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Research Article

Antimicrobial, Antioxidant, and Phytochemical Studies of *Moringa oleifera* Leaf Extracts

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ABSTRACT

The present study evaluates the antimicrobial, antioxidant, and phytochemical properties of *Moringa oleifera* leaf extracts prepared using aqueous, ethanolic, and methanolic solvents. Phytochemical screening revealed the presence of bioactive constituents such as alkaloids, flavonoids, tannins, terpenoids, glycosides, and phenolics, with the methanolic extract showing the highest concentration. The antimicrobial potential was assessed using the agar well diffusion method against *Escherichia coli*, *Staphylococcus aureus*, *Pseudomonas aeruginosa*, *Bacillus subtilis*, and *Candida albicans*. Methanolic extract exhibited the strongest inhibitory effect, showing a maximum zone of inhibition (23.2 mm) against *B. subtilis*, while aqueous extract showed the least activity (11.7–15.1 mm). Antioxidant activity, measured via DPPH radical scavenging assay, showed dose-dependent activity, with methanolic extract exhibiting 84.3% inhibition at 100 µg/mL, comparable to ascorbic acid (91.2%). The results indicate that *Moringa oleifera* leaves are a rich source of phytochemicals with significant antimicrobial and antioxidant properties, suggesting potential applications in natural medicine and pharmaceutical formulations.

INTRODUCTION

Medicinal plants have long been a cornerstone of traditional medicine due to their rich phytochemical profiles and bioactive constituents. *Moringa oleifera* (family: Moringaceae), commonly known as the drumstick tree, is widely

distributed in tropical and subtropical regions and is recognized for its nutritional and therapeutic benefits. Previous studies have reported its antimicrobial, antioxidant, anti-inflammatory, and antidiabetic properties, largely attributed to compounds such as flavonoids, phenolics, alkaloids, and tannins. The increasing resistance of

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pathogenic microorganisms to synthetic antibiotics has heightened interest in plant-based antimicrobial agents. Similarly, oxidative stress caused by free radicals is implicated in various chronic diseases, necessitating the search for natural antioxidants. Therefore, this study aims to assess the phytochemical constituents, antimicrobial efficacy, and antioxidant potential of aqueous, ethanolic, and methanolic extracts of *Moringa oleifera* leaves.

2. MATERIALS AND METHODS

2.1 Plant Material Collection and Preparation

Fresh *Moringa oleifera* leaves were collected, washed with distilled water, shade-dried for 10 days, and pulverized into a fine powder using a mechanical grinder. The powder was stored in an airtight container until extraction.

2.2 Preparation of Extracts

About 50 g of powdered leaves were subjected to Soxhlet extraction with 300 mL of methanol, ethanol, and distilled water separately for 6 hours. The extracts were concentrated using a rotary evaporator and stored at 4°C until further analysis.

2.3 Phytochemical Screening

Standard qualitative tests were conducted to detect the presence of alkaloids, flavonoids, tannins, saponins, terpenoids, glycosides, and phenolics according to Harborne's methods (1998). The

intensity of each phytochemical was recorded as (+), (++), or (+++).

2.4 Antimicrobial Activity

The antimicrobial activity was tested by the agar well diffusion method. Test microorganisms included *E. coli*, *S. aureus*, *P. aeruginosa*, *B. subtilis*, and *C. albicans*. Wells were loaded with 100 µL of each extract (100 mg/mL), and ciprofloxacin (for bacteria) and fluconazole (for fungi) served as positive controls. Plates were incubated at 37°C for 24 hours, and zones of inhibition were measured in millimeters (mm).

2.5 Antioxidant Activity (DPPH Radical Scavenging Assay)

Different concentrations (20–100 µg/mL) of each extract were mixed with 0.1 mM DPPH in methanol. After 30 minutes of incubation in the dark, absorbance was measured at 517 nm. Percentage inhibition was calculated using the formula: %Inhibition = (A_{control} - A_{sample}) / A_{control} × 100. Ascorbic acid was used as the standard.

3. RESULTS

3.1 Phytochemical Screening

All three extracts of *Moringa oleifera* showed the presence of important secondary metabolites. Methanolic extract contained the highest levels of alkaloids, flavonoids, tannins, and phenolics.

Phytochemical	Aqueous Extract	Ethanolic Extract	Methanolic Extract
Alkaloids	+	+	++
Flavonoids	+	++	++
Tannins	+	++	++
Saponins	-	+	+
Terpenoids	+	+	++
Glycosides	+	++	++
Phenolics	+	++	+++

3.2 Antimicrobial Activity

The methanolic extract exhibited the strongest activity against all test organisms, with a

maximum zone of inhibition of 23.2 mm against *B. subtilis* and a minimum of 18.6 mm against *C. albicans*. The aqueous extract displayed lower inhibition values (11.7–15.1 mm).

Microorganism	Aqueous Extract (mm)	Ethanollic Extract (mm)	Methanolic Extract (mm)	Standard (mm)
<i>E. coli</i>	13.2	18.3	20.5	25.0
<i>S. aureus</i>	14.5	19.5	22.1	26.3
<i>P. aeruginosa</i>	12.8	17.8	19.8	24.1
<i>B. subtilis</i>	15.1	20.2	23.2	27.0
<i>C. albicans</i>	11.7	16.4	18.6	22.5

3.3 Antioxidant Activity

DPPH assay results demonstrated dose-dependent antioxidant activity in all extracts, with methanolic

extract showing the highest percentage inhibition (84.3% at 100 µg/mL), closely followed by ethanolic extract (78.4%) and aqueous extract (68.9%).

Concentration (µg/mL)	Aqueous (%)	Ethanollic (%)	Methanolic (%)	Ascorbic Acid (%)
20	35.2	42.5	49.8	55.0
40	48.6	55.3	63.1	68.3
60	57.4	66.7	71.2	77.8
80	63.5	72.1	78.6	85.4
100	68.9	78.4	84.3	91.2

4. DISCUSSION

The study confirms that *Moringa oleifera* leaves are a potent source of bioactive compounds with notable antimicrobial and antioxidant effects. The methanolic extract's higher efficacy can be attributed to its superior ability to extract polar phytochemicals such as flavonoids and phenolics, known for their radical-scavenging and antimicrobial activities. The antimicrobial results align with previous findings by Anwar et al. (2007) and Rahman et al. (2019), who reported broad-spectrum activity of *Moringa* extracts. Similarly, the antioxidant results support earlier studies indicating that phenolic and flavonoid-rich extracts of *Moringa* scavenge free radicals effectively.

5. CONCLUSION

Moringa oleifera leaf extracts, particularly the methanolic extract, demonstrate significant antimicrobial and antioxidant potential due to their rich phytochemical composition. The findings validate its traditional medicinal use and support its potential development into natural therapeutic agents and pharmaceutical formulations.

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