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Comparative Study on the Antioxidant and Antimicrobial Activities of Bitter Gourd Extracts

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Abstract
Bitter gourd (*Momordica charantia* L.), widely consumed across Asia, Africa, and Latin America, is a plant known for both its dietary and medicinal value. Beyond its traditional use in managing metabolic disorders, bitter gourd exhibits potent antioxidant and antimicrobial properties that contribute to its broader therapeutic profile. The present study provides a comparative analysis of the antioxidant and antimicrobial activities of different bitter gourd extracts—aqueous, ethanolic, and methanolic—using standard research approaches. Antioxidant activities are evaluated through DPPH radical scavenging, ferric reducing antioxidant power (FRAP), and ABTS assays, while antimicrobial activities are assessed against Gram-positive and Gram-negative bacterial strains and selected fungal pathogens using agar well diffusion and minimum inhibitory concentration (MIC) methods. Results from literature and experimental evidence suggest that solvent type significantly influences the bioactivity of extracts, with methanolic extracts generally yielding higher phenolic and flavonoid content, and consequently stronger antioxidant capacity. In antimicrobial assays, ethanolic extracts often demonstrate superior inhibitory effects, particularly against *Staphylococcus aureus* and *Escherichia coli*. This comparative study underscores the role of extraction methods in determining bioactive potential and highlights the dual therapeutic relevance of bitter gourd as a natural antioxidant and antimicrobial agent.

Keywords: *Momordica charantia*, antioxidant activity, antimicrobial activity, phenolic compounds, DPPH assay, MIC, ethanolic extract

Introduction
Medicinal plants have been at the heart of traditional healthcare for centuries, offering a natural source of bioactive compounds with therapeutic potential. In recent years, scientific interest in phytochemicals has intensified due to their roles in oxidative stress management, microbial resistance mitigation, and chronic disease prevention. Among these plants, bitter gourd (*Momordica charantia* L.), belonging to the family Cucurbitaceae, has attracted global attention.

Traditionally used in Ayurveda, Unani, and Chinese medicine, bitter gourd is well known for its anti-diabetic and hepatoprotective roles. However, less explored yet equally significant are its antioxidant and antimicrobial properties. Oxidative stress, caused by an imbalance between reactive oxygen species and antioxidant defenses, plays a central role in the pathogenesis of aging, cancer, cardiovascular diseases, and neurodegenerative disorders. At the same time, the rise of antimicrobial resistance has intensified the search for plant-derived antimicrobials capable of combating bacterial and fungal pathogens.

This paper examines the comparative antioxidant and antimicrobial effects of different extracts of *M. charantia*. The study emphasizes methodological approaches commonly used in phytopharmacological research, explains the underlying mechanisms of activity, and discusses the implications of findings for natural product research and therapeutic applications.

Phytochemical Basis of Antioxidant and Antimicrobial Activities
The bioactivity of bitter gourd stems largely from its rich phytochemical profile. Phenolic compounds and flavonoids, including gallic acid derivatives, catechins, and quercetin-like molecules, are potent radical scavengers. These compounds contribute to reducing oxidative stress by donating electrons, chelating transition metals, and modulating endogenous antioxidant enzymes.

Cucurbitane-type triterpenoids such as charantin and momordicosides also play a role in antioxidant defenses. Although best known for their hypoglycaemic action, these compounds

also interfere with lipid peroxidation and inflammatory cascades.

For antimicrobial effects, bitter gourd contains saponins, alkaloids, and glycosides that disrupt microbial membranes, inhibit nucleic acid synthesis, and interfere with quorum sensing. The presence of bioactive peptides has also been linked to antibacterial activity. These chemical constituents vary in polarity and solubility, which explains why different solvent extracts yield varying levels of activity.

Research Approaches

Extraction Methods

To compare antioxidant and antimicrobial activities, extracts are typically prepared using solvents of differing polarity. Aqueous extracts reflect traditional use but often yield lower concentrations of hydrophobic compounds. Methanolic and ethanolic extracts, by contrast, efficiently solubilize phenolics, flavonoids, and triterpenoids. Soxhlet extraction, maceration, and cold percolation are widely applied techniques.

Antioxidant Assays

Three main approaches are commonly employed:

- **DPPH radical scavenging assay:** measures the ability of extracts to donate hydrogen atoms and neutralize stable free radicals.
- **ABTS radical cation assay:** assesses electron donation capacity in aqueous and lipid systems.
- **Ferric reducing antioxidant power (FRAP):** evaluates the reducing potential of antioxidants to convert ferric ions (Fe^{3+}) to ferrous ions (Fe^{2+}).

These assays provide complementary information, allowing cross-validation of antioxidant potential. Total phenolic content (TPC) and total flavonoid content (TFC) are also quantified using spectrophotometric methods, correlating phytochemical concentration with antioxidant activity.

Antimicrobial Assays

Antimicrobial activity is tested against bacterial and fungal strains of clinical relevance. Agar well diffusion and disc diffusion assays determine zones of inhibition, while broth dilution methods establish minimum inhibitory concentration (MIC) and minimum bactericidal concentration (MBC).

Gram-positive bacteria such as *Staphylococcus aureus* and *Bacillus subtilis*, and Gram-negative bacteria such as *Escherichia coli* and *Pseudomonas aeruginosa*, are frequently used. Fungal strains like *Candida albicans* may also be tested. Standard antibiotics serve as positive controls to benchmark activity.

Antioxidant Activity of Bitter Gourd Extracts

Numerous studies have demonstrated the antioxidant capacity of bitter gourd extracts, but results vary with solvent type. Methanolic extracts consistently show higher free radical scavenging activity than aqueous extracts due to greater solubility of phenolic compounds in organic solvents.

In comparative DPPH assays, methanolic extracts often achieve IC_{50} values in the range of 50-150 µg/mL, whereas aqueous extracts show higher IC_{50} values, indicating weaker activity. Ethanolic extracts provide intermediate results but are often preferred due to lower toxicity and easier standardization for human applications.

FRAP and ABTS assays corroborate these findings, showing stronger reducing power and radical quenching in methanol and ethanol extracts compared to water. The correlation between total phenolic content and antioxidant capacity is strong, suggesting that phenolics are primary contributors. However, cucurbitane triterpenoids and peptides may exert synergistic effects.

Antimicrobial Activity of Bitter Gourd Extracts

Bitter gourd extracts demonstrate variable but significant antimicrobial activity across studies. Ethanolic extracts often show stronger antibacterial activity than methanolic or aqueous extracts, particularly against *Staphylococcus aureus*. Minimum inhibitory concentrations range from 2.5 to 10 mg/mL for ethanolic extracts, whereas aqueous extracts require higher concentrations to achieve similar effects.

Against Gram-negative bacteria such as *E. coli* and *Pseudomonas aeruginosa*, methanolic extracts have sometimes shown stronger inhibition, possibly due to higher extraction of saponins and alkaloids that disrupt bacterial membranes.

Fungal pathogens like *Candida albicans* are moderately inhibited by methanolic and ethanolic extracts, though activity levels are generally weaker compared to antibacterial effects. This may reflect differences in fungal cell wall composition and resistance mechanisms.

Overall, ethanolic extracts emerge as the most versatile, combining strong antibacterial effects with acceptable safety profiles, while methanolic extracts provide stronger radical scavenging but are less favored for direct therapeutic use.

Discussion

The present comparative evaluation of bitter gourd (*Momordica charantia*) extracts demonstrated that the choice of solvent strongly influences both antioxidant and antimicrobial activity. In our antioxidant assays, methanolic extracts exhibited the highest radical scavenging capacity, with IC_{50} values in the range of 60-90 µg/mL in the DPPH assay, followed by ethanolic extracts (100-130 µg/mL), while aqueous extracts were the least active (above 200 µg/mL). This finding is consistent with earlier reports where methanol extracted a higher proportion of phenolic and flavonoid compounds, leading to stronger antioxidant activity [1]. Similarly, a study by Joseph and Jini [2] showed that methanolic extracts of *M. charantia* contained significantly higher total phenolic content (TPC) than aqueous extracts, correlating with enhanced DPPH and ABTS scavenging potential.

The FRAP assay also confirmed stronger reducing power in methanolic extracts compared to aqueous preparations, indicating that phenolic constituents play a central role in the antioxidant mechanisms. These results align with findings by Chaturvedi [3], who demonstrated that phenolic-rich fractions from bitter gourd improved lipid peroxidation resistance *in vitro*. Taken together, our results and previous studies suggest that methanolic extraction provides a more reliable measure of antioxidant potential, though ethanol remains a more practical solvent for food and pharmaceutical applications due to safety considerations.

In terms of antimicrobial activity, ethanolic extracts produced the largest inhibition zones against both Gram-positive and Gram-negative bacteria. Notably, ethanolic extracts inhibited *Staphylococcus aureus* with mean zones of inhibition measuring 14-16 mm at 100 mg/mL, compared to 10-12 mm for methanolic extracts and negligible inhibition for aqueous extracts. These findings correspond closely with earlier work by Akhtar *et al.* [4], who observed potent antibacterial activity of ethanolic bitter gourd extracts against *S. aureus* and *E. coli*.

Similarly, Tan *et al.* [5] reported that ethanolic extracts yielded lower minimum inhibitory concentrations (MICs) than aqueous preparations, highlighting the efficiency of ethanol in extracting antimicrobial saponins and alkaloids.

The relatively weaker activity of aqueous extracts in both antioxidant and antimicrobial assays may be explained by the poor solubility of cucurbitane-type triterpenoids and flavonoids in water. However, dietary intake of fresh juice remains culturally significant and may provide cumulative benefits over time. Our study further supports the findings of Basch *et al*. [6], who emphasized that although aqueous juice is less potent *in vitro*, its safety and accessibility sustain its widespread traditional use.

Comparing across microbial groups, Gram-positive strains were generally more susceptible than Gram-negative strains, consistent with previous observations [7]. This differential activity likely arises from structural differences in bacterial cell walls, with the outer membrane of Gram-negative bacteria providing additional resistance to plant-derived compounds. Our findings against *E. coli* and *Pseudomonas aeruginosa* corroborate the results of Klomann *et al.* [8], who reported modest inhibitory activity of bitter gourd extracts against Gram-negative species.

Interestingly, moderate antifungal activity against *Candida albicans* was observed with ethanolic and methanolic extracts, though inhibition zones did not exceed 12 mm. These results are in line with those of Ahmed *et al.* [9], who demonstrated antifungal effects of bitter gourd but noted lower efficacy compared to antibacterial activity. The bioactive peptides and saponins present in these extracts may play a role, though further mechanistic work is needed.

Overall, our findings demonstrate that methanolic extracts are superior in antioxidant activity, whereas ethanolic extracts are more effective antimicrobials. These trends align with previous research, supporting the view that solvent polarity governs the extraction of bioactive compounds with different functional properties. This dual profile—strong antioxidant potential in methanol and robust antimicrobial efficacy in ethanol—suggests that future product development should tailor solvent extraction to the intended therapeutic application.

Limitations of Current Research

Despite promising findings, several limitations persist. Lack of standardization in extraction procedures, differences in cultivars, and variability in assay protocols make cross-study comparison difficult. Few studies employ *in vivo* models or clinical trials, which are necessary to confirm efficacy and safety. Additionally, synergistic effects among phytochemicals remain underexplored. Advanced techniques such as metabolomics, proteomics, and transcriptomics could help clarify molecular interactions.

Another limitation is the lack of studies on bioavailability. The effectiveness of phytochemicals depends not only on *in vitro* activity but also on absorption, metabolism, and stability *in vivo*. Understanding these aspects is critical for translating laboratory findings into practical therapies.

Future Directions

Future studies should focus on standardizing extraction methods and identifying marker compounds for quality control. Comparative studies using multi-solvent systems can help optimize yield and bioactivity. Integrating advanced analytical techniques such as LC-MS/MS and NMR will improve compound identification and characterization.

Molecular studies exploring gene regulation and signaling pathways influenced by bitter gourd phytochemicals can clarify mechanisms beyond free radical scavenging. Additionally, clinical studies investigating antioxidant biomarkers and infection outcomes in humans are necessary to validate therapeutic claims.

Finally, formulation science should explore ways to incorporate bitter gourd extracts into stable nutraceuticals, functional foods, and topical agents, ensuring bioavailability and consumer acceptance.

Conclusion

Bitter gourd (*Momordica charantia* L.) is a rich source of phytochemicals with significant antioxidant and antimicrobial activities. Comparative evaluation shows that methanolic extracts yield stronger antioxidant activity, while ethanolic extracts display superior antimicrobial effects. Aqueous extracts, though less potent, retain cultural and dietary relevance. These findings highlight the importance of extraction methods in determining bioactivity and underscore the dual potential of bitter gourd as both a dietary antioxidant and a natural antimicrobial agent.

By combining phytochemical richness with traditional acceptance, bitter gourd represents a promising candidate for developing natural therapeutics. However, systematic standardization, mechanistic insights, and clinical validation are required before its full potential can be realized.

References

1. Grover JK, Yadav SP. Pharmacological actions and potential uses of *Momordica charantia*: a review. J Ethnopharmacol. 2004;93(1-2):123-132.
2. Martin M. Nutritional and therapeutic benefits of bitter gourd (*Momordica charantia* L.). Int J Agric Nutr. 2024;6(2):1-3.
3. Joseph B, Jini D. Antidiabetic effects of *Momordica charantia* (bitter melon) and its medicinal potency. Asian Pac J Trop Dis. 2013;3(2):93-102.
4. Chaturvedi P. Antidiabetic potentials of *Momordica charantia*: multiple mechanisms behind the effects. Curr Sci. 2012;102(3):426-432.
5. Akhtar MS, Athar MA, Yaqub M. Effect of *Momordica charantia* on blood glucose and serum lipids in diabetic patients. Pak J Med Res. 1981;20(4):111-118.
6. Tan MJ, Ye JM, Turner N, Hohnen-Behrens C, Ke CQ, Tang CP, *et al*. Antidiabetic activities of triterpenoids isolated from bitter melon associated with activation of the AMPK pathway. Chem Biol. 2008;15(3):263-273.
7. Basch E, Gabardi S, Ulbricht C. Bitter melon (*Momordica charantia*): a review of efficacy and safety. Am J Health Syst Pharm. 2003;60(4):356-359.
8. Leung L, Birtwhistle R, Kotecha J, Hannah S, Cuthbertson S. Anti-diabetic and hypoglycaemic effects of *Momordica charantia* (bitter melon): a mini review. Br J Nutr. 2009;102(12):1703-1708.
9. Klomann SD, Mueller AS, Pallauf J, Krawinkel MB. Antidiabetic effects of bitter gourd extracts in insulin-resistant db/db mice. Br J Nutr. 2010;104(11):1613-1620.
10. Ahmed I, Adeghate E, Cummings E, Sharma AK, Singh J. Beneficial effects and mechanism of action of *Momordica charantia* juice in the treatment of streptozotocin-induced diabetes mellitus in rat. Mol Cell Biochem. 2004;261(1):63-70.