

Full Length Research Paper

Antibacterial activity of *Lantana camara*. Tulsi (*Ocimum sanctum*) was more effective in inhibiting *Escherichia coli* growth than Neem (*Azadirachta indica*) and *Lantana camara*

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Lantana camara has attracted significant attention due to its phytochemical, biological, and pharmacological properties. This study aimed to evaluate the antibacterial potential of *L. camara* leaf extracts and compare it with well-established medicinal plants, *Ocimum sanctum* (Tulsi) and *Azadirachta indica* (Neem), against *Escherichia coli*. Additionally, the study explored the application of these extracts in developing herbal sanitizing wraps to enhance the shelf life of sprouts. Leaf extracts were prepared at different concentrations (1, 5, and 10%) using aqueous and methanolic solvents. Antibacterial activity was assessed using standard agar-based techniques against *E. coli*, a model organism due to its rapid growth rate. Furthermore, herbal-treated muslin cloth wraps were used for sprout preservation, and their effectiveness was evaluated under room temperature conditions. Results indicated that all three plant extracts exhibited antibacterial activity, with *O. sanctum* demonstrating the highest efficacy, followed by *A. indica* and *L. camara*. Methanolic extracts of *L. camara* showed enhanced activity compared to aqueous extracts, suggesting solvent-dependent efficacy. Sprouts wrapped in *O. sanctum*-treated cloth showed extended shelf life by approximately two days compared to control samples. The findings highlight the potential of plant-based antimicrobial agents as cost-effective, eco-friendly alternatives for food preservation and surface sanitization, while also suggesting a productive use of invasive species such as *L. camara*.

Key words: *Lantana camara*, invasive species, *Ocimum sanctum* (Tulsi: in Hindi), *Azadirachta indica* (Neem: in Hindi), *Escherichia coli*, antibacterial activity, sprouts preservation, herbal sanitizing wraps.

INTRODUCTION

Modern science education emphasizes inquiry-based and experiential learning, as highlighted in national educational frameworks (Ministry of Education, 2020). This study integrates scientific investigation with real-world application by addressing two key challenges: understanding plant-

based antimicrobial properties and developing sustainable methods for food preservation. *Lantana camara*, a member of the Verbenaceae family, is one of the world's most invasive plant species and has significantly impacted ecosystems, including the Delhi Ridge. The toxic effects

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of the leaves have usually been attributed to a series of pentacyclic triterpenes (Sharma et al., 1988).

Species of genus *L. camara* are plants that are practically immune to attack by herbivores, due to the presence of a great diversity of secondary metabolites (Kohli et al., 2006; Subapriya and Nagini, 2005). Neem (*Azadirachta indica*) leaf and their constituents exhibit immunomodulatory, anti-inflammatory, anti-hyperglycemic, antiulcer, anti-malarial, antifungal, antibacterial, antiviral, antioxidant, anti-mutagenic, anti-carcinogenic properties (Alzohairy, 2016; Sahoo, 2025; Cohen, 2014) and anti-cataract and anticoagulant activities (Biswas et al., 2002, Prakash and Gupta, 2005). Despite its ecological threat, *L. camara* possesses a wide range of secondary metabolites such as terpenoids, flavonoids, and pentacyclic triterpenoids, which are associated with biological activities, including antimicrobial effects. *A. indica* (Neem) and *Ocimum sanctum* (Tulsi) are well-documented medicinal plants known for their broad-spectrum antimicrobial, anti-inflammatory, and antioxidant properties.

Their bioactive compounds, including nimbidin, azadirachtin, and eugenol, have been shown to inhibit bacterial growth effectively. Tulsi contains bioactive compounds like eugenol, ursolic acid, and carvacrol, which interfere with bacterial metabolism. Extracts (especially in ethanol) show inhibition zones in lab cultures, indicating suppression of bacterial growth (Ganjewala et al., 2009, Ravva and Korn, 2015). Leaf extracts of *L. camara* demonstrate antibacterial activity against *Escherichia coli*, with variable effectiveness depending on the type of extract used, with methanolic extracts often showing greater potency (Yamani et al., 2016; Versha, 2019).

This study was designed to:

- 1) Compare the antibacterial activity of *L. camara* with *O. sanctum* and *A. indica* against *E. coli*.
- 2) Develop herbal sanitizing wraps using plant extracts.
- 3) Evaluate their effectiveness in extending the shelf life of sprouts (*Cicer arietinum* and *Vigna radiata*).

MATERIALS AND METHODS

Study design

This experimental study was conducted to evaluate and compare the antibacterial activity of *L. camara*, *O. sanctum* and *A. indica* leaf extracts against *E. coli*, and to assess their application in extending the shelf life of sprouts.

Collection and preparation of plant material

Fresh, healthy leaves of *L. camara*, *O. sanctum*, and *A. indica* were collected from local areas in New Delhi, India. The plant materials were authenticated based on morphological characteristics. The leaves were thoroughly washed with distilled water to remove dust and contaminants and then air-dried followed by lyophilization to preserve bioactive compounds. The dried leaves were ground into a fine powder using a sterile grinder and stored in airtight containers

until further use.

Preparation of leaf extracts

Leaf extracts were prepared at concentrations of 1, 5, and 10% (w/v).

- 1) Aqueous extract: The powdered plant material was dissolved in distilled water and stirred continuously for 24 h at room temperature.
- 2) Methanolic extract: The powdered material was soaked in methanol under similar conditions. The extracts were filtered using Whatman No. 1 filter paper and stored at 4°C until further analysis. The pH, color, odor, and texture of each extract were recorded.

Microorganism and culture conditions

The bacterial strain *E. coli* was used as the test organism due to its rapid growth and relevance in food contamination studies. The culture was maintained on nutrient agar medium. The nutrient agar medium was prepared by dissolving 28 g of nutrient agar powder in 1 L of distilled water. The pH of the medium was adjusted to 7.2 to ensure suitable conditions for bacterial growth. The prepared medium was then sterilized in an autoclave at 121°C for 15 min. After sterilization, sterile Petri plates were prepared and stored at 4°C until further use. Prior to experimentation, the bacterial culture was incubated at 30°C for 24 h to obtain active bacterial growth.

Antibacterial assay

Two standard methods were employed to evaluate the antibacterial activity of the plant extracts against *E. coli*. In the agar incorporation method, plant extracts of different concentrations were mixed with molten nutrient agar, and the mixture was poured into sterile Petri dishes and allowed to solidify. A standardized inoculum of *E. coli* (0.1 mL) was then spread uniformly over the agar surface, and the plates were incubated at 30°C for 24 h. In the disc diffusion method, sterile nutrient agar plates were inoculated with *E. coli* using a micropipette containing 0.1 mL of the bacterial culture. Sterile filter paper discs soaked in the plant extracts were placed at the center of the agar plates. The plates were incubated at 30°C for 24 h, after which the zones of inhibition were measured in millimetres to assess the antibacterial activity of the extracts.

Preparation of herbal sanitizing wraps

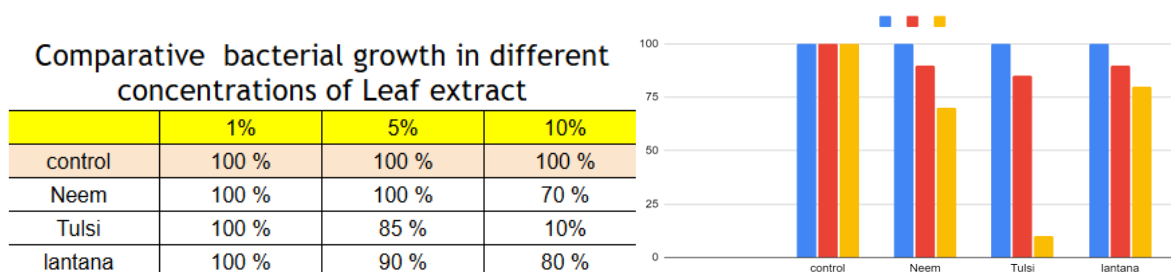
Herbal sanitizing wraps were prepared using muslin cloth pieces of approximately handkerchief size. The cloth pieces were first sterilized and then soaked separately in plant extracts of *Lantana*, *O. sanctum*, and Neem. After soaking, the treated cloths were air-dried under sterile conditions to prevent contamination. These herbal-treated wraps were subsequently used for wrapping sprouts during the experiment.

Preparation and storage of sprouts

- 1) Seeds of *Cicer arietinum* (g) and *Vigna radiata* (moong dal) were procured from a local market
- 2) The seeds were soaked in distilled water for 12 h
- 3) After soaking, seeds were wrapped separately in:
 - a) Neem-treated cloth
 - b) Tulsi-treated cloth

Table 1. Comparison of physical and chemical properties of Neem, Tulsi and Lantana leaves.

Variable	Neem leaves	Tulsi Leaves	Lantana leaves
Leaf texture	Hard,thick and smooth	Thin and soft	Thick and coarse
Colour of 10% extract	Dark green	Very dark green	light green
Smell	grassy	sweet	Distinct and strong
pH oF extract	6	8	7
Taste	Extremely bitter	Bitter and burning	Strong pungent

**Figure 1.** The comparative bacterial growth in different concentrations of leaf extract. Blue bar: 1% concentration leaf extract, Red bar: 5% concentration leaf extract, Yellow bar: 10% concentration leaf extract.

- c) Lantana-treated cloth
d) Untreated cloth (control)

All samples were stored at room temperature under identical conditions.

Assessment of shelf life

The sprouts were observed daily for signs of microbial spoilage such as odor, discoloration, and visible fungal/bacterial growth. Figure 1 shows the comparative % bacterial growth in different concentrations of leaf extract.

- Shelf life was recorded as the number of days until visible spoilage occurred.
- Comparative analysis was performed between treated and control samples.

Data analysis

All experiments were conducted in replicates. The antibacterial activity was assessed based on:

- Zone of inhibition (mm)
- Visual growth comparison
- Shelf-life duration (days)

Results were expressed in comparative terms to evaluate the effectiveness of each plant extract.

RESULTS

Comparison of physical and chemical properties of leaves

The pH of *A. indica* extract was on acidic side while pH of

O. sanctum and *L. camara* were alkaline and neutral respectively (Table 1).

Leaf extracts of *L. camara*, *O. sanctum*, and *A. indica* were prepared at concentrations of 1, 5, and 10% (w/v). All plant extracts exhibited antibacterial activity against *E. coli*, with maximum inhibition observed at 10% concentration. 100% growth of bacteria was observed in 5% extract of *A. indica* (neem) while 85% growth with 5% extract of *O. sanctum* and 90% growth in 5% extract of *L. camara*. 10% growth of *E. coli* colonies was observed with 10% extract of *O. sanctum* (Tulsi), 70% growth of *E. coli* colonies was observed with 10% extract of *A. indica* (Neem), *0% growth of *E. coli* colonies was observed with 10% extract of *L. camara*. *O. sanctum* showed the strongest antibacterial effect, followed by *A. indica* and *L. camara*. Figure 2 shows the methanolic extracts of *L. camara* demonstrated greater efficacy than aqueous extracts. Figure 3 shows the active compound in *Lantana* appears to be more soluble in methanol than water and hence bacterial growth decreases when leaf extract is made in water. Figure 4 shows the bacterial growth-tulsi extract in methanol and water. Figure 5 shows the comparison rate of infection in the sprouts with different herbal wraps. The study demonstrated that herbal-treated cloth wraps helped in extending the shelf life of sprouts by reducing spoilage. Sprouts wrapped in cloth treated with *O. sanctum* showed the most effective preservation, remaining fresh and unspoiled for up to 7 days, compared to the control samples which remained fresh for only 5 days. This indicates the strong antimicrobial and preservative properties of *O. sanctum*. In addition, cloth wraps treated with Neem and Lantana also demonstrated positive

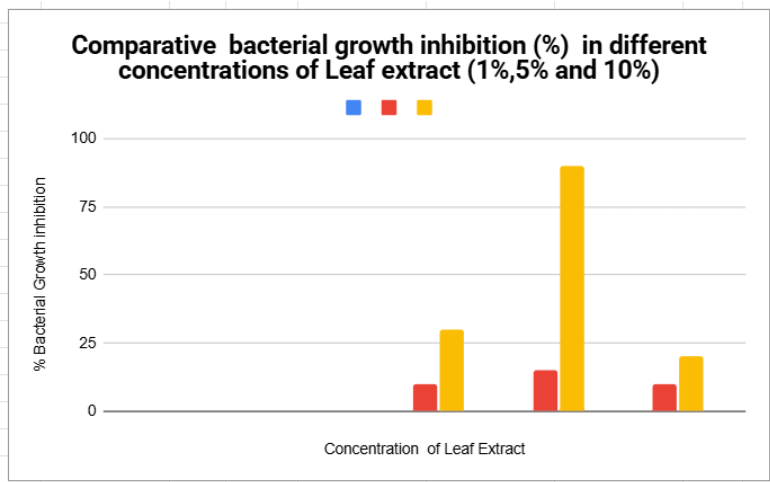


Figure 2. Comparative bacterial growth inhibition (%) in different concentration of leaf extract (1, 5 and 10%).

Neem Extract -in methanol				Bacterial Growth-Tulsi Extract -in methanol				Lantana Extract -in methanol			
	1%	5%	10%		1%	5%	10%		1%	5%	10%
control	100 %	100 %	100 %	control	100 %	100 %	100 %	control	100 %	100 %	100 %
set 1	100 %	100 %	60 %	set 1	90 %	85 %	10 %	set 1	100 %	90 %	80 %
set 2	100 %	100 %	70 %	set 2	100 %	85 %	10 %	set 2	100 %	90 %	80 %
set 3	100 %	100 %	70 %	set 3	100 %	85 %	10 %	set 3	100 %	90 %	80 %

Neem Extract -in water				Bacterial Growth-Tulsi Extract -in water				Lantana Extract -in water			
	1%	5%	10%		1%	5%	10%		1%	5%	10%
control	100 %	100 %	100 %	control	100 %	100 %	100 %	control	100 %	100 %	100 %
set 1	100 %	100 %	100 %	set 1	100 %	90 %	70 %	set 1	100 %	100 %	100 %
set 2	100 %	100 %	100 %	set 2	100 %	90 %	70 %	set 2	100 %	100 %	100 %
set 3	100 %	100 %	100 %	set 3	100 %	90 %	70 %	set 3	100 %	100 %	100 %

Figure 3. The active compound in *Lantana* appears to be more soluble in methanol than water and hence bacterial growth decreases when leaf extract is made in water.

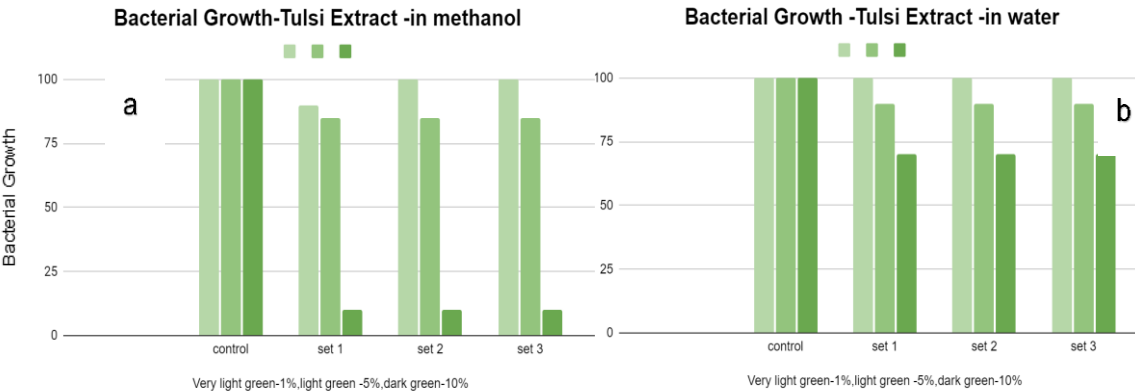


Figure 4. Comparison of bacterial growth-tulsi extract in methanol and water.

effects by extending the freshness of the sprouts by approximately one extra day beyond the control samples.

The findings suggest that plant-based herbal treatments can serve as natural and eco-friendly alternatives for

COMPARISON OF RATE OF INFECTION IN THE SPROUTS WITH DIFFERENT HERBAL WRAPS								
DAYS	CONTROL		TULSI WRAP		NEEM WRAP		LANTANA WRAP	
	Chana	Moong	Chana	Moong	Chana	Moong	Chana	Moong
DAY 1	SOAKING FOR 12 HOURS AND PUTTING IN HERBAL WRAPS							
DAY 2								
DAY 3								
DAY 4	x	x	x	x	x	x	x	x
DAY 5	✓	✓	x	x	x	x	x	x
DAY 6	✓	✓	x	x	x	x	x	x
DAY 7	✓	✓	x	x	✓	✓	✓	✓
✓ -Microbial Growth			x -No Microbial Growth					

Figure 5. Comparison rate of infection in the sprouts with different herbal wraps.

enhancing food preservation and reducing spoilage.

DISCUSSION

The study confirms the antimicrobial potential of all three-plant species, with *O. sanctum* showing superior efficacy due to its rich composition of bioactive compounds such as eugenol and carvacrol. The enhanced activity of methanolic extracts of *L. camara* suggests that its active compounds are more soluble in semi-polar solvents. The application of these extracts in sprout preservation demonstrates their practical utility in food safety. The results indicate that plant-based antimicrobial wraps can serve as effective, natural alternatives to chemical preservatives, contributing to sustainable food handling practices.

Conclusion

This study demonstrates that plant-derived extracts, particularly from *O. sanctum*, possess significant antibacterial properties and practical applications in food preservation. The ability to extend the shelf life of sprouts using herbal sanitizing wraps offers an eco-friendly and cost-effective alternative to synthetic preservatives. Additionally, the utilization of *L. camara* presents an opportunity to convert an invasive species into a valuable resource.

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CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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