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Comparative Evaluation of Antibacterial and Anti-Yeast Potential of Aloe vera and Cymbopogon flexuosus Extracts against Human Pathogens

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ABSTRACT

The rapid emergence of antimicrobial resistance and the increasing prevalence of opportunistic yeast infections necessitate the exploration of alternative antimicrobial agents from natural sources. Medicinal plants represent a promising reservoir of bioactive compounds with broad-spectrum antimicrobial properties. In the present study, methanolic and ethanolic extracts of Aloe vera and Cymbopogon flexuosus were evaluated for their antibacterial and anti-yeast activities against selected human pathogenic microorganisms. Antimicrobial efficacy was assessed using well diffusion, filter paper disc diffusion, invert plate assays, and minimum inhibitory concentration (MIC) determination. The methanolic extract of Aloe vera gel exhibited pronounced antibacterial activity, particularly against Escherichia coli (33.00 mm inhibition zone), followed by Bacillus brevis and Bacillus cereus. Cymbopogon flexuosus extracts demonstrated strong activity against Gram-positive bacteria, with maximum inhibition against B. cereus (31.00 mm). Both plant extracts showed notable anti-yeast activity against Saccharomyces cerevisiae and Rhodotorula species. MIC values ranged from 370–1290 µg mL^{-1} for A. vera and 950–1500 µg mL^{-1} for C. flexuosus. The results indicate that solvent polarity significantly influences antimicrobial efficacy. Overall, the findings validate the broad-spectrum antimicrobial potential of Aloe vera and Cymbopogon flexuosus, highlighting their potential as natural alternatives to synthetic antimicrobial agents.

Keywords: *Aloe vera; Cymbopogon flexuosus; antibacterial activity; yeast inhibition; medicinal plants; antimicrobial resistance*

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1. INTRODUCTION

The increasing incidence of infectious diseases caused by antibiotic-resistant microorganisms has become a major global health concern. Excessive and often indiscriminate use of synthetic antibiotics has resulted in the development of multidrug-resistant bacterial and fungal strains, significantly limiting available therapeutic options. In addition to bacterial infections, opportunistic yeast infections have also increased, particularly among immunocompromised individuals. These challenges have stimulated renewed interest in identifying effective, safe, and affordable antimicrobial agents from natural sources and darker oils because of continuing evaporation of the lighter fractions of the oil (Moro and Basil 2000; Nakata et al., 2007).

Essential oils were thought to perform more than one function in living plants, they seems to be a part of the plants immune system while on the other hand they were considered simply the end product of plants metabolism or waste product of plant biosynthesis. However, the function of essential oil in a plant is not clearly understood.

Medicinal plants have been utilized for centuries in traditional healthcare systems for the treatment of infectious diseases. Plant-derived antimicrobial agents offer several advantages over synthetic drugs, including structural diversity, multi-target mechanisms of action, reduced toxicity, and lower risk of resistance development. Secondary metabolites such as phenolics, flavonoids, terpenoids, alkaloids, and tannins play crucial roles in plant defense and have been reported to exhibit strong antimicrobial properties. Essential oils have been known for their inherent antibacterial (Kedzia and Ostrowski, 2003; Hammer *et al*., 2003; Minija and Thoppil, 2002), antifungal (Hodgson *et al*., 1998; Packiyasothy *et al*., 2002; Svendsen *et al*., 1990), insecticidal and antihelminthic properties which makes them highly valuable as skin stimulants, expectorants, diuretics, antiseptics, disinfectants, antibacterial, antifungal and antiviral agents.

Aloe vera is a well-known medicinal plant extensively used in traditional and modern medicine for its antimicrobial,

antioxidant, wound-healing, and immunomodulatory properties. Its bioactivity is attributed to anthraquinones, phenolics, polysaccharides, and flavonoids. Similarly, *Cymbopogon flexuosus* (lemongrass) is valued for its essential oil rich in terpenoids, particularly citral, which exhibits potent antimicrobial and antifungal activity.

Although both plants have been individually studied, comparative evaluations using standardized antimicrobial assays against human pathogens remain limited. Therefore, the present study aimed to comparatively assess the antibacterial and anti-yeast potential of *Aloe vera* and *Cymbopogon flexuosus* extracts using multiple bioassay techniques.

2. MATERIALS AND METHODS

2.1 Plant Material and Extraction

Fresh leaves of *Aloe vera* and *Cymbopogon flexuosus* were collected, thoroughly washed, shade-dried, and pulverized. Methanolic and ethanolic extracts were prepared using standard solvent extraction methods. The extracts were concentrated under reduced pressure and stored at 4 °C until further use.

2.2 Test Microorganisms

The antimicrobial activity was evaluated against the following microorganisms:

- **Gram-positive bacteria:** *Bacillus cereus*, *Bacillus subtilis*, *Bacillus brevis*, *Bacillus megaterium*, *Staphylococcus aureus*
- **Gram-negative bacteria:** *Escherichia coli*
- **Yeasts:** *Saccharomyces cerevisiae*, *Rhodotorula rubra*, *Rhodotorula aurantiaca*, *Kluyveromyces fragilis*

All cultures were maintained on appropriate media and standardized prior to testing.

2.3 Antibacterial and Anti-Yeast Assays

Antimicrobial activity was assessed using:

- **Well diffusion method** for primary screening
- **Filter paper disc diffusion method** for comparative evaluation
- **Invert plate method** to assess volatile antimicrobial activity

Zones of inhibition were measured in millimeters after incubation.

2.4 Determination of Minimum Inhibitory Concentration (MIC)

MIC values were determined using a modified micro-dilution method in 96-well microtiter plates. Optical density was measured at 595 nm, and MIC was defined as the lowest concentration inhibiting visible growth.

3. RESULTS

3.1 Antibacterial Activity of *Aloe vera*

Methanolic extract of *Aloe vera* gel exhibited strong antibacterial activity. The maximum inhibition zone was observed against *E. coli* (33.00 mm), followed by *B. brevis* (30.67 mm) and *B. cereus* (30.50 mm). Ethanolic extracts also showed substantial inhibition against Gram-positive bacteria, confirming broad-spectrum antibacterial activity.

3.2 Anti-Yeast Activity of *Aloe vera*

Significant anti-yeast activity was observed, with maximum inhibition against *R. rubra* (24.00 mm), followed by *R. aurantiaca* (22.67 mm) and *S. cerevisiae* (18.83 mm). Volatile fractions exhibited moderate inhibitory effects.

3.3 Antibacterial Activity of *Cymbopogon flexuosus*

Methanolic extract of *C. flexuosus* demonstrated pronounced antibacterial activity against Gram-positive bacteria, with maximum inhibition against *B. cereus* (31.00 mm), followed by *B. megaterium* (29.00 mm) and *B. subtilis*. Activity against Gram-negative bacteria was comparatively moderate.

3.4 Anti-Yeast Activity of *Cymbopogon flexuosus*

The extract showed notable inhibition against *S. cerevisiae* (19.67 mm), *K. fragilis* (17.83 mm), and *R. rubra* (15.80 mm), indicating effective anti-yeast potential.

3.5 MIC Determination

MIC values ranged from **370–1290 µg mL^{-1}** for ethanolic extracts of *Aloe vera* and **950–1500 µg mL^{-1}** for methanolic extracts of *C. flexuosus*, confirming dose-dependent antimicrobial activity.

Table 1. Antibacterial activity of **Aloe vera** *extracts against human bacterial pathogens (Well diffusion method)*

Test organism	Zone of inhibition (mm) – Methanolic extract	Zone of inhibition (mm) – Ethanolic extract
Escherichia coli	33.00 ± 0.58	30.00 ± 0.62
Bacillus brevis	30.67 ± 0.33	27.50 ± 0.50
Bacillus cereus	30.50 ± 0.29	29.00 ± 0.41
Bacillus megaterium	28.83 ± 0.44	28.50 ± 0.35
Bacillus subtilis	27.33 ± 0.38	26.80 ± 0.46
Staphylococcus aureus	26.00 ± 0.50	25.67 ± 0.58

Values represent mean ± standard deviation (n = 3).

Table 2 Anti-yeast activity of Aloe vera extracts (Well diffusion method)

Yeast strain	Zone of inhibition (mm) – Methanolic extract	Zone of inhibition (mm) – Ethanolic extract
Rhodotorula rubra	24.00 ± 0.41	21.83 ± 0.44
Rhodotorula aurantiaca	22.67 ± 0.33	20.50 ± 0.50
Saccharomyces cerevisiae	18.83 ± 0.29	17.00 ± 0.41
Kluyveromyces fragilis	17.50 ± 0.35	15.67 ± 0.38

Values represent mean ± standard deviation (n = 3).

Table 3 Antibacterial activity of Cymbopogon flexuosus ***extracts against human pathogens***

Test organism	Zone of inhibition (mm) – Methanolic extract	Zone of inhibition (mm) – Ethanolic extract
Bacillus cereus	31.00 ± 0.50	28.83 ± 0.44
Bacillus megaterium	29.00 ± 0.41	27.50 ± 0.50
Bacillus subtilis	28.00 ± 0.33	26.67 ± 0.38
Staphylococcus aureus	26.83 ± 0.29	25.00 ± 0.41
Escherichia coli	24.50 ± 0.35	22.83 ± 0.44

Values represent mean ± standard deviation (n = 3).

Table 4 Anti-yeast activity of Cymbopogon flexuosus ***extracts***

Yeast strain	Zone of inhibition (mm) – Methanolic extract	Zone of inhibition (mm) – Ethanolic extract
Saccharomyces cerevisiae	19.67 ± 0.33	17.83 ± 0.38
Kluyveromyces fragilis	17.83 ± 0.29	16.00 ± 0.41
Rhodotorula rubra	15.80 ± 0.35	14.33 ± 0.29

Values represent mean ± standard deviation (n = 3).

Table 5. Minimum inhibitory concentration (MIC) values of plant extracts

Plant extract	MIC range (µg mL^{-1})
Aloe vera (ethanolic)	370 – 1290
Aloe vera (methanolic)	420 – 1350
Cymbopogon flexuosus (methanolic)	950 – 1500

4. DISCUSSION

The results demonstrate that both *Aloe vera* and *Cymbopogon flexuosus* possess significant antibacterial and anti-yeast activities. The higher susceptibility of Gram-positive bacteria may be attributed to the absence of an outer membrane, facilitating penetration of bioactive compounds. The effectiveness of alcohol-based extracts highlights the role of solvent polarity in extracting antimicrobial phytochemicals.

The observed anti-yeast activity suggests interference with cell membrane integrity and metabolic processes. The presence of phenolics, flavonoids, and terpenoids likely contributes to the observed bioactivity through synergistic mechanisms. These findings align with earlier studies reporting the antimicrobial potential of both plants and further strengthen their relevance as natural antimicrobial agents. it was found that well diffusion method was more sensitive method to evaluating antimicrobial activities because there is a better contact and diffusion of the extracts into the media and organisms but filter paper disc may act as barrier between the extract and the organisms. There may not be proper diffusion and total release of active compounds observed by the disc into the media. Similarly in the invert plate method most of the volatile part of compounds gets lost. Similar consideration was also given by Toda *et al.* (1991) and Jonathan & Fasidi (2003).

It has been reported to result in gross membrane damage (Aureli, 1992; Hodgson *et al.,* 1998). Rath *et al.* (2002) and Dorman and and Dean (2000) also reported that some antimicrobial agents cause gross membrane damage provoke whole cell lysis. Many antimicrobial compounds such as terpenes, lectins, polysaccharides etc. act on the bacterial cytoplasmic membrane and it also inhibit respiratory activity in yeast mitochondria (Dubey *et al*., 1998; Yang *et al*., 2002).

5. CONCLUSION

The present study provides clear evidence that *Aloe vera* and *Cymbopogon flexuosus* extracts exhibit broad-spectrum antibacterial and anti-yeast activities against human pathogens. Solvent-dependent variation in efficacy underscores the importance of extraction strategy. The findings support the potential application of these plants as natural alternatives or adjuncts to synthetic antimicrobial agents and warrant further investigation for pharmaceutical development.

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Conflict of Interest
The authors declare no conflict of interest.

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