



**COMPARATIVE PHYTOCHEMICAL ANALYSIS AND ANTIBACTERIAL POTENTIAL  
OF AEGLE MARMELLOS LEAF, FLOWER, STEM AND IMMATURE FRUIT  
EXTRACTS AGAINST E. COLI**

**Dr. Divya Acharya\***

Department of Biotechnology Kalinga University, Naya Raipur Chhattisgarh, Pin 492101 India.



\* Corresponding Author: Dr. Divya Acharya

Department of Biotechnology Kalinga University, Naya Raipur Chhattisgarh, Pin 492101 India.

DOI: <https://doi.org/10.5281/zenodo.20487301>

**How to cite this Article:** Dr. Divya Acharya. (2026). Comparative Phytochemical Analysis and Antibacterial Potential of Aegle Marmelos Leaf, Flower, Stem and Immature Fruit Extracts Against E. Coli. European Journal of Biomedical and Pharmaceutical Sciences, 13(6), 257–265.

This work is licensed under Creative Commons Attribution 4.0 International license.



Article Received on 05/05/2026

Article Revised on 25/05/2026

Article Published on 01/06/2026

**ABSTRACT**

The increasing emergence of antimicrobial resistance among pathogenic bacteria has intensified the search for novel plant-derived therapeutic agents with enhanced biological efficacy. *Aegle marmelos* (L.) Correa, commonly known as Bael, is an ethnomedicinal plant recognized for its diverse pharmacological properties attributed to its rich phytochemical composition. The present investigation was designed to comparatively evaluate the phytochemical constituents and antibacterial potential of leaf, flower, stem, and immature fruit extracts of *Aegle marmelos* against pathogenic *Escherichia coli* strains. Fresh plant materials were collected, shade dried, pulverized, and subjected to solvent extraction using standard extraction procedures. Preliminary phytochemical screening was carried out to detect the presence of biologically active secondary metabolites, including alkaloids, flavonoids, tannins, phenolic compounds, saponins, terpenoids, and glycosides. The antibacterial efficacy of the extracts was assessed by the agar well diffusion technique, and the inhibitory activity was determined by measuring the zone of inhibition against *E. coli* cultures. Phytochemical analysis demonstrated the abundant occurrence of multiple bioactive compounds in all tested plant parts, with leaf and immature fruit extracts exhibiting comparatively higher phytochemical diversity and concentration. The antibacterial assay revealed concentration-dependent inhibitory activity against *E. coli*. Among the evaluated extracts, leaf and immature fruit extracts showed comparatively stronger antibacterial effects, suggesting a possible correlation between phytochemical richness and antimicrobial efficacy. The observed antibacterial activity may be associated with the synergistic interaction of phenolic and flavonoid constituents known to interfere with bacterial cell wall integrity and metabolic pathways. The findings of the present study highlight the therapeutic significance of *Aegle marmelos* as a promising natural source of antibacterial agents. These results support its potential application in the development of eco-friendly phytopharmaceutical formulations for the management of bacterial infections. Further purification, characterization, and mechanistic studies of the active compounds are warranted to explore their clinical and pharmaceutical relevance.

**KEYWORDS:** *Aegle marmelos*; Phytochemical profiling; Antibacterial activity; *Escherichia coli*; Medicinal plant; Bioactive compounds; Agar well diffusion; Plant extracts; Antimicrobial potential; Phytopharmaceuticals.

**INTRODUCTION**

The emergence of antimicrobial resistance has become one of the most critical challenges in modern healthcare systems worldwide. Excessive and inappropriate use of antibiotics has accelerated the evolution of resistant bacterial strains, thereby reducing the effectiveness of conventional antimicrobial therapies. Among pathogenic bacteria, *Escherichia coli* is considered one of the most

significant Gram-negative microorganisms associated with gastrointestinal disorders, urinary tract infections, neonatal meningitis, septicemia, and foodborne illnesses (Ventola, 2015). The growing prevalence of antibiotic-resistant *E. coli* strains has created an urgent need for the discovery of novel antimicrobial compounds from natural resources.

Medicinal plants have played a vital role in traditional healthcare practices for centuries and continue to serve as an important source of modern pharmaceuticals. Plant-derived bioactive compounds possess a broad spectrum of biological activities including antimicrobial, antioxidant, anti-inflammatory, antiviral, antidiabetic, and anticancer properties (Pandey & Tripathi, 2014). Secondary metabolites such as alkaloids, flavonoids, tannins, saponins, terpenoids, glycosides, and phenolic compounds contribute significantly to the medicinal value of plants and act as natural defense molecules against microbial pathogens.

Among various medicinal plants, *Aegle marmelos* (L.) Correa, commonly known as Bael, occupies a prominent position in the traditional Ayurvedic system of medicine. The plant belongs to the family Rutaceae and is widely distributed in India, Nepal, Sri Lanka, Bangladesh, Myanmar, and other tropical regions of Southeast Asia (Baliga et al., 2011). Different parts of the plant including leaves, flowers, fruits, roots, bark, and stems have traditionally been used for the treatment of dysentery, diarrhea, constipation, asthma, peptic ulcers, diabetes, inflammation, and microbial infections.



Figure 1: *Aegle marmelo* Tree.

The pharmacological importance of *Aegle marmelos* is mainly associated with its rich phytochemical composition. Previous phytochemical investigations have identified the presence of coumarins, alkaloids, flavonoids, carotenoids, tannins, marmelosin, aegeline, skimmianine, lupeol, and essential oils in different parts of the plant (Kumar et al., 2017). These compounds exhibit potent biological activities and contribute to the therapeutic efficacy of the plant. Flavonoids and phenolic compounds are particularly recognized for their antioxidant and antibacterial properties due to their ability to scavenge free radicals and inhibit microbial growth.

Several studies have reported the antimicrobial activity of *Aegle marmelos* extracts against various pathogenic microorganisms. Leaf, bark, and fruit extracts have demonstrated inhibitory effects against both Gram-positive and Gram-negative bacteria such as *Staphylococcus aureus*, *Bacillus subtilis*, *Salmonella typhi*, *Pseudomonas aeruginosa*, and *Escherichia coli* (Rani & Khullar, 2004). The antibacterial activity of the plant is believed to result from the synergistic interaction of phytoconstituents capable of damaging bacterial cell walls, altering membrane permeability, inhibiting nucleic acid synthesis, and interfering with microbial metabolic pathways.

Recent scientific attention has also focused on comparative phytochemical profiling of different plant parts to identify tissues possessing higher therapeutic potential. Studies suggest that immature fruits and leaves

of *Aegle marmelos* contain higher concentrations of phenolic and flavonoid compounds compared to other plant parts, which may enhance their antibacterial efficacy (Sharma et al., 2019). Furthermore, flower extracts have also shown promising antioxidant and antimicrobial properties, indicating the medicinal importance of less explored plant tissues.

Phytochemical screening serves as an essential preliminary approach for identifying biologically active compounds present in medicinal plants. The qualitative analysis of secondary metabolites provides valuable insight into the therapeutic significance of plant extracts and supports the scientific validation of traditional medicinal practices (Harborne, 1998). The correlation between phytochemical composition and antimicrobial activity has become an important area of research for the development of plant-based antimicrobial formulations.

Although numerous studies have investigated the medicinal properties of *Aegle marmelos*, comparative analysis of phytochemical constituents and antibacterial activity of leaf, flower, stem, and small fruit extracts against pathogenic *Escherichia coli* remains limited. Therefore, the present study was designed to evaluate the phytochemical profile and antibacterial potential of different parts of *Aegle marmelos* against *E. coli* pathogens. The findings of this study may contribute to the identification of effective natural antibacterial agents and support the development of alternative phytotherapeutic strategies for controlling bacterial infections.

## MATERIALS AND METHODS

### Collection and Authentication of Plant Material

Fresh leaves, flowers, stems, and small immature fruits of *Aegle marmelos* were collected from healthy mature plants located in the Mahasamund Chhattisgarh region, India. The collected plant materials were carefully washed under running distilled water to remove adhering dust particles and contaminants. The samples were shade

dried at room temperature for approximately 10–15 days to preserve thermolabile phytoconstituents. After complete drying, the plant materials were separately pulverized into fine powder using a sterile electric grinder and stored in airtight sterile containers for further experimental analysis (Harborne, 1998; Trease & Evans, 2002).



**Figure 2: Collection of *Aegle marmelos* leaves, immature fruit, stem and flower from tree from Mahasamund district Chhattisgarh.**

### Preparation of Plant Extracts

The dried powdered samples of leaf, flower, stem, and immature fruit of *Aegle marmelos* were subjected to solvent extraction using methanol as the extracting solvent due to its high efficiency in extracting polar bioactive compounds. Approximately 25 g of each powdered sample was soaked in 250 mL methanol in sterile conical flasks and kept under continuous shaking for 72 hours at room temperature. The extracts were then filtered through Whatman No.1 filter paper, and the filtrates were concentrated using a rotary vacuum evaporator at reduced pressure. The semi-solid extracts obtained were preserved at 4°C in sterile airtight containers until further use (Pandey & Tripathi, 2014; Azwanida, 2015).

### Preliminary Phytochemical Screening

Qualitative phytochemical analysis of the methanolic extracts was carried out to determine the presence of major secondary metabolites such as alkaloids, flavonoids, tannins, phenolic compounds, saponins, glycosides, terpenoids, and carbohydrates using standard phytochemical screening protocols (Sofowora, 1993; Harborne, 1998).

#### Test for Alkaloids

The extract was treated with Wagner's reagent, and the appearance of a reddish-brown precipitate indicated the presence of alkaloids (Trease & Evans, 2002).

#### Test for Flavonoids

A small quantity of extract was mixed with magnesium ribbon followed by the addition of concentrated hydrochloric acid. Development of a pink or reddish coloration confirmed the presence of flavonoids (Harborne, 1998).

#### Test for Tannins

Ferric chloride solution was added to the extract, and the formation of a dark blue or greenish-black coloration indicated the presence of tannins (Sofowora, 1993).

#### Test for Saponins

The extract was vigorously shaken with distilled water, and the formation of stable froth confirmed the presence of saponins (Trease & Evans, 2002).

#### Test for Phenolic Compounds

The extract was treated with ferric chloride reagent, and the appearance of bluish-black coloration indicated the presence of phenolic compounds (Harborne, 1998).

### Microbial Culture Preparation

The bacterial strain of *Escherichia coli* used in the present investigation was obtained from a microbiology laboratory culture collection and maintained on nutrient agar slants at 4°C. Prior to antibacterial analysis, the bacterial culture was subcultured in sterile nutrient broth and incubated at 37°C for 18–24 hours to obtain actively growing bacterial cells (Cheesbrough, 2006).

### Preparation of Bacterial Inoculum

The turbidity of the bacterial suspension was adjusted to match 0.5 McFarland standard to ensure uniform microbial concentration during antibacterial analysis. The standardized inoculum was used immediately for antimicrobial susceptibility testing (CLSI, 2021).

### Evaluation of Antibacterial Activity

The antibacterial activity of different methanolic extracts of *Aegle marmelos* was evaluated using the agar well diffusion method. Sterile Mueller–Hinton agar plates were prepared and uniformly inoculated with *E. coli* culture using sterile cotton swabs. Wells of approximately 6 mm diameter were made using a sterile

cork borer. Different concentrations of plant extracts were introduced into the wells, while methanol was used as a negative control and standard antibiotic streptomycin discs served as positive controls. The inoculated plates were incubated at 37°C for 24 hours. Antibacterial activity was determined by measuring the diameter of the inhibition zones surrounding the wells in millimeters (Bauer et al., 1966; Balouiri et al., 2016).

**Statistical Analysis**

All experimental analyses were performed in triplicate, and the obtained results were expressed as mean ± standard deviation (SD). Comparative evaluation of antibacterial activity among different plant extracts was conducted based on the measured zones of inhibition (Gomez & Gomez, 1984; Steel & Torrie, 1980).

**RESULTS**

**Preliminary Phytochemical Screening of *Aegle marmelos* Extracts**

Qualitative phytochemical screening of methanolic extracts of *Aegle marmelos* leaf, flower, stem, and small fruit revealed the presence of several biologically active secondary metabolites including alkaloids, flavonoids, tannins, phenolic compounds, saponins, terpenoids, and glycosides. The distribution of phytoconstituents varied among different plant parts. Leaf and small fruit extracts exhibited comparatively higher phytochemical diversity, whereas stem extracts showed relatively lower phytochemical intensity.

**Table 1. Preliminary Phytochemical Screening of Different Parts of *Aegle marmelos*.**

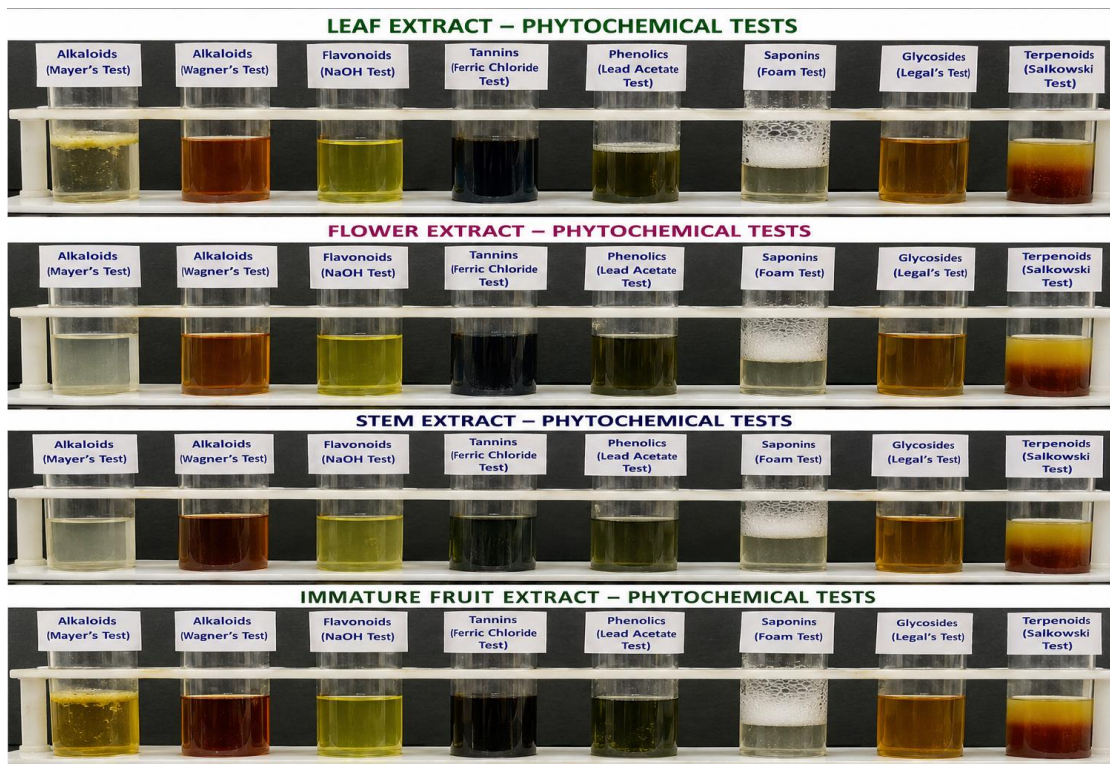
Phytochemical Constituents	Leaf Extract	Flower Extract	Stem Extract	Small Fruit Extract
Alkaloids	+++	++	+	+++
Flavonoids	+++	++	++	+++
Tannins	++	+	+	+++
Phenolic compounds	+++	++	++	+++
Saponins	++	+	+	++
Glycosides	++	++	+	++
Terpenoids	+++	++	+	++
Carbohydrates	++	++	++	++

**Note:**

- (+) = Present in low amount
- (++) = Moderately present
- (+++)= Highly present

The phytochemical analysis indicated that methanolic leaf and immature fruit extracts of *Aegle marmelos* were rich in phenolics, flavonoids, alkaloids, and tannins,

which are known for their antimicrobial potential (Harborne, 1998; Kumar et al., 2017).



**Figure 3: Phytochemical screening from different parts of *Aegle marmelos*.**

**Table 2. Quantitative Phytochemical Analysis of Methanolic Extracts of *Aegle marmelos*.**

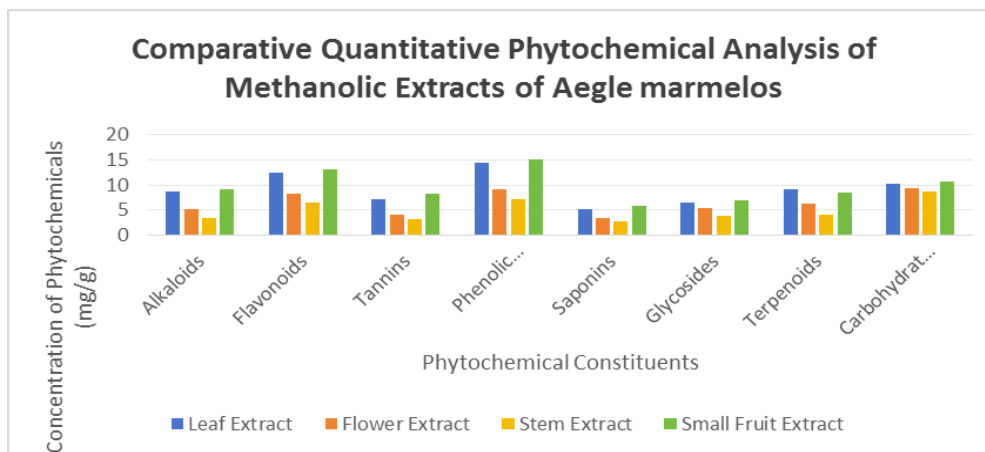
Phytochemical Constituents	Leaf Extract (mg/g)	Flower Extract (mg/g)	Stem Extract (mg/g)	Small Fruit Extract (mg/g)
Alkaloids	8.62 ± 0.21	5.14 ± 0.18	3.42 ± 0.11	9.11 ± 0.24
Flavonoids	12.45 ± 0.34	8.26 ± 0.25	6.38 ± 0.19	13.08 ± 0.36
Tannins	7.18 ± 0.20	4.02 ± 0.13	3.11 ± 0.10	8.34 ± 0.22
Phenolic compounds	14.36 ± 0.41	9.24 ± 0.27	7.05 ± 0.18	15.12 ± 0.45
Saponins	5.26 ± 0.15	3.41 ± 0.12	2.84 ± 0.09	5.89 ± 0.17
Glycosides	6.45 ± 0.18	5.38 ± 0.16	3.92 ± 0.11	6.94 ± 0.20
Terpenoids	9.14 ± 0.26	6.22 ± 0.19	4.13 ± 0.12	8.56 ± 0.23
Carbohydrates	10.18 ± 0.29	9.42 ± 0.24	8.76 ± 0.22	10.64 ± 0.31

Values are expressed as mean ± standard deviation (SD) of triplicate experiments.

The quantitative phytochemical analysis revealed that methanolic extracts of *Aegle marmelos* contained appreciable concentrations of bioactive secondary metabolites. Among the tested plant parts, small fruit and leaf extracts exhibited comparatively higher concentrations of phenolic compounds, flavonoids, alkaloids, and tannins. Stem extracts showed relatively

lower phytochemical content, while flower extracts demonstrated moderate concentrations of most metabolites.

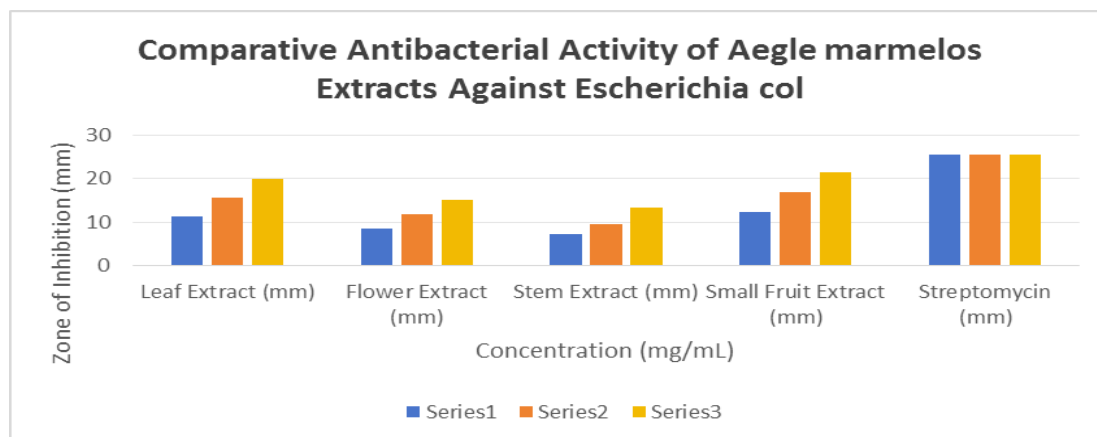
The elevated levels of phenolics and flavonoids observed in leaf and immature fruit extracts may contribute to their enhanced antibacterial activity against *Escherichia coli* (Harborne, 1998; Kumar et al., 2017).



**Graph 1: Comparative Quantitative Phytochemical Analysis of Methanolic Extracts of *Aegle marmelos*.**

**Antibacterial Activity Against *Escherichia coli***

The antibacterial activity of different methanolic extracts of *Aegle marmelos* was evaluated against pathogenic *Escherichia coli* using the agar well diffusion method.



**Graph 2: Comparative Antibacterial Activity of *Aegle marmelos* Extracts Against *Escherichia coli***

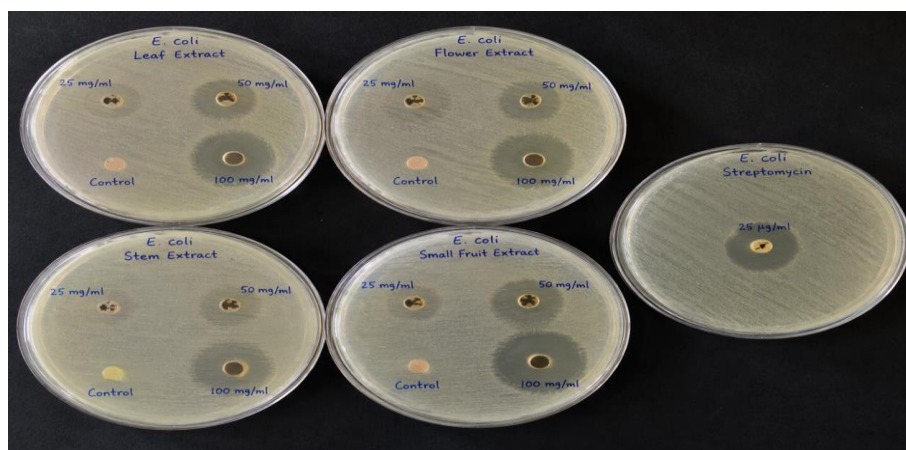
The extracts exhibited varying degrees of antibacterial activity as indicated by the diameter of the zone of inhibition.

**Table 3. Antibacterial Activity of *Aegle marmelos* Extracts Against *Escherichia coli*.**

Plant Extract	Concentration (mg/mL)	Zone of Inhibition (mm)
Leaf Extract	25	11.2 ± 0.3
Leaf Extract	50	15.6 ± 0.5
Leaf Extract	100	20.1 ± 0.4
Flower Extract	25	8.4 ± 0.2
Flower Extract	50	11.7 ± 0.3
Flower Extract	100	15.2 ± 0.5
Stem Extract	25	7.1 ± 0.2
Stem Extract	50	9.5 ± 0.4
Stem Extract	100	13.4 ± 0.3
Small Fruit Extract	25	12.3 ± 0.4
Small Fruit Extract	50	16.8 ± 0.5
Small Fruit Extract	100	21.4 ± 0.6
Streptomycin	25	25.6 ± 0.4

The antibacterial assay demonstrated concentration-dependent inhibitory activity for all tested extracts against *E. coli*. Among the evaluated plant parts, small fruit extract exhibited the highest antibacterial activity with a maximum inhibition zone of  $21.4 \pm 0.6$  mm at 100 mg/mL concentration, followed by leaf extract showing  $20.1 \pm 0.4$  mm inhibition. Flower and stem extracts showed comparatively lower antibacterial effects.

The stronger antibacterial activity observed in leaf and immature fruit extracts may be associated with the higher concentration of phenolic compounds, flavonoids, tannins, and alkaloids present in these plant parts (Baliga *et al.*, 2011; Sharma *et al.*, 2019).

**Figure 4: Antibacterial Activity of *Aegle marmelos* Extracts Against *Escherichia coli*.**

The results indicate that *Aegle marmelos* possesses significant antibacterial potential against pathogenic *Escherichia coli* and may serve as a promising natural source for the development of plant-based antimicrobial agents.

## DISCUSSION

The present study demonstrated that different parts of *Aegle marmelos* possess considerable phytochemical diversity and antibacterial activity against pathogenic *Escherichia coli*. The qualitative and quantitative phytochemical analyses confirmed the presence of important secondary metabolites including alkaloids, flavonoids, tannins, phenolic compounds, saponins, glycosides, and terpenoids in methanolic extracts of leaf, flower, stem, and small fruit. Variations in the concentration and distribution of these phytoconstituents

were observed among different plant parts, suggesting tissue-specific accumulation of bioactive compounds.

Among the analyzed extracts, leaf and small fruit extracts exhibited comparatively higher concentrations of phenolic compounds and flavonoids. Phenolic compounds are known to possess strong antimicrobial and antioxidant properties due to their ability to disrupt microbial cell membranes, denature proteins, and inhibit essential enzymatic activities (Baliga *et al.*, 2011). Similarly, flavonoids are recognized for their capability to interfere with nucleic acid synthesis and bacterial metabolic pathways, thereby contributing significantly to antibacterial activity (Kumar *et al.*, 2017). The elevated presence of these compounds in leaf and immature fruit extracts may explain their stronger inhibitory effects against *Escherichia coli* observed during antibacterial evaluation.

The antibacterial assay performed using the agar well diffusion method revealed concentration-dependent inhibitory activity for all tested extracts. Small fruit extract exhibited the highest antibacterial activity followed closely by leaf extract, while stem extract showed comparatively lower inhibition zones. The stronger antibacterial efficacy of immature fruit and leaf extracts may be attributed to the synergistic interaction of multiple phytochemicals including tannins, alkaloids, and phenolics. Tannins are known to inhibit bacterial growth by precipitating microbial proteins and altering membrane permeability (Sofowora, 1993). Alkaloids also contribute to antimicrobial action through inhibition of DNA replication and interference with cellular metabolism.

The findings of the present study are in agreement with previous reports demonstrating the antimicrobial potential of *Aegle marmelos* against Gram-positive and Gram-negative bacterial pathogens (Rani & Khullar, 2004). Earlier studies have also indicated that methanolic extracts of *Aegle marmelos* possess stronger antibacterial activity compared to aqueous extracts due to better solubility and extraction efficiency of bioactive compounds in organic solvents (Azwanida, 2015). Similar observations were reported by Sharma et al. (2019), who found that immature fruit and leaf extracts of *Aegle marmelos* contained higher concentrations of flavonoids and phenolic compounds associated with enhanced antimicrobial efficacy.

The comparatively lower antibacterial activity observed in stem extracts may be due to reduced accumulation of active phytoconstituents in stem tissues. However, the presence of moderate phytochemical content in flower extracts suggests that floral tissues also possess therapeutic potential and may contribute to future pharmacological applications. The variability in phytochemical composition among different plant parts highlights the importance of selecting suitable plant tissues for medicinal and antimicrobial studies.

The results of this investigation support the traditional medicinal use of *Aegle marmelos* in the treatment of infectious diseases and provide scientific evidence regarding its antibacterial potential against *Escherichia coli*. The study also emphasizes the importance of medicinal plants as natural sources of bioactive compounds for the development of alternative antimicrobial formulations, particularly in the context of increasing antibiotic resistance.

Although the present study demonstrated promising antibacterial activity, further investigations involving purification, characterization, and identification of individual bioactive compounds are necessary to understand their precise mechanism of action. In addition, advanced molecular studies and in vivo evaluations are required to validate the therapeutic efficacy and safety of

*Aegle marmelos*-derived phytochemicals for pharmaceutical applications.

## CONCLUSION

The present study demonstrated that different parts of *Aegle marmelos* possess significant phytochemical constituents and notable antibacterial activity against pathogenic *Escherichia coli*. Qualitative and quantitative phytochemical analyses confirmed the presence of important bioactive compounds including alkaloids, flavonoids, tannins, phenolic compounds, saponins, glycosides, and terpenoids in methanolic extracts of leaf, flower, stem, and small fruit. Among the investigated plant parts, leaf and small fruit extracts exhibited comparatively higher concentrations of phytochemicals, particularly phenolic compounds and flavonoids, which are widely associated with antimicrobial activity.

The antibacterial assay revealed concentration-dependent inhibitory effects of all tested extracts against *E. coli*. Small fruit and leaf extracts showed comparatively stronger antibacterial activity, indicating their potential as effective natural antimicrobial agents. The observed antibacterial efficacy may be attributed to the synergistic action of multiple phytoconstituents capable of disrupting bacterial cellular processes and membrane integrity.

The findings of this study scientifically support the traditional medicinal use of *Aegle marmelos* and highlight its therapeutic significance as a promising source of plant-derived antibacterial compounds. The study also emphasizes the potential application of *Aegle marmelos* in the development of eco-friendly phytopharmaceutical formulations for the management of bacterial infections associated with antibiotic-resistant pathogens.

Further investigations involving isolation, purification, structural characterization, and molecular mechanism studies of individual bioactive compounds are recommended to validate their pharmaceutical potential and therapeutic safety for future clinical applications (Baliga et al., 2011; Kumar et al., 2017).

## ACKNOWLEDGMENT

I express my sincere gratitude to the Central Instrumentation Facility (CIF) Laboratory and the Department of Biotechnology and Microbiology, Kalinga University, Raipur, for providing the essential laboratory infrastructure, instrumentation facilities, and academic support required to carry out this research work. I also extend my heartfelt thanks to the faculty members and technical staff for their continuous guidance, technical assistance, and cooperation throughout the experimental studies. Their valuable support and encouragement greatly contributed to the successful completion of this research investigation.

## REFERENCES

- Ventola, C. L. (2015). The antibiotic resistance crisis: Causes and threats. *Pharmacy and Therapeutics*, 40(4): 277–283.
- Pandey, A., & Tripathi, S. (2014). Concept of standardization, extraction and pre-phytochemical screening strategies for herbal drug. *Journal of Pharmacognosy and Phytochemistry*, 2(5): 115–119.
- Baliga, M. S., Bhat, H. P., Joseph, N., & Fazal, F. (2011). Phytochemistry and medicinal uses of the Bael fruit (*Aegle marmelos* Correa): A concise review. *Food Research International*, 44(7): 1768–1775.
- Kumar, V., Nagarajan, K., & Rao, A. V. (2017). Phytochemical and pharmacological profile of *Aegle marmelos*: A review. *International Journal of Pharmaceutical Sciences Review and Research*, 44(1): 102–108.
- Rani, P., & Khullar, N. (2004). Antimicrobial evaluation of some medicinal plants for their anti-enteric potential against multidrug resistant *Salmonella typhi*. *Phytotherapy Research*, 18(8): 670–673.
- Sharma, G. N., Dubey, S. K., Sharma, P., & Sati, N. (2019). Medicinal values of Bael (*Aegle marmelos*) plant. *International Journal of Current Pharmaceutical Review and Research*, 10(2): 12–18.
- Harborne, J. B. (1998). *Phytochemical Methods: A Guide to Modern Techniques of Plant Analysis*. Chapman and Hall, London.
- Harborne, J. B. (1998). *Phytochemical Methods: A Guide to Modern Techniques of Plant Analysis*. Chapman and Hall, London.
- Trease, G. E., & Evans, W. C. (2002). *Pharmacognosy* (15th ed.). Saunders Publishers, London.
- Pandey, A., & Tripathi, S. (2014). Concept of standardization, extraction and pre-phytochemical screening strategies for herbal drug. *Journal of Pharmacognosy and Phytochemistry*, 2(5): 115–119.
- Azwanida, N. N. (2015). A review on the extraction methods use in medicinal plants, principle, strength and limitation. *Medicinal & Aromatic Plants*, 4(3): 196.
- Sofowora, A. (1993). *Medicinal Plants and Traditional Medicine in Africa* (2nd ed.). Spectrum Books Ltd., Nigeria.
- Cheesbrough, M. (2006). *District Laboratory Practice in Tropical Countries*. Cambridge University Press, UK.
- Clinical and Laboratory Standards Institute (CLSI). (2021). *Performance Standards for Antimicrobial Susceptibility Testing*. CLSI Supplement M100.
- Bauer, A. W., Kirby, W. M., Sherris, J. C., & Turck, M. (1966). Antibiotic susceptibility testing by a standardized single disk method. *American Journal of Clinical Pathology*, 45(4): 493–496.
- Balouiri, M., Sadiki, M., & Ibsouda, S. K. (2016). Methods for in vitro evaluating antimicrobial activity: A review. *Journal of Pharmaceutical Analysis*, 6(2): 71–79.
- Gomez, K. A., & Gomez, A. A. (1984). *Statistical Procedures for Agricultural Research* (2nd ed.). John Wiley and Sons, New York.
- Steel, R. G. D., & Torrie, J. H. (1980). *Principles and Procedures of Statistics: A Biometrical Approach* (2nd ed.). McGraw-Hill, New York.
- Harborne, J. B. (1998). *Phytochemical Methods: A Guide to Modern Techniques of Plant Analysis*. Chapman and Hall, London.
- Kumar, V., Nagarajan, K., & Rao, A. V. (2017). Phytochemical and pharmacological profile of *Aegle marmelos*: A review. *International Journal of Pharmaceutical Sciences Review and Research*, 44(1): 102–108.
- Baliga, M. S., Bhat, H. P., Joseph, N., & Fazal, F. (2011). Phytochemistry and medicinal uses of the Bael fruit (*Aegle marmelos* Correa): A concise review. *Food Research International*, 44(7): 1768–1775.
- Sharma, G. N., Dubey, S. K., Sharma, P., & Sati, N. (2019). Medicinal values of Bael (*Aegle marmelos*) plant. *International Journal of Current Pharmaceutical Review and Research*, 10(2): 12–18.
- Harborne, J. B. (1998). *Phytochemical Methods: A Guide to Modern Techniques of Plant Analysis*. Chapman and Hall, London.
- Kumar, V., Nagarajan, K., & Rao, A. V. (2017). Phytochemical and pharmacological profile of *Aegle marmelos*: A review. *International Journal of Pharmaceutical Sciences Review and Research*, 44(1): 102–108.
- Baliga, M. S., Bhat, H. P., Joseph, N., & Fazal, F. (2011). Phytochemistry and medicinal uses of the Bael fruit (*Aegle marmelos* Correa): A concise review. *Food Research International*, 44(7): 1768–1775.
- Kumar, V., Nagarajan, K., & Rao, A. V. (2017). Phytochemical and pharmacological profile of *Aegle marmelos*: A review. *International Journal of Pharmaceutical Sciences Review and Research*, 44(1): 102–108.
- Sofowora, A. (1993). *Medicinal Plants and Traditional Medicine in Africa* (2nd ed.). Spectrum Books Ltd., Nigeria.
- Rani, P., & Khullar, N. (2004). Antimicrobial evaluation of some medicinal plants for their anti-enteric potential against multidrug resistant *Salmonella typhi*. *Phytotherapy Research*, 18(8): 670–673.
- Azwanida, N. N. (2015). A review on the extraction methods use in medicinal plants, principle, strength and limitation. *Medicinal & Aromatic Plants*, 4(3): 196.
- Sharma, G. N., Dubey, S. K., Sharma, P., & Sati, N. (2019). Medicinal values of Bael (*Aegle marmelos*) plant. *International Journal of Current Pharmaceutical Review and Research*, 10(2): 12–18.

30. Baliga, M. S., Bhat, H. P., Joseph, N., & Fazal, F. (2011). Phytochemistry and medicinal uses of the Bael fruit (*Aegle marmelos* Correa): A concise review. *Food Research International*, 44(7): 1768–1775.
31. Kumar, V., Nagarajan, K., & Rao, A. V. (2017). Phytochemical and pharmacological profile of *Aegle marmelos*: A review. *International Journal of Pharmaceutical Sciences Review and Research*, 44(1): 102–108.