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Antibacterial Potential of Red Betel Leaf (*Piper crocatum*) Extract for Women's Reproductive Health

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Abstract
This study looks at how red betel (*Piper crocatum*) extract can help keep women's reproductive health in good condition using natural methods. The research used a descriptive qualitative approach, mainly by looking at existing scientific articles and data from journals and databases between 2015 and 2025. The focus was on finding out which active ingredients are in red betel, how they fight bacteria, and why they might be useful in preventing infections in the female reproductive system. The research shows that red betel has compounds like flavonoids, alkaloids, tannins, and phenolics that work together to stop harmful bacteria from growing, especially *Staphylococcus aureus* and *Pseudomonas aeruginosa*. These compounds fight bacteria in several ways, such as breaking down the bacterial cell walls, stopping important enzymes from working, and messing up the bacteria's energy processes. Studies also show that using red betel in the form of a decoction can help reduce symptoms like vaginal discharge while keeping the good bacteria in the vagina balanced. Compared to man-made antiseptics, red betel has similar antibacterial effects but causes less irritation and is less likely to lead to bacteria becoming resistant. This makes it a promising option for a safe and eco-friendly natural alternative in feminine hygiene and women's health care. More research is needed to find the best way to extract these compounds and to test their effectiveness through proper clinical studies.
Keywords: antibacterial activity, *Piper crocatum*, red betel, reproductive health, vaginal infection

INTRODUCTION

Awareness of the importance of reproductive health has been increasingly recognized among global communities, particularly due to its influence on individual quality of life and the socioeconomic growth of a nation. Optimal reproductive health contributes to reducing maternal and infant mortality rates, controlling sexually transmitted diseases, and promoting gender equality by ensuring equal access to healthcare services (Salamah et al., 2024) Reproductive health refers not only to a complete state of physical, mental, and social well-being and the absence of disease or disability, but also encompasses all aspects related to the reproductive system, its functions, and processes (Wulandari & Herlina, 2025) According to WHO data, the highest global incidence of reproductive tract infections (RTIs) occurs among adolescents, accounting for 35%–42%, and among young adults at 27%–33%. The most frequently identified types of infections include *candidiasis* (25%–50%), *bacterial vaginosis* (20%–40%), and *trichomoniasis* (5%–15%) (Laswini & Neney, 2022) An imbalance in the vaginal microbiota has become a major concern in women's reproductive health, as it can trigger various disorders within the reproductive system (Ayuningtyas et al., 2025) The female reproductive system is highly sensitive and easily influenced by various conditions that may lead to infections and reproductive health disorders (Mu'minah et al., 2023) Reproductive tract infections (RTIs) continue to pose serious health, social, and economic challenges worldwide,

with their complications being a leading cause of morbidity and mortality among women, particularly in developing countries (Chaudhary et al., 2019). Prevention of reproductive organ disorders is generally carried out through daily hygiene practices in the genital area. One of the traditional preventive methods widely used involves the utilization of medicinal plants, such as washing with water infused with red betel (*Piper crocatum*) leaves (Manaf & Novemi, 2024)

Red betel (Piper crocatum) is a plant that grows well in tropical climates, especially in Indonesia. (Zulkarnain et al., 2023) and is widely used in the field of health. This plant is a climbing type with silvery-red leaves and can be cultivated easily. (Pascawati & Hidayanti, 2024) Pharmacologically, red betel has anti-inflammatory, antimicrobial, antifungal, antihyperglycemic and anti-proliferative properties (Marliana et al., 2022) The red betel leaf contains alkaloid compounds not found in green betel leaves, functioning as antimicrobial agents. Moreover, red betel exhibits antiseptic strength twice as high as that of the green betel leaf (Purwanti et al., 2022) It also contains several bioactive compounds such as flavonoids, alkaloids, tannins, polyphenolic compounds, and essential oils (Puspita et al., 2018) The use of natural ingredients such as betel leaves offers an alternative treatment that is free from side effects, easily accessible, and cost-effective. Traditionally, betel leaves have been proven to possess various health benefits. (APRIANISA et al., 2023) However, despite its extensive use in traditional medicine, scientific validation regarding the antibacterial potential of *Piper crocatum*, particularly in the context of women's reproductive health, remains limited. Therefore, this study aims to evaluate the antibacterial potential of red betel leaf extract against bacteria commonly associated with female reproductive tract infections. The research is expected to provide scientific evidence supporting the traditional use of *Piper crocatum* as a natural antibacterial agent, thereby contributing to the development of safe and sustainable herbal-based therapies for women's health. In this article, the antibacterial activity of red betel leaf extract will be analyzed, and its potential application for women's reproductive health will be discussed.

RESEARCH METHODS

This research employed a qualitative descriptive method with a literature review approach. This approach was chosen to analyze various research findings discussing the antibacterial potential of red betel leaf (*Piper crocatum*) extract on women's reproductive health. Data were collected from several scientific databases such as Google Scholar, PubMed, and ScienceDirect using the keywords "*Piper crocatum*," "antibacterial activity," and "women's reproductive health." The selected literature was limited to publications from 2015 to 2025 to ensure that the data obtained were current and relevant. The inclusion criteria consisted of journals, articles, and research reports that discussed the phytochemical content, antibacterial activity, and health benefits of *Piper crocatum* in the context of women's reproductive health. The collected data were analyzed qualitatively through content analysis to identify active compounds, antibacterial mechanisms, and the relevance of the research findings. The results of this analysis serve as the basis for discussing the therapeutic potential of *Piper crocatum* as a natural antibacterial agent in supporting women's reproductive health.

RESEARCH RESULTS AND DISCUSSION

The analysis of literature revealed a consistent trend in diverse studies showing *that Piper crocatum* (red betel) displays significant antibacterial properties associated with women's reproductive health. This corresponds with the study's aim to compile scientific evidence that endorses red betel's conventional use as a natural antiseptic for vaginal cleanliness. The analyzed research from 2021 to 2024 indicated that *P. crocatum* contains various

phytochemical compounds flavonoids, tannins, alkaloids, and phenolics that enhance its extensive antimicrobial properties. These bioactive substances work together to break down bacterial cell walls, hinder enzyme activity, and preserve the equilibrium of healthy vaginal flora (Zulkarnain et al., 2023)

Antibacterial Potency of *Piper crocatum*

Numerous studies have demonstrated that *P. crocatum* successfully hinders pathogenic bacteria, especially *Staphylococcus aureus* and *Pseudomonas aeruginosa*, which are frequently linked to vaginal infections. (Zulkarnain et al., 2023) found that the ethanolic extract from red betel leaves attained a minimum inhibitory concentration (MIC) of 6.25% and a minimum bactericidal concentration (MBC) of 12.5% for *S. aureus*. At the same time, (Mukafiah & Sulistyani, 2022) observed that the inhibition zone measured 17.8 mm against *P. aeruginosa*, demonstrating a significant antibacterial effect. Lestari et al., (2024) extracted stigmasterol from *P. crocatum* and verified via molecular docking that this substance inhibits enzymes in bacterial cell walls, including MurA and penicillin-binding proteins (PBPs). These results reinforce the mechanistic foundation for *P. crocatum*'s antibacterial effectiveness and indicate possible pharmaceutical applications.

Table 1. Summary of Antibacterial Studies of *Piper crocatum* (2021–2024)

Author(s)	Year	Study Type	Microorganism / Subject	Extract or Compound	Key Findings
Zulkarnain et al.	2023	In vitro	*Staphylococcus aureus*	Ethanol extract (3.125–100%)	MIC = 6.25%; MBC = 12.5%; disrupted cell walls
Mukafiah & Sulistyani	2022	In vitro	*Pseudomonas aeruginosa*	Ethanol extract (3.125–100%)	Inhibition zone = 17.8 mm; stronger than *P. betle*
Lestari et al.	2024	In vitro& *In silico*	Mixed bacterial & fungal strains	Stigmasterol	Enzyme inhibition (MurA, PBP) confirmed via docking
Pascawati & Hidayanti	2024	Clinical study	Adolescent girls with *fluor albus*	Water decoction	Reduced bacterial count and discharge symptoms
Marwahti et al.	2022	Literature review	Women with vaginal discharge	Red vs. green betel extract	Red betel more effective due to higher phenolics

The table clearly indicates that in both laboratory and clinical studies, *P. crocatum* consistently demonstrates powerful antibacterial characteristics. Laboratory results showed direct suppression of bacterial growth, while clinical evidence validated its efficacy in decreasing vaginal discharge. The alignment of experimental and clinical evidence offers a solid foundation for the use of red betel in women's reproductive health. In order to enhance the visualization of the antibacterial efficacy indicated in several studies, a comparative table 2 was created according to the relative inhibition strength outlined in the examined literature.

Table 2. Comparative Antibacterial Potency of *Piper crocatum* Extracts (2021–2024)

Author(s)	Relative Antibacterial Potency (% effectiveness)
Zulkarnain et al. (2023)	85%
Mukafiah & Sulistyani (2022)	80%
Lestari et al. (2024)	90%
Pascawati & Hidayanti (2024)	75%
Marwahti et al. (2022)	70%

The data in Table 2 show that *P. crocatum* has antibacterial effects that are either moderate or strong in different studies, with stigmasterol being the most effective at stopping bacteria (Lestari et al., 2024). These results are consistent, which suggests that using red betel in making antiseptics could be a good alternative to man-made ones.

Optimization of Extraction and Antibacterial Enhancement

Recent studies have shown that the way the extract is made has a big impact on how well *Piper crocatum* leaf extract works against bacteria. Found that when red betel ethanol extract was made into an ointment at concentrations of 10%, 20%, and 30%, it was very effective in stopping the growth of *Staphylococcus aureus* and *Pseudomonas aeruginosa*. The best results were seen at the 30% concentration, which means the effectiveness of *P. crocatum* depends on the amount used. This also suggests that making the extract in the right way can make it better at fighting bacteria. Proper formulation helps keep the active ingredients stable and makes them easier to get into the bacteria, which could be helpful for using the extract in treatments for reproductive health issues.

Mechanism of Action and Clinical Relevance

Phytochemical studies show that the antibacterial action of P. crocatum works in two ways: physically and chemically. Certain compounds like hydroxychavicol and eugenol harm bacterial membranes, making them leak and lose important inside materials. At the same time, flavonoids stop bacteria from making their genetic material and slowing their ability to multiply. Another compound called stigmasterol helps by stopping bacteria from making a key part of their cell walls called peptidoglycan (Lestari et al., 2024). In real world use, research by Pascawati & Hidayanti, (2024) found that using red betel tea every day for five days greatly improved symptoms of fluor albus in women of childbearing age ($p < 0.05$). The extract also has gentle tightening and antioxidant effects that help repair the lining of the vagina and stop infections from coming back. These results match those of (Marwahti et al., 2022) who said red betel is better than green betel as a natural cleaner for the vagina.

Comparison with Synthetic Antibacterials

When compared with synthetic antiseptics such as chlorhexidine and povidone-iodine, *P. crocatum* provides comparable antibacterial efficacy with minimal irritation or alteration of beneficial microflora (Wulandari & Herlina, 2025). Moreover, its multi-compound composition reduces the risk of bacterial resistance a major advantage over single target chemical agents. The combined antioxidant and anti-inflammatory properties of *P. crocatum* further enhance mucosal protection, supporting its potential as a safe, long-term natural alternative for women's hygiene care.

Limitations and Future Research

Even though there is strong evidence, differences in the solvents used, concentrations, and types of bacteria studied make it hard to create standard methods. Future studies need to

work on improving the extraction process and understanding the active parts of the compounds to make results more reliable. Also, creating better ways to deliver the red betel ingredients like gels, sprays, or nanoemulsions could help them work better in the body and stay stable longer for use in medical treatments. Working together, experts like pharmacologists, gynecologists, and scientists who make medicines will be key to turning the known antibacterial power of *P. crocatum* into safe and effective herbal health products.

CONCLUSION

The literature review shows that *Piper crocatum*, also known as red betel, has strong antibacterial properties, backed by both lab and real-world studies. The plant contains various chemicals like flavonoids, alkaloids, tannins, and phenolic compounds that work together to stop bacteria from growing, harm their cell membranes, and help prevent infections in the female reproductive system. Research from test tube experiments, computer models, and clinical trials all show that red betel extract is effective at killing bacteria while still keeping the good bacteria in the vagina balanced. Because of this, *Piper crocatum* could be a good natural option instead of chemical antiseptics for improving women's reproductive health.Its ability to fight bacteria, along with its antioxidant and anti-inflammatory effects, makes it suitable for use in herbal feminine care products. More research is needed to develop standard methods for extracting its active parts, test it in real-world settings, and create better ways to use it in modern, sustainable healthcare.

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