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COMPARATIVE STUDY ON THE ANTIMICROBIAL ACTIVITY OF HERBAL EXTRACTS (TULSI, GARLIC AND TURMERIC) AND SYNTHETIC ANTIBIOTICS (AMOXICILLIN AND CIPROFLOXACIN) AGAINST *ESCHERICHIA COLI* & *STAPHYLOCOCCUS AUREUS*

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ABSTRACT

The study describes the comparison of the antimicrobial activity of Tulsi (*Ocimum sanctum*), Garlic (*Allium sativum*), and Turmeric (*Curcuma longa*) with standard antibiotics, Amoxicillin and Ciprofloxacin, against *Escherichia coli* and *Staphylococcus aureus*. Plant materials were collected locally, extracted using ethanol (Tulsi and Turmeric) and crude aqueous extraction (Garlic). Extracts were subjected to preliminary phytochemical screening. Antimicrobial activity was determined using disc diffusion (zone of inhibition) and broth microdilution methods (MIC). Results were compared with Amoxicillin and Ciprofloxacin as positive controls. It is anticipated that Garlic and Tulsi extracts has shown significant antimicrobial activity, while Turmeric has exhibit moderate effects, especially against Gram-positive bacteria. Although synthetic antibiotics are expected to display stronger inhibitory action, plant extracts may also demonstrate significant activity, suggesting their potential as adjunct therapies. Tulsi, Garlic, and Turmeric possess promising antimicrobial properties and may serve as complementary or alternative options to conventional antibiotics. Their bioactive compounds could be explored further for development into effective antimicrobial agents, helping to address the global challenge of antibiotic resistance.

KEYWORDS: Antimicrobial activity, Tulsi, Garlic, Turmeric, Amoxicillin, Ciprofloxacin, *Escherichia coli*, *Staphylococcus aureus.*

INTRODUCTION

In recent decades, the global healthcare system has faced an escalating challenge due to the rise in antimicrobial resistance (AMR). The misuse and overuse of antibiotics in humans, animals, and agriculture have accelerated the evolution of resistant strains, making common infections harder to treat and increasing the risk of disease spread, severe illness, and mortality.[1]

Pathogens such as *Escherichia coli* and *Staphylococcus aureus* have developed resistance mechanisms that render conventional antibiotics ineffective. This growing public health threat has prompted a renewed interest in alternative treatment options, including plant-derived antimicrobials with fewer side effects and a lower propensity to induce resistance. Many decades after the first patients were treated with antibiotics, bacterial infections have again become a threat.[2]

Ethnopharmacologists, botanists, microbiologists, and natural product chemists are exploring diverse ecosystems worldwide in search of phytochemicals and potential 'lead' compounds for the treatment of infectious diseases. While 25% to 50% of current pharmaceuticals are derived from plants, few are used as antimicrobial.[3] The increasing incidence of drug-resistant pathogens raises an urgent need to identify and isolate new bioactive compounds from medicinal plants using standardized modern analytical procedures.[4]

It is reported in India that scientists are in search of new phytochemicals that could be developed as useful antimicrobials for the treatment of infectious diseases.[5] Literature from many thousand years ago describes the use of therapeutic herbs in traditional medicine.[6] Books on Ayurvedic medicine, written in the Vedic period (3500-1600 B.C) describe practices, including the use of medicinal plants, that formed the basis of all other medical sciences developed on the Indian subcontinent.[7]

Phytochemicals such as alkaloids, flavonoids, and terpenoids have been found to be responsible for medicinal plants' antibacterial properties.[8] The growing interest in phytomedicine and plant-derived compounds has sparked investigations into their potential to serve as alternatives or adjuncts to conventional antibiotics.[9]

This study is designed to compare the antimicrobial activity of herbal extracts of Tulsi, Garlic, and Turmeric with that of Amoxicillin and Ciprofloxacin against *Escherichia coli* and *Staphylococcus aureus* using two standard *in vitro* methods, disc diffusion and broth dilution (MIC) techniques. The outcome of this research may contribute to identifying plant-based alternatives to combat resistant pathogens and enhance integrated antimicrobial strategies.[10]

MATERIALS AND METHODS

Collection and authentication of Herbal materials

The fresh leaves of *Ocimum sanctum* (Tulsi), Bulbs of *Allium sativum* (Garlic) and Rhizomes of *Curcuma longa* (Turmeric) were collected from the nearby market at Belthangady.

Preparation of ethanolic extract of Tulsi, Garlic and Turmeric

Fresh plant materials including *Ocimum sanctum* (Tulsi) leaves, *Allium sativum* (Garlic) bulbs, and *Curcuma longa* (Turmeric) rhizomes were collected, washed thoroughly under tap water, shade-dried at room temperature for 7–10 days, and then pulverized into coarse powder using a mechanical grinder. The powdered materials were stored in air-tight container. The powdered materials (~40 g each) of Tulsi and Turmeric were packed into a thimble and subjected to Soxhlet extraction using 250mL of 95% ethanol for approximately 6 hours at a temperature range of 60 - 70°C.

The fresh garlic was washed properly by running tap water and peeled and sliced into small pieces and ground with mortar and pestle, the crushed material was subjected to Soxhlet extraction using ethanol as the solvent. The extraction was carried out until the solvent became colorless, indicating complete extraction of the bioactive compounds. The obtained extracts were then filtered and concentrated under reduced pressure using a rotary evaporator. The dried crude extracts were stored in airtight containers at 4°C until further use.[11-18]

Preliminary Phytochemical Evaluation[18, 19, 20]

The ethanolic extract of *Ocimum sanctum* (Tulsi), *Allium sativum* (Garlic) and *Curcuma longa* (Turmeric) were subjected to preliminary phytochemical screening using standard procedure.

Bacterial Culture and Inoculum Preparation

The bacterial strains were sub-cultured on nutrient agar and incubated overnight at 37°C to obtain isolated colonies. A single colony was transferred into the nutrient broth and incubated for 18-24 hours to reach the logarithmic phase. The bacterial suspension was then adjusted to 0.5 McFarland standard, which approximately corresponds to 1×10^8 CFU/ml. This turbidity was verified by measuring the optical density at 600 nm (OD600), aiming for a range of 0.08 to 0.13, using a UV-visible spectrophotometer.[21] The standardized inoculum was diluted 1:20 in Mueller-Hinton broth to achieve a final concentration of ~5×10^5 CFU/mL for antimicrobial testing.[22,23]

Antimicrobial Assays

The antimicrobial potential of the ethanol-based extracts of *Ocimum sanctum*, *Allium sativum* and *Curcuma longa* with the concentrations of 10mg/ml, 25mg/ml, 50mg/ml, 75mg/ml, 100mg/ml of each extract were assessed through the Disc diffusion method (Kirby–Bauer technique).

In the disc diffusion assay, Nutrient Agar plates were uniformly seeded with the standardized bacterial inoculum using sterile cotton swabs. Sterile 6mm filter paper discs were saturated with 50µL of plant extract solution at a concentration of 100mg/mL and carefully positioned onto the surface of the agar. Discs containing Amoxicillin and Ciprofloxacin with 10mg/ml, 25mg/ml, 50mg/ml, 75mg/ml, 100mg/ml served as reference antibiotics for comparison. After incubation at 37°C for 24 hours, the diameter of inhibition zones around each disc was measured in millimeters. Each assay was carried out in triplicate to ensure reliability.[11,16,23]

RESULT AND DISCUSSION

Extraction of plant material

The crude extracts of *Ocimum sanctum* (Tulsi), *Allium sativum* (Garlic), and *Curcuma longa* (Turmeric) were successfully prepared using ethanol as solvent in this extraction method.

Figure No. 01: Crude drug Extracts.

Preliminary Phytochemical Screening

Results of the preliminary phytochemical investigation of various herbal extracts is shown the presence Alkaloids, Flavonoids, Glycosides, Steroids, Tannins and Phenolic Compounds, Carbohydrates and Proteins.

Antimicrobial Assay

Table No. 01: Results showing the Zone of Inhibition of different herbal extracts and antibiotics against *Escherichia coli*.

Conc. / Discs	10mg/ml	25mg/ml	50mg/ml	75mg/ml	100mg/ml
Ocimum sanctum	7.0 ± 1.0	10.8±0.6	12.6±1.1	14.7±1.3	16.4 ± 1.5
Allium sativum	0.0±0.0	9.1±1.1	12±1.3	15.80±1.0	17.4±0.5
Curcuma longa	6.21±0.31	7.45±0.26	8.32±1.06	8.52±0.32	8.81±0.23
Amoxicillin	17.0±0.3	19.0±0.2	21.0±0.3	22.0±0.3	23.0±0.5
Ciprofloxacin	21.0±0.2	23.0±0.2	25.0±0.3	26.0±0.2	27.0±03

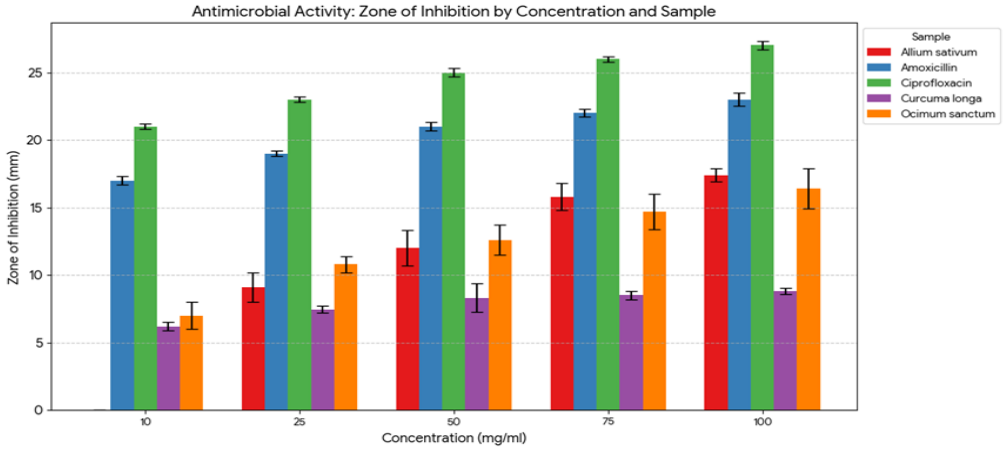

Figure No. 02: Graphical representation for Zone of Inhibition of different herbal extracts and antibiotics against *Escherichia coli*.

Table No. 02: Results showing the Zone of Inhibition of different herbal extracts and antibiotics against *Staphylococcus aureus*.

Conc. / Discs	10mg/ml	25mg/ml	50mg/ml	75mg/ml	100mg/ml
Ocimum sanctum	9.0±0.3	12.1±0.3	15.0±1.0	17.0±0.5	19±1.5
Allium sativum	9.61±0.80	11.12±1.2	12±1.4	14.3±1.2	21±1.3
Curcuma longa	6.18±0.23	7.03±0.23	7.88±0.14	9.11±0.12	11.33±0.58
Amoxicillin	19.0±0.2	21.0±0.3	23.0±1.0	24.0±0.6	25.0±0.3
Ciprofloxacin	23.0±0.3	25.0±0.2	27.0±0.3	28.0±0.2	29.0±0.4

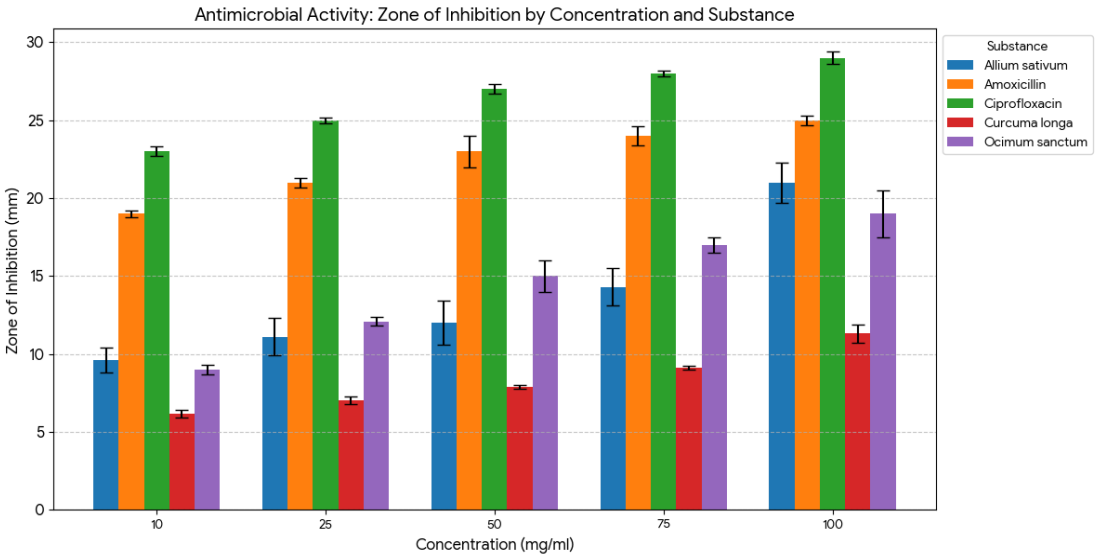

Figure No.: 03: Graphical representation for Zone of Inhibition of different herbal extracts and antibiotics against *Staphylococcus aureus.*

The findings indicate that although synthetic antibiotics remain more potent, herbal extracts, particularly *Allium sativum* (Garlic) and *Ocimum sanctum* (Tulsi), exhibited notable concentration-dependent antibacterial activity against *E. coli* and *S. aureus*. Garlic showed the strongest inhibition, attributed to sulphur-containing compounds such as allicin and ajoene, while Tulsi demonstrated moderate efficacy due to its phenolic and terpenoid constituents. *Curcuma longa* (Turmeric) displayed the least effect, likely due to limited curcumin solubility. Compared to standard antibiotics, Ciprofloxacin showed superior efficacy; however, the herbal extracts showed considerable potential as supportive or alternative therapeutic agents, particularly against resistant or mild bacterial infections.

CONCLUSION

The ethanolic extracts of Garlic, Tulsi, and Turmeric showed concentration-dependent antibacterial activity, with Garlic being the most effective against both test organisms. Although less potent than Amoxicillin and Ciprofloxacin, the herbal extracts exhibited significant antibacterial potential, supporting their traditional medicinal use. Garlic, in particular, presents promise as a natural alternative or adjunct to antibiotics. Further research on purification and formulation is warranted to enhance their therapeutic applicability.

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