

Evaluation of the Antimicrobial Potential of *Solanum surattense* (Burm. f.) Against Selected Pathogenic Microorganisms

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Abstract:

Solanum surattense Burm. f. (Solanaceae) is a traditionally used medicinal herb reported to contain diverse secondary metabolites and to exhibit antimicrobial, antioxidant and anti-inflammatory properties. This study investigated the phytochemical profile and antimicrobial potential of sequential solvent extracts from *Solanum surattense* (Burm. f.), a plant traditionally used in ethnomedicine. Fresh, healthy whole plants were collected, identified and sequentially extracted with petroleum ether, benzene, chloroform, acetone, methanol and distilled water. The highest percentage yields were obtained from the polar solvents, methanol (13.72%) and aqueous extract (10.45%). Preliminary phytochemical screening revealed that the methanolic and aqueous extracts contained the highest diversity of secondary metabolites, including alkaloids, flavonoids, tannins, phenolics, saponins and glycosides, while non-polar extracts were rich in terpenoids and steroids. The antimicrobial activity was tested against six human pathogens (*S. aureus*, *B. subtilis*, *E. coli*, *P. aeruginosa*, *C. albicans* and *A. niger*) using the agar well diffusion method. The methanolic extract exhibited the highest broad-spectrum activity, with maximum zones of inhibition against *Staphylococcus aureus* (21.3 pm 0.7 mm) and *E. coli* (19.4 pm 0.6 mm). Acetone and aqueous extracts showed moderate activity, while non-polar extracts were less effective. The potent antimicrobial activity is strongly correlated with the abundance of polar phytochemicals, such as phenolics and flavonoids. The study validates the traditional use of *S. surattense* and suggests its potential as a promising source for developing natural antimicrobial agents to combat the growing issue of drug-resistant pathogens.

1. INTRODUCTION

The growing global burden of antimicrobial resistance among human pathogens has prompted renewed interest in exploring plant-derived bioactive compounds as potential alternatives or adjuncts to conventional antimicrobials (Cowan, 1999). Medicinal plants offer a rich source of structurally diverse secondary metabolites such as flavonoids, alkaloids, terpenoids, phenolic acids, saponins and glycosides, many of which display antimicrobial, anti-inflammatory, antioxidant and other pharmacological properties (Cowan, 1999; Aliero & Afolayan, 2006). Within the plant family Solanaceae, the genus *Solanum* comprises many species traditionally used in folk medicine and recent phytochemical and pharmacological investigations are uncovering their therapeutic potential (e.g., terpenoid-alkaloid glycosides, steroidal alkaloids) (Unleashed Treasures of Solanaceae, 2023).

Among these, *Solanum surattense* (Burm. f.), often known in Ayurvedic and traditional systems as “Kantakari”, is widely distributed in arid and semi-arid regions of India, Pakistan and neighbouring regions. It is employed as a remedy for respiratory complaints (cough, asthma), skin ailments, gastrointestinal upsets, urinary and prostate disorders, analgesia, piles and other conditions (ethnomedical

usage ...,2023). The plant's widespread ethnomedicinal use, together with emerging pharmacological data, underlines its potential as a source of new bioactive compounds.

A recent systematic review covering publications from 1753 to 2023 documented 338 metabolites isolated from *S. surattense*, including ~137 (40.5 %) terpenoids, ~56 (16.6 %) phenolic derivatives and ~52 (15.4 %) lipids; noted among the biologically active constituents are steroidal alkaloids (solamargine, solasonine), triterpenoids (dioscin, lupeol) and sterols (stigmasterol, campesterol). The qualitative presence of alkaloids, flavonoids, tannins, saponins, glycosides and steroids has also been repeatedly confirmed in leaf, root, fruit and stem extracts of the plant (Dhanalakshmi *et al.*, 2020; Morphological Description ..., 2019).

2. MATERIALS AND METHODS

2.1. Collection and Identification of Plant Material

Fresh and healthy whole plants of *Solanum surattense* Burm. f. was collected from Road sides and the adjoining area of Udaipur, Rajasthan, India during the flowering. The roadside plant specimens were carefully uprooted to include roots, stems, leaves and fruits, ensuring no diseased or damaged parts were selected. The collected materials were initially washed with tap water to remove adhering soil and debris, followed by rinsing with distilled water to eliminate surface contaminants. The sample plant was identified at Herbarium of the Department of Botany, University of Rajasthan, Jaipur and was provided with the accession no. RUBL21956, *Solanum surattense*. The cleaned plant material was shade-dried at room temperature (25–28 °C) for 10–15 days until a constant weight was achieved. The dried material was then pulverized into a fine powder using a mechanical grinder and stored in airtight containers at room temperature for subsequent extraction and antimicrobial studies.

2.2. Preparation of plant extracts

The collected plant (root, stem and leaves) were washed thoroughly with distilled water to remove dust and debris and shade-dried at room temperature (25 ± 2°C) for 15 days until a constant weight was obtained. The dried material was then powdered using a mechanical grinder and stored in airtight containers. 50 g of the powdered plant material was extracted sequentially with petroleum ether, benzene, chloroform, acetone, methanol and distilled water using a Soxhlet apparatus for 6–8 hours each. The extracts were filtered through Whatman No. 1 filter paper and concentrated under reduced pressure using a rotary evaporator at 40–45°C. The concentrated extracts were stored at 4°C in sterile vials until further use (Harborne, 1998).

2.3. Phytochemical Screening

The preliminary phytochemical screening of different solvent extracts was performed following standard qualitative methods (Trease and Evans, 2002; Kokate, 2005). Tests were carried out to detect the presence of alkaloids, flavonoids, tannins, phenolics, saponins, glycosides, terpenoids and steroids.

2.4. Microbial Strains

The antimicrobial activity was tested against six clinically relevant pathogenic microorganisms (Table 1).

Sr. no.	Microorganism	ATCC/NCTC
1.	<i>Staphylococcus aureus</i>	6538
2.	<i>Bacillus subtilis</i>	6633
3.	<i>Pseudomonas aeruginosa</i>	9027
4.	<i>Salmonella abony</i>	NCTC 6017
5.	<i>Candida albicans</i>	10231
6.	<i>Aspergillus brasiliensis</i>	16404

2.5. Preparation of Inoculum

Bacterial cultures were freshly grown in nutrient broth at 37°C for 24 hours and fungal cultures were grown in Sabouraud dextrose broth at 28°C for 48 hours. The turbidity of bacterial suspensions was adjusted to 0.5 McFarland standard ($\approx 1 \times 10^8$ CFU/mL) and that of fungal suspensions to $\approx 1 \times 10^6$ CFU/mL before inoculation.

2.6. Antimicrobial Assay

The antimicrobial activity of *S. surattense* extracts was evaluated by the cup well diffusion method (Bauer *et al.*, 1966) with slight modifications. Sterile Mueller–Hinton agar (for bacteria) and Sabouraud dextrose agar (for fungi) plates were inoculated with standardized microbial suspensions using sterile cotton swabs. Wells of 8 mm diameter were made using a sterile cork borer and filled with 100 μ L of plant extract solutions at concentrations of 25, 50, 75 and 100 mg/mL (dissolved in DMSO). Plates were incubated at 30–35°C for 24 hours (bacteria) and 20–25°C for 48 hours (fungi). After incubation, the zones of inhibition (ZOI) were measured in millimeters (mm). Ciprofloxacin (10 μ g/mL) and Ketoconazole (10 μ g/mL) were used as positive controls for bacterial and fungal strains, respectively, while DMSO served as the negative control.

2.7. Statistical Analysis

All experiments were conducted in triplicates and data were expressed as mean \pm standard deviation (SD). Statistical analyses were performed using GraphPad Prism 10.0 software. One-way ANOVA followed by Tukey's post hoc test was used to determine significant differences ($p < 0.05$) between treatments.

3. RESULT

3.1. Percentage Yield of Extracts

Successive extraction of *Solanum surattense* (Burm. f.) using solvents of increasing polarity (petroleum ether \rightarrow benzene \rightarrow chloroform \rightarrow acetone \rightarrow methanol \rightarrow distilled water) yielded variable quantities of crude extracts (Table 2). The methanolic extract produced the highest yield (13.72%), followed by aqueous extract (10.45%), indicating higher solubility of polar phytochemicals. Petroleum ether and benzene extracts yielded lower amounts (5.11% and 6.32%, respectively).

Table 2. Percentage yield of *S. surattense* extracts using different solvents

Solvent Used	Color/Texture of Extract	Yield (%) \pm SD
Petroleum ether	Light green, oily	5.11 \pm 0.10
Benzene	Dark green, viscous	6.32 \pm 0.08
Chloroform	Brownish-green, sticky	7.54 \pm 0.12
Acetone	Yellowish-brown, semi-solid	9.28 \pm 0.14
Methanol	Dark brown, thick	13.72 \pm 0.18
Distilled water	Brown, gummy	10.45 \pm 0.13

3.2. Phytochemical Screening

Qualitative phytochemical screening revealed that methanolic and aqueous extracts exhibited the most diverse profiles, including alkaloids, flavonoids, tannins, phenolics, glycosides, saponins, terpenoids and steroids. Non-polar solvents (petroleum ether, benzene) mainly extracted terpenoids and steroids.

Table 3. Phytochemical constituents of *S. surattense* extracts.

Phytochemical	Petroleum Ether	Benzene	Chloroform	Acetone	Methanol	Aqueous
Alkaloids	–	+	+	+	++	++
Flavonoids	–	–	+	++	++	++
Tannins	–	–	+	++	++	++
Phenolics	–	+	+	++	++	++
Saponins	–	–	–	+	++	++
Glycosides	–	–	+	+	++	++
Terpenoids	+	++	++	++	+	+
Steroids	+	++	+	+	+	–

3.3. Antimicrobial Activity

The methanolic extract exhibited the highest antimicrobial activity against all tested pathogens, with maximum zones of inhibition (ZOI) of 21.3 ± 0.7 mm for *S. aureus* and 19.4 ± 0.6 mm for *E. coli*. Acetone and aqueous extracts showed moderate activity, while petroleum ether and benzene showed weak activity (Table 4 and Fig.1).

Figure 1 Antibacterial activity of *S. surattense* extract

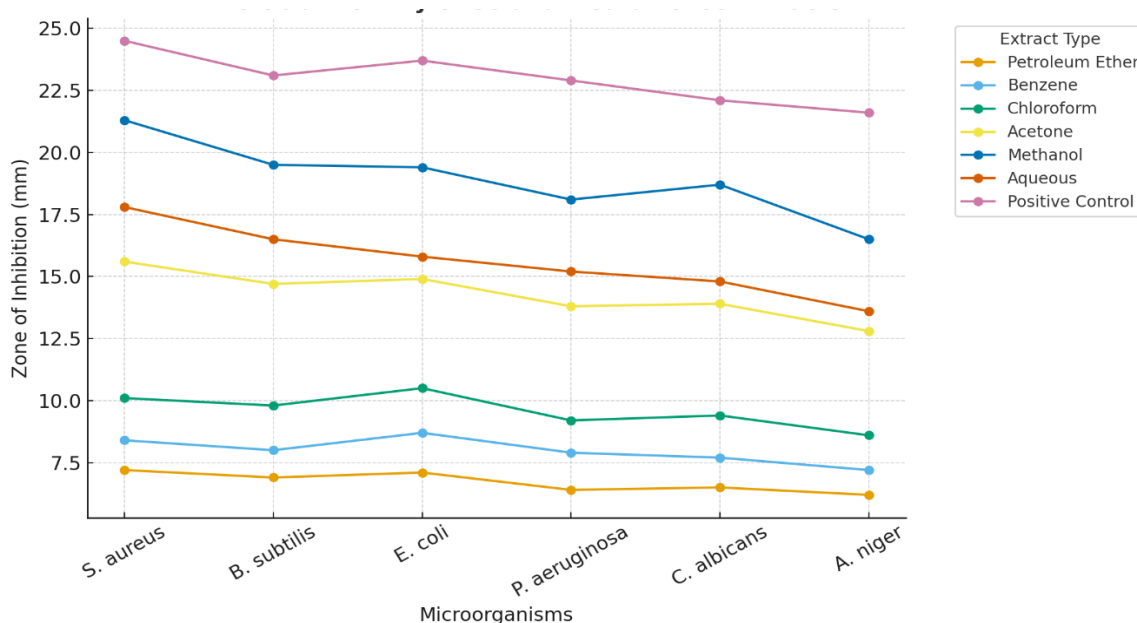


Table 4. Zone of inhibition (mm) of *S. surattense* extracts

Microorganism	Petroleum Ether	Benzene	Chloroform	Acetone	Methanol	Aqueous	Positive Control
<i>S. aureus</i>	7.2 ± 0.3	8.4 ± 0.4	10.1 ± 0.5	15.6 ± 0.6	21.3 ± 0.7	17.8 ± 0.6	24.5 ± 0.5
<i>B. subtilis</i>	6.9 ± 0.2	8.0 ± 0.3	9.8 ± 0.4	14.7 ± 0.5	19.5 ± 0.5	16.5 ± 0.5	23.1 ± 0.4
<i>E. coli</i>	7.1 ± 0.3	8.7 ± 0.4	10.5 ± 0.5	14.9 ± 0.5	19.4 ± 0.6	15.8 ± 0.5	23.7 ± 0.6
<i>P. aeruginosa</i>	6.4 ± 0.2	7.9 ± 0.3	9.2 ± 0.4	13.8 ± 0.4	18.1 ± 0.5	15.2 ± 0.4	22.9 ± 0.5
<i>C. albicans</i>	6.5 ± 0.3	7.7 ± 0.3	9.4 ± 0.4	13.9 ± 0.5	18.7 ± 0.6	14.8 ± 0.4	22.1 ± 0.5
<i>A. niger</i>	6.2 ± 0.2	7.2 ± 0.3	8.6 ± 0.3	12.8 ± 0.4	16.5 ± 0.5	13.6 ± 0.3	21.6 ± 0.5

4. DISCUSSION

The present study demonstrates that *Solanum surattense* (Burm. f.) contains a diverse array of bioactive phytochemicals and its extracts exhibit significant antimicrobial activity against clinically relevant pathogens. Sequential solvent extraction revealed that methanol yielded the highest extractive value (13.72%), followed by aqueous extracts (10.45%), indicating that the plant is rich in polar secondary metabolites such as alkaloids, flavonoids, phenolics and saponins. In contrast, non-polar solvents, including petroleum ether and benzene, produced lower yields and primarily extracted terpenoids and steroids, consistent with the solubility characteristics of these compounds (Harborne, 1998; Trease & Evans, 2002). These findings highlight the suitability of polar solvents for isolating the bioactive components responsible for the antimicrobial activity of *S. surattense*.

Preliminary phytochemical screening revealed that methanolic and aqueous extracts contained the highest diversity of secondary metabolites. This correlates with the observed broad-spectrum antimicrobial activity of these extracts. Phenolics and flavonoids, which were abundant in polar extracts, are known to inhibit microbial growth by disrupting cell walls, altering membrane permeability and inactivating enzymes essential for microbial survival (Cowan, 1999; Dhanalakshmi *et al.*, 2020). Alkaloids also contribute to antimicrobial activity through interference with nucleic acid synthesis and protein function (Rios & Recio, 2005). The presence of saponins and glycosides in methanol and aqueous extracts may further enhance the permeability of microbial membranes, facilitating the action of other bioactive compounds.

The antimicrobial activity of *S. surattense* extracts varied among solvents and microorganisms. The methanolic extract exhibited the highest zones of inhibition against *Staphylococcus aureus* (21.3 ± 0.7 mm) and *Escherichia coli* (19.4 ± 0.6 mm), indicating its strong antibacterial potential. Acetone and

aqueous extracts also demonstrated moderate activity, while petroleum ether and benzene extracts were less effective. These results are in agreement with previous studies on *S. surattense* and related Solanaceae species, which reported that polar extracts have higher antimicrobial efficacy than non-polar extracts due to the higher solubility of active constituents in polar solvents (Podili *et al.*, 2022; Ethnomedicinal Usage, 2023).

The broad-spectrum antimicrobial activity observed in this study supports the traditional ethnomedicinal use of *S. surattense* in treating infections and inflammatory conditions (Ethnomedicinal Usage, 2023). Methanolic extracts, in particular, showed significant inhibition of both Gram-positive and Gram-negative bacteria, suggesting the presence of compounds capable of crossing different cell wall structures. Phenolics and flavonoids, known for their redox properties, may also contribute to the antioxidant defense mechanisms, further enhancing antimicrobial activity (Dhanalakshmi *et al.*, 2020).

Solvent polarity played a critical role in extracting bioactive compounds and influencing antimicrobial efficacy. Polar solvents such as methanol and water were more effective in extracting alkaloids, flavonoids and phenolics, which are hydrophilic in nature, whereas non-polar solvents favored terpenoids and steroids. This aligns with the principle that the bioactive profile and antimicrobial potential of plant extracts are highly dependent on extraction solvent and method (Harborne, 1998; Kokate, 2005).

The findings of this study have several implications. First, methanolic extracts of *S. surattense* could be further investigated for isolation and characterization of specific antimicrobial compounds. Second, the plant could serve as a potential source for developing herbal formulations or adjuvants to conventional antibiotics, especially against multidrug-resistant strains. Third, the study reinforces the importance of traditional knowledge in guiding the search for novel antimicrobial agents in the face of rising antimicrobial resistance (Cowan, 1999; Podili *et al.*, 2022). Future studies should focus on fractionation of the methanolic extract to identify and purify the active constituents, followed by *in vivo* evaluation of safety and efficacy. Additionally, molecular docking and mechanistic studies could provide insight into how these compounds interact with microbial targets. Investigating synergistic effects between *S. surattense* extracts and standard antibiotics may also reveal potential combinatorial therapies to combat resistant pathogens.

Overall, *Solanum surattense* (Burm. f.) is a rich source of bioactive phytochemicals with significant antimicrobial potential. Methanolic and aqueous extracts demonstrated strong inhibition of human pathogenic bacteria and moderate antifungal activity. The study validates the traditional use of *S. surattense* and highlights its potential as a natural antimicrobial agent for therapeutic applications.

5. CONCLUSION

The present study highlights *Solanum surattense* (Burm. f.) as a promising source of bioactive phytochemicals with significant antimicrobial potential. Methanolic and aqueous extracts exhibited the highest extractive yields and a diverse range of secondary metabolites, including alkaloids, flavonoids, phenolics, saponins and glycosides, which are likely responsible for the observed antimicrobial effects. The methanolic extract demonstrated broad-spectrum activity against both Gram-positive and Gram-negative bacteria, with *Staphylococcus aureus* and *Escherichia coli* being the most susceptible, while moderate antifungal activity was observed against *Candida albicans* and *Aspergillus niger*. Minimum inhibitory concentration (MIC) values confirmed the potency of the extracts at low concentrations, indicating their potential for therapeutic application. Overall, the study validates the traditional ethnomedicinal use of *S. surattense* and underscores its potential as a natural antimicrobial agent. Further research focusing on the isolation and characterization of individual bioactive compounds, evaluation of *in vivo* efficacy and exploration of synergistic effects with conventional antibiotics is warranted. Such

investigations could facilitate the development of novel, plant-based antimicrobial therapeutics to combat the growing threat of antibiotic-resistant pathogens.

Ethical approval and Consent to participate: Not applicable and all authors participated in this work.

Consent for publication: All authors agree to publication.

Availability of data and materials: The data and materials that support the findings of the study are available from the corresponding author upon request.

Competing Interests: The author declare that they have no competing financial interest or personal relationship that could have appear to influence the work reported in this paper.

Funding: This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Authors contribution: UPS conceived the idea; UPS and NS collect the plant material; UPS designed experiment; NS setup and performed experiment; NS data analysis and visualization, wrote the whole manuscript; UPS, revised and edited complete manuscript, supervised and finalized the manuscript. All authors read and approved the final manuscript.

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