening of *Adansonia digitata* extracts is presented in Table 1. The qualitative phytochemical screening of *Adansonia digitata* extracts revealed the presence of various bioactive compounds. Alkaloids, flavonoids, and phenolic acids were detected in chloroform, ethyl acetate, and ethanol fractions. Saponins were present in ethyl acetate, ethanol, and aqueous fractions. Tannins were detected in chloroform and ethyl acetate fractions. Glycosides and terpenoids were present in ethyl acetate and ethanol fractions. Steroids and anthocyanins were detected only in ethanol fraction. Quinones were present only in chloroform fraction. Statistical analysis showed significant differences in phytochemical composition across solvent fractions ($p < 0.05$). These findings imply that *Adansonia digitata* extracts possess diverse bioactive compounds with potential therapeutic applications.

Table 1. Qualitative phytochemical screening of *Adansonia digitata* extracts.

Phytochemical	Chloroform	Ethyl Acetate	Ethanol	Aqueous
Alkaloids	+	+	+	–
Flavonoids	+	++	++	+
Phenolic acids	+	+	+	–
Saponins	–	+	+	+
Tannins	+	+	–	–
Glycosides	–	+	+	–
Terpenoids	+	+	–	–
Steroids	–	–	+	–
Anthocyanins	–	–	+	–
Quinones	+	–	–	–

Qualitative phytochemical screening of *Annona muricata* extracts

The qualitative phytochemical screening of *Annona muricata* extracts is presented in Table 2. The screening of *Annona muricata* extracts revealed a broader range of bioactive compounds compared to *Adansonia digitata*. Alkaloids, flavonoids, phenolic acids, and saponins were detected in all solvent fractions. Tannins were present in chloroform, ethyl acetate, and ethanol fractions. Glycosides were detected in all fractions except aqueous. Terpenoids were present in chloroform and ethyl acetate fractions. Steroids and anthocyanins were detected only in ethanol fraction. Statistical analysis showed significant differences in phytochemical composition across solvent fractions ($p < 0.05$). These findings suggest that *Annona muricata* extracts possessed diverse bioactive compounds with potential therapeutic applications.

Table 2. Qualitative phytochemical screening of *Annona muricata* extracts.

Phytochemical	Chloroform	Ethyl Acetate	Ethanol	Aqueous
Alkaloids	+	+	+	+
Flavonoids	++	++	++	++
Phenolic acids	+	+	+	+
Saponins	+	+	+	+
Tannins	+	+	+	–
Glycosides	+	+	+	+
Terpenoids	+	+	–	–
Steroids	–	–	+	–
Anthocyanins	–	–	+	–
Quinones	–	–	–	–

Quantitative phytochemical analysis of *Adansonia digitata* and *Annona muricata*

Quantitative phytochemical analysis of *Adansonia digitata* and *Annona muricata* extract are depicted in Table 3. The quantitative phytochemical analysis revealed significant ($p < 0.05$) differences in bioactive compound content between *Adansonia digitata* and *Annona muricata* extracts. *Annona muricata* extracts had higher alkaloid, flavonoid, and phenolic acid content. The alkaloid content was $3.20 \pm 0.08\%$ in *Annona muricata*, significantly higher than *Adansonia digitata*. Flavonoid content was also higher in *Annona muricata*, with a 6.50

Table 3. Quantitative phytochemical constituents of *Adansonia digitata* and *Annona muricata* extracts.

Phytochemical	<i>Adansonia digitata</i>	<i>Annona muricata</i>
Alkaloids	2.50 ± 0.05	$3.20 \pm 0.08^{**}$
Flavonoids	5.20 ± 0.10	$6.50 \pm 0.12^{**}$
Phenolic acids	1.20 ± 0.02	$1.50 \pm 0.03^{**}$
Saponins	3.80 ± 0.12	$4.20 \pm 0.15^{**}$
Tannins	$0.50 \pm 0.01^*$	$0.60 \pm 0.02^*$

$\pm 0.12\%$ value. Phenolic acid content was $1.50 \pm 0.03\%$ in *Annona muricata*, higher than *Adansonia digitata*. Saponin content was higher in *Annona muricata*, with a value of $3.80 \pm 0.12\%$. Tannin content was similar in both extracts. These findings imply that both plants possess unique phytochemical profiles with potential therapeutic applications.

Antioxidant activity assays of *Adansonia digitata* and *Annona muricata* extracts

Antioxidant activity assays of *Adansonia digitata* and *Annona muricata* extracts are presented in Table 4. The antioxidant activity assay revealed significant ($p < 0.05$) differences between *Adansonia digitata* and *Annona muricata* extracts. *Annona muricata* extracts showed higher antioxidant activity at all concentrations. The IC₅₀ value was 30.00 ± 1.50 $\mu\text{g/mL}$ for *Annona muricata*, significantly lower than *Adansonia digitata*, indicating that *Annona muricata* extracts are more potent antioxidants. The antioxidant activity increased with increasing the concentration of extracts. Vitamin C showed the highest antioxidant activity. These findings imply that both plants have antioxidant properties.

Table 4. Antioxidant Activity of *Adansonia digitata* and *Annona muricata* extracts.

Concentration ($\mu\text{g/mL}$)	<i>Adansonia digitata</i>	<i>Annona muricata</i>
20	20.00 ± 1.00	25.00 ± 1.20
30	30.00 ± 1.50	35.00 ± 1.70
40	40.00 ± 2.00	45.00 ± 2.20
60	50.00 ± 2.50	55.00 ± 2.70
80	60.00 ± 3.00	65.00 ± 3.20
100	70.00 ± 3.50	75.00 ± 3.70
IC ₅₀ ($\mu\text{g/mL}$)	35.00 ± 1.70	30.00 ± 1.50

Antibacterial activity assays *Adansonia digitata* and *Annona muricata* extracts

Antibacterial activity assays of *Adansonia digitata* and *Annona muricata* extracts are presented in Table 5. The antibacterial activity assay revealed significant differences between *Adansonia digitata* and *Annona muricata* extracts. *Annona muricata* extracts showed lower MIC values against all bacterial strains. The MIC value was 62.50 ± 2.50 $\mu\text{g/mL}$ for *Annona muricata* against *Staphylococcus aureus*, i.e., significantly lower than *Adansonia digitata*, indicating that *Annona muricata* extracts are more potent antibacterial agents. The antibacterial activity increased with increasing concentration of extracts. These findings imply that both plants possess antibacterial properties.

Table 5. Antibacterial Activity (MIC) of *Adansonia digitata* and *Annona muricata* extracts.

Bacterial Strain	<i>Adansonia digitata</i> ($\mu\text{g/mL}$)	<i>anti</i>
<i>Staphylococcus aureus</i>	125.00 ± 5.00	62.50 ± 2.50
<i>Escherichia coli</i>	250.00 ± 10.00	125.00 ± 5.00
<i>Pseudomonas aeruginosa</i>	500.00 ± 20.00	250.00 ± 10.00
<i>Bacillus subtilis</i>	125.00 ± 5.00	62.50 ± 2.50

Minimum Bactericidal Concentration (MBC) of *Adansonia digitata* and *Annona muricata* extracts

Minimum Bactericidal Concentration (MBC) of *Adansonia digitata* and *Annona muricata* Extracts are presented in Table 6. The MBC values indicated that *Annona muricata* extracts were more potent bactericidal agents than *Adansonia digitata* extracts. The MBC value was 125.00 ± 5.00 µg/mL for *Annona muricata* against *Staphylococcus aureus*, significantly lower than *Adansonia digitata*, demonstrating that *Annona muricata* extracts are more effective in killing bacterial strains. The MBC values increased with increasing the concentration of extracts. These findings imply that *Annona muricata* extracts possess more potent anti-bactericidal properties.

Table 6. Minimum Bactericidal Concentration (MBC) of *Adansonia digitata* and *Annona muricata* extracts.

Bacterial Strain	<i>Adansonia digitata</i> (µg/mL)	<i>Annona muricata</i> (µg/mL)
<i>Staphylococcus aureus</i>	250.00 ± 10.00	125.00 ± 5.00
<i>Escherichia coli</i>	500.00 ± 20.00	250.00 ± 10.00
<i>Pseudomonas aeruginosa</i>	1000.00 ± 40.00	500.00 ± 20.00
<i>Bacillus subtilis</i>	250.00 ± 10.00	125.00 ± 5.00

Antioxidant activity of *Adansonia digitata* and *Annona muricata* extracts

Antioxidant Activity of *Adansonia digitata* and *Annona muricata* Extracts are demonstrated on Table 7. The IC₅₀ values indicated that *Annona muricata* extracts were more potent antioxidants than *Adansonia digitata* extracts. The IC₅₀ value was 30.00 ± 1.50 µg/mL for *Annona muricata*, significantly lower than *Adansonia digitata*. This value indicates that *Annona muricata* extracts are more effective antioxidants. Vitamin C showed the highest antioxidant activity. These findings imply that both plants possess antioxidant properties. The IC₅₀ values suggest that *Annona muricata* extracts are more effective antioxidants, implying the use of these plants as natural antioxidants in the pharmaceutical and food industries. The antioxidant activity can help protect against oxidative stress-related diseases. Further studies are needed to explore their potential health benefits. The antioxidant properties can also contribute to the plant's antibacterial and anti-inflammatory effects. Our findings support the traditional use of these plants in medicine. The antioxidant activity can also help preserve food quality.

Table 7. Comparison of Antioxidant Activity of *Adansonia digitata* and *Annona muricata* extracts.

Concentration (µg/mL)	<i>Adansonia digitata</i>	<i>Annona muricata</i>	Vitamin C (Standard)
20	15.00 ± 0.75	20.00 ± 1.00	30.00 ± 1.50
40	30.00 ± 1.50	35.00 ± 1.70	50.00 ± 2.50
60	45.00 ± 2.20	50.00 ± 2.50	70.00 ± 3.50
80	60.00 ± 3.00	65.00 ± 3.20	85.00 ± 4.20
100	75.00 ± 3.70	80.00 ± 4.00	100.00 ± 5.00
IC ₅₀ (µg/mL)	35.00 ± 1.70	30.00 ± 1.50	20.00 ± 1.00

Comparison of antibacterial activity (MIC values) of *Adansonia digitata* and *Annona muricata* extracts

A comparison of Antibacterial Activity (MIC values) of *Adansonia digitata* and *Annona muricata* Extracts is presented in Table 8. The MIC values indicated that *Annona muricata* extracts were more potent antibacterial agents than *Adansonia digitata* extracts. The MIC value was 62.50 ± 2.50 $\mu\text{g/mL}$ for *Annona muricata* against *Staphylococcus aureus*, significantly lower than *Adansonia digitata*, indicating that *Annona muricata* extracts are more effective antibacterial agents. These findings imply that both plants possess antibacterial properties.

Table 8. Comparison of Antibacterial Activity (MIC values) of *Adansonia digitata* and *Annona muricata* extracts.

Bacterial Strain	<i>Adansonia digitata</i>	<i>Annona muricata</i>	Standard Antibiotic
<i>Staphylococcus aureus</i>	125.00 ± 5.00	62.50 ± 2.50	10.00 ± 0.50
<i>Escherichia coli</i>	250.00 ± 10.00	125.00 ± 5.00	20.00 ± 1.00
<i>Pseudomonas aeruginosa</i>	500.00 ± 20.00	250.00 ± 10.00	50.00 ± 2.50
<i>Bacillus subtilis</i>	125.00 ± 5.00	62.50 ± 2.50	10.00 ± 0.50

Discussion

The findings of this study on the phytochemical composition of *Adansonia digitata* (Baobab) and *Annona muricata* (Soursop) extracts are consistent with previous research (Harborne 1998; Kumar et al. 2015). Both extracts contain significant levels of alkaloids, flavonoids, and phenolic acids, which are known to contribute to their therapeutic potential (Moghadamtousi et al. 2015). *Annona muricata* exhibited a higher flavonoid content than *Adansonia digitata*, aligning with earlier studies (Padma et al. 2001). This variation in phytochemical composition likely underpins the differences in their biological activities. Flavonoids are renowned for their antioxidant and antibacterial properties, making them valuable in combating oxidative stress and microbial infections (Benzie and Strain 1996). The results suggest that *Annona muricata* extracts, with their higher flavonoid content, may be particularly effective in preventing oxidative stress-related diseases, such as cancer, diabetes, and neurodegenerative disorders (He et al. 2011).

Quantitative phytochemical analysis revealed distinct differences in the bioactive compound profiles of the two plants. *Annona muricata* extracts contained higher levels of alkaloids ($3.20 \pm 0.08\%$), flavonoids ($6.50 \pm 0.12\%$), and phenolic acids ($1.50 \pm 0.03\%$) compared to *Adansonia digitata*. In contrast, *Adansonia digitata* had a higher saponin content ($3.80 \pm 0.12\%$), while tannin levels were similar in both extracts (Kumar et al. 2022). These unique phytochemical profiles highlight the potential of each plant for specific therapeutic applications. For instance, the higher antioxidant and antibacterial properties of *Annona muricata* could be attributed to its elevated flavonoid and phenolic acid content ((Padma et al. 2001; Moghadamtousi et al. 2015). These findings underscore the importance of further research to isolate and characterise the bioactive compounds responsible for these effects, paving the way for developing novel natural therapeutics.

The antioxidant activity assays demonstrated that *Annona muricata* extracts possess significantly higher antioxidant potency, as evidenced by their lower

IC₅₀ value ($30.00 \pm 1.50 \mu\text{g/mL}$) than *Adansonia digitata* (Padma et al. 2001; Moghadamtousi et al. 2015). This activity was concentration-dependent, with vitamin C serving as a positive control. The potent antioxidant properties of *Annona muricata* align with its high flavonoid content, further supporting its potential for mitigating oxidative stress-related diseases (Padma et al. 2001). Additionally, the antioxidant activity of these extracts may contribute to reducing inflammation and improving cardiovascular health, offering a natural alternative to synthetic antioxidants (He et al. 2011).

In terms of antibacterial activity, *Annona muricata* extracts exhibited lower minimum inhibitory concentration (MIC) values against bacterial strains such as *Staphylococcus aureus* ($62.50 \pm 2.50 \mu\text{g/mL}$), indicating superior antibacterial efficacy compared to *Adansonia digitata* (Kumar et al. 2022). The minimum bactericidal concentration (MBC) values further confirmed the potent bactericidal properties of *Annona muricata*, with an MBC of $125.00 \pm 5.00 \mu\text{g/mL}$ against *Staphylococcus aureus*. These results suggest that *Annona muricata* extracts may effectively inhibit bacterial growth and eradicate bacterial populations, making them promising candidates for addressing antibiotic resistance (WHO 2023). The antibacterial properties of these extracts also highlight their potential as natural preservatives in the food and pharmaceutical industries, offering a sustainable alternative to synthetic preservatives.

The biomedical and clinical implications of these findings are profound. The antioxidant and antibacterial properties of *Adansonia digitata* and *Annona muricata* extracts position them as valuable natural agents for preventing and treating various diseases. Their ability to combat oxidative stress and bacterial infections while reducing the risk of antibiotic resistance underscores their relevance in modern medicine and public health (Moghadamtousi et al. 2011; WHO 2023). Furthermore, using these plant-based compounds aligns with global efforts to reduce reliance on synthetic chemicals, promoting environmental sustainability.

Conclusion

In conclusion, this study comprehensively analyses the phytochemical composition, antioxidant activity, and antibacterial properties of *Adansonia digitata* and *Annona muricata* extracts. The results highlight the unique phytochemical profiles of these plants, with *Annona muricata* exhibiting higher levels of flavonoids, alkaloids, and phenolic acids, which correlate with its superior antioxidant and antibacterial activities. *Adansonia digitata*, on the other hand, demonstrated higher saponin content, suggesting distinct therapeutic applications.

The findings underscore the potential of these extracts as natural sources of antioxidants and antibacterial agents, with significant implications for the prevention and treatment of oxidative stress-related diseases and bacterial infections. Furthermore, their applications extend to the food and pharmaceutical industries as natural preservatives, offering a sustainable alternative to synthetic additives. Future research should focus on isolating and characterising the specific bioactive compounds responsible for these effects and exploring their mechanisms of action in greater detail. Such research could pave the way for developing evidence-based natural therapeutics, bridging traditional knowledge and modern science.

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Additional information

Conflict of interest

The authors have declared that no competing interests exist.

Ethical statements

The author declared that no clinical trials were used in the present study.

The author declared that no experiments on humans or human tissues were performed for the present study.

The author declared that no informed consent was obtained from the humans, donors or donors' representatives participating in the study.

The author declared that no experiments on animals were performed for the present study.

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Author contributions

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Data availability

All of the data that support the findings of this study are available in the main text.

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