

Antibacterial Efficacy of *Solanum nigrum* Leaf Extracts Against Urinary Tract Infections-Causing Bacteria in Female Patients

Kuldeep Prasad¹, Dr Asha Mishra²

¹Research scholar, Department of Microbiology, YBN University, Ranchi, Jharkhand, India, 834010

²Assistant professor, Department of Biotechnology, YBN University, Ranchi, Jharkhand, India, 834010

Abstract

Urinary Tract Infection (UTI) is one of the most significant health concerns worldwide affecting both genders. However, incidents of UTI have been found to be more prevalent among women (Harrington and Hooton, 2020). It is estimated that about 50-60% of women around the world have witnessed infection in their urinary tract once in their lifetime. In India, UTI cases have seen significant rise in recent years. Although infections in urinary tract are caused by a variety of microbes that include bacteria, fungus and viruses, about 80% of cases are caused by bacteria like *Escherichia coli*, *Klebsiella pneumoniae*, *Proteus mirabilis*, *Enterococcus faecalis* and *Staphylococcus saprophyticus*. The current study investigates the phytochemical analysis and antibacterial efficacy of *Solanum nigrum* against UTI causing bacteria.

Keywords: Medicinal plants, *Solanum nigrum*, Antibacterial activity, UTI pathogens, Alternative therapies, Antibiotic resistance.

Introduction

Urinary tract infections (UTIs) are a significant health concern, particularly among women, affecting millions annually. The primary causative agents include *Escherichia coli*, *Klebsiella pneumoniae*, *Staphylococcus saprophyticus* and *Pseudomonas aeruginosa*, which are known for their pathogenicity and adaptability (Hiroshi N 2009). Over time, the efficacy of conventional antibiotics against these pathogens has diminished due to the alarming rise in antibiotic resistance, leading to increased treatment failures and healthcare costs (Hiroshi N 2009).

The search for alternative treatments has directed attention toward medicinal plants, often rich in bioactive compounds with therapeutic potential (Cowan M M 1999; Cragg G M and Newman D J 2013). *Solanum nigrum*, commonly known as black nightshade, is a traditional medicinal plant widely used for treating various ailments (Chopra R N *et al.*, 1956; Kirtikar K R and Basu B D 1987; Nadkarni K M 1976). Its leaves contain alkaloids, flavonoids, and phenols, contributing to its antimicrobial properties (Evans W C 2009; Harborne J B 1998).

This study aims to evaluate the antibacterial efficacy of *Solanum nigrum* leaf extracts against UTI-causing bacteria. By assessing its activity through in vitro methods, this research seeks to explore the plant's potential as a natural alternative to combat antibiotic-resistant infections (Pandey G 2013).

Materials and Methods

Sample collection and processing: *Solanum nigrum* leaf samples were collected from Harli area of Hazaribagh district (Geo-location: 23.825706, 85.274701) and brought to laboratory. The leaves were cleaned to remove dust and other impurities, followed by air drying in a shaded area at room temperature.

5 grams dried leaves were crushed in distilled water using mortar and pestle. Extract was collected in a centrifuge tube and spin at 8,000 rpm to remove the solid particles. The supernatant was collected in fresh centrifuge tube and concentrated using desiccator. The final yield of the extract was approximately 4.84% relative to the dry leaf powder.

Phytochemical Analysis: The phytochemical composition of the *Solanum nigrum* aqueous leaf extract was assessed. Standard qualitative methods were employed for the detection of alkaloids, flavonoids and phenolic phytochemicals (Harborne J B 1998; Wagner H and Bladt S 2001, Banu K S and Catherin L 2015): (a) Alkaloid test: Wagner's Test - *Solanum nigrum* extract was treated with a few drops of Wagner's Reagent to test the presence of alkaloid. (b) Phenol test: Ferric Chloride Test - *Solanum nigrum* extract was treated with a few drops of Ferric Chloride to test the presence of phenols (c) Flavonoids test: Alkaline Reagent tests - *Solanum nigrum* extract was treated with a few drops of Sodium Hydroxide and dilute Hydrochloric Acid to test the presence of flavonoids.

Sourcing bacterial isolates: Urine samples were collected from female patients clinically diagnosed with urinary tract infections (UTIs) and processed to isolate the causative bacterial pathogens (Cheesbrough M 2006).

Antibiotic Sensitivity Test: Antibiotic sensitivity testing was performed to evaluate the susceptibility of the isolated UTI-causing bacteria. *Escherichia coli*, *Klebsiella pneumoniae* and *Pseudomonas aeruginosa* isolates were tested against the *Solanum nigrum* aqueous leaf extract. The Kirby-Bauer disc diffusion method was employed on Luria Bertani agar, a standard medium for antimicrobial susceptibility testing.

Results

Phytochemical analysis: Phytochemicals analysis of *Solanum nigrum* revealed the presence of alkaloids, flavonoids and phenol group of phytochemicals (Table – 1).

Table – 1: Phytochemical tests of *Solanum nigrum*

Phytochemical Compound	Presence (+/–)	Role in Antibacterial Activity
Alkaloids	+	Enzyme inhibition, DNA intercalation.
Flavonoids	+	Antioxidant activity, membrane disruption.
Phenols	+	Protein denaturation, ROS generation.

Antibacterial activity: Aqueous extract of *Solanum nigrum* significantly inhibited the growth of *E.coli* bacteria. 0.1mg *Solanum nigrum* extract formed 0.5mm zone of inhibition against *E.coli*, 5mg *Solanum nigrum* extract formed 1.5mm zone of inhibition against *Pseudomonas aeruginosa* and 15mg *Solanum nigrum* extract formed 3mm zone of inhibition against *Klebsiella pneumonia* (Figure 2)



Figure: 2 (a) *Solanum nigrum* extract 5 mg against *Pseudomonas aeruginosa* (b) 0.1 mg *Solanum nigrum* extract 0.1 mg against *E. coli* (c) 20 mg *Solanum nigrum* extract 20 mg against *Klebsiella pneumoniae*

Discussion

Phytochemical analysis:

The detection of alkaloids, flavonoids, and phenols suggests that these compounds contribute significantly to the antibacterial activity of *Solanum nigrum* extract (Cowan M M 1999; Doughari J H 2012). The presence of flavonoids and phenols, known for their potent antimicrobial properties, aligns with the observed antibacterial efficacy against UTI pathogens.

Phytochemical Compound	Role in Antibacterial Activity
Alkaloids	Enzyme inhibition, DNA intercalation.
Flavonoids	Antioxidant activity, membrane disruption.
Phenols	Protein denaturation, ROS generation.

Antibacterial activity: The disc diffusion method results confirm the antibacterial potential of aqueous extract of *Solanum nigrum*. The concentration-dependent activity of the extract highlights its effectiveness, particularly against *Escherichia coli*, *Klebsiella pneumoniae* and *Pseudomonas aeruginosa*. However, further studies are needed to isolate the specific bioactive compounds responsible for the observed antibacterial activity.

Conclusion:

The current study concluded that *Solanum nigrum* is a potent candidate to target UTI infection caused by *E. coli*, *Klebsiella pneumoniae* and *Pseudomonas aeruginosa* bacteria. However, for the plant to be used effectively against UTI, adequate dose determination is crucial. Further study needs to be done to identify the exact phyto-component responsible for antibacterial activity.

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