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A Short Review on *Piper Betle* L Study of Its Phytoconstituents and Pharmacological Activities.

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ABSTRACT:
Herbal plants continue to play a important role in global healthcare systems owing to their chemical diversity, therapeutic versatility. *Piper betle* L., a perennial climber of the family Piperaceae, is widely cultivated in South and Southeast Asia and has long been valued in traditional medical systems such as Ayurveda, Siddha, Unani. The present review provides a comprehensive overview of the phytochemistry, pharmacological activities, nutritional attributes and economic significance of *P. betel*. Betel leaves are rich in essential oils and phenolic compounds, including chavibetol, chavicol, eugenol, hydroxychavicol, and along with terpenoids, flavonoids, sterols, and other bioactive constituents. Experimental studies demonstrate a broad spectrum of biological activities such as antioxidant antimicrobial, antifungal, antidiabetic, anti-inflammatory, analgesic, anticancer, antihypertensive, antiprotozoal effects. In addition to therapeutic potential, *Piper betle has* gained increasing attention in the food industry as a natural preservative and functional ingredient due to its strong antimicrobial as well as antioxidant properties. Overall, *Piper betle* represents a valuable natural resource with significant potential for future development of pharmaceuticals, nutraceuticals, and functional foods.

KEYWORDS: *Piper betle, phytochemistry*; digestive, methyl eugenol, antioxidant activity& antifertility activity

INTRODUCTION:

Medicinal plants have progressively transitioned from marginal to mainstream healthcare owing to the growing preference for natural therapies.[1]
The economic condition of a herbal drugs in the worldwide market depends on the physical nature of the products. [2.] India has a rich biodiversity and officially recognizes more than 4,000 plant species for their medicinal value. [3]
In present years, substantial research efforts have focused on the identification, characterization, and validation of bioactive principal derived from plants for the management of various diseases. Traditional Indian medicine encompasses several well-established systems, including Ayurveda, Siddha, Unani, and Homoeopathy, wherein drug evaluation relies on phytochemical, pharmacological, and advanced instrumental techniques such as chromatography and microscopy and other instrumental different methods. [3]

The plant *Piper betle* L possesses a wide spectrum of ethnopharmacological uses and contains different phytoconstituents with demonstrated pharmacological activities, making it a promising candidate for applications in pharmaceutical, nutraceutical, cosmetic. Therefore, a comprehensive evaluation of its traditional uses, bioactive constituents, and therapeutic potential is essential to support its rational utilization and industrial development. The present review aims to provide overview of the industrial and therapeutic applications of *Piper betle* L., with emphasis on its phytochemistry, ethnopharmacology and pharmacological properties.[4,5,6]

Betel leaf (*Piper betle* L.) is a perennial climbing vine (family -Piperaceae) and is widely cultivated for its aromatic and medicinal leaves. In India, the leaves are popularly known as *paan* and are commonly used as a mouth refresher after meals.

BOTANICAL IDEA:

Piper betle L. is a semi-woody perennial climber with short adventitious roots that aid in climbing. The plant bears glabrous, heart-shaped leaves possessing a strong aromatic odor and pungent. Variations in leaf characteristics such as size, taste, color, aroma, and are influenced by the cultivar, nutritional composition, and chemical constituents.[2]

GEOGRAPHICAL DISTRIBUTION:

Malaysia, origin place from cultivation betel leaf. Betel leaf cultivation is also prevalent in several Southeast Asian countries, including Sri Lanka, Thailand, Taiwan, Malaysia, the Philippines, Bangladesh, and Burma. Approximately 100 varieties of betel leaf have been found in India.[2]

TRADITIONAL USES OF BETEL LEAF

In Hindu culture, Betel leaf holds an important place in India and is extensively used in social, religious, and ceremonial practices along with Areca nut. The leaves are considered the most valuable and edible part of the plant[2].The roots and fruits of *Piper betle* are traditionally used in the treatment of different condition likes malaria and asthma treatment.

Different types of Ayurvedic formulations such as Brhat Sarwajwarahara, Lokantha Rasa, Puspadhava Rasa, , Laghu and Brhat Vishamajwarantaka Rasa include *Piper betle* as a main ingredient. Betel leaf juice is commonly used as an adjuvant in Ayurvedic preparations to enhance therapeutic efficacy of digestion.

According to the Unani system of medicine, betel leaf is considered aromatic, and stimulant in nature, improving appetite, digestion, and acting as a tonic for the brain, heart, and liver. It is also believed to purify blood, relieve thirst, and clear the throat.

In folk medicine, betel leaf is used for the treatment of headache, itching, mastitis, cuts, abrasions, constipation, wounds, burns, eczema, lymphangitis, and respiratory disorders.[7]

CHEMICAL CONSTITUENTS:

Piper betle leaves are rich in volatile oil, commonly known as betel oil, which represents the principal phytochemical constituent of the plant. The essential oil primarily contains phenolic compounds such as betel phenol (chavibetol) and chavicol, which contribute to the characteristic aroma and biological activity of the leaves. An alkaloid, arakene, has also been reported from the leaves and is noted to possess pharmacological properties similar to cocaine. The volatile oil content of the leaf ranges between 0.8 and 1.8% and includes

chavicol, chavibetol, eugenol, allyl pyrocatechol, cineole, caryophyllene, cadinene, menthone and other terpenes, [8]

The chemical composition of the essential oil varies among different plant parts and developmental stages. Safrole has been identified as a major constituent in the leaf, stalk, stem, and root, whereas β-phellandrene predominates in the fruit.[8]

Phytochemical investigations of *Piper betle* leaves and other plant parts have resulted in the isolation of several bioactive compounds, including hydroxychavicol, allyl pyrocatechol, chavibetol and its acetate derivatives, piperbetol, methylpiperbetol, piperol A, and piperol B. Analysis of the essential oil and ether-soluble fractions revealed fourteen components, among which chavibetol and chavibetol acetate were the major constituents. Minor components included allyl pyrocatechol diacetate, methyl eugenol, eugenol, α-pinene, β-pinene, limonene, safrole, and 1,8-cineole.[9]

The plant also contains various aliphatic compounds, sterols, triterpenoids, and flavonoid derivatives, including ursolic acid, β-sitosterol, stigmasterol, piperlonguminine, and allyl pyrocatechol derivatives. [8]

PHARMACOLOGY STUDY:

Antimicrobial Properties:

Betel leaf (*Piper betle* L.) had shown powerful antimicrobial activity due to present in the bioactive compounds such as chavicol, chavibetol, allyl pyrocatechol, chavibetol acetate. These compounds inhibit a wide range of pathogenic microorganisms, including *Escherichia coli*, *Streptococcus pyogenes*, Pseudomonas *aeruginosa*, *Staphylococcus aureus*, and *Proteus vulgaris*, the high concentrate of phenolic content of ethanolic and methanolic extracts showed enhances their antioxidant and antimicrobial potential. [1]

Antifungal Properties:

The leaves of *Piper betle* exhibit broad-spectrum antifungal activity against *Microsporum*, *Candida, aspergillus*, *Trichophyton*, mainly due to phenolic compounds like eugenol and chavicol. [9]

Antidiabetic activity:

Spray-dried powder of *Piper betle* has demonstrated significant antidiabetic activity in diabetes mellitus patients. Its use as a nutraceutical was found to be effective in the management of type 2 diabetes, indicating the therapeutic potential of *Piper betle* as a natural adjunctcontrol .[3]

Antioxidant activity:

The leaves of *Piper betle* (Hot water and cold ethanolic extracts) exhibit strong antioxidant activity, with effective free-radical scavenging that remains stable over time.[3]

Oxidative and anti-hemolytic activities:

The aqueous extract of fresh *Piper betle* leaves shows significant antioxidative and anti-hemolytic properties, as well as antimicrobial activity against pathogens such as *Staphylococcus aureus*, *Streptococcus pyogenes*, *Pseudomonas aeruginosa*, and *Escherichia coli*. This effectiveness is due to the synergistic effects of flavonoids and polyphenolic compounds. [3]

Analgesic and anti-inflammatory activities:

The hydroalcoholic extract of *Piper betle* leaves (HEPBL) exhibited significant analgesic and anti-inflammatory activities in experimental animal models. Analgesic effects were observed at doses of 100 and 200 mg/kg, while anti-inflammatory activity was significant at 50, 100, and 200 mg/kg using standard *in vivo* models. These activities are attributed to phytoconstituents such as flavonoids, tannins, phenols, and glycosides. [10]

Anti-cancer activity:

Reactive oxygen species (ROS) play a dual role in cancer by causing DNA damage and also promoting apoptosis. Among the Piperaceae family, *Piper betle* demonstrates exceptional antioxidant and anticancer properties. Its ethyl acetate extract exhibits cytotoxic effecs on MCF-7 cells, while hydroxychavicol inhibits the proliferation of PC-3 cells and triggers ROS-dependent apoptosis, with effects that depend on the dosage.[11]

Anti-hypertensive activity:

Betel leaves display anti-hypertensive and cardioprotective properties by enhancing lipid profiles. Research has indicated that they lower total cholesterol, triglycerides, LDL, and VLDL levels while boosting HDL cholesterol. These impacts are primarily linked to eugenol, which functions as a natural antioxidant, inhibits liver cholesterol production, and decreases the absorption of lipids in the intestines. As a result, improved LDL breakdown and increased bile acid secretion contribute to the overall cholesterol-lowering effects of *Piper betle* . [12]

Protozoal diseases:

Research has shown that *Piper betle* has notable antiprotozoal effects against *Giardia lamblia*, *Leishmania donovani*, *Entamoeba histolytica*, and malaria-causing parasites. These results emphasize the possible therapeutic significance of *Piper betle* in treating protozoal infections. [13]

Antifertility activity:

Betel leaf extract reduces fertility by altering the pituitary-gonadal axis and compromising estrogen balance. Female rats with ovarian abnormalities demonstrated lower gonadotropin release, reproductive organ weight, and estrogen levels. Serum glucose, cholesterol, and vitamin C levels indicate that estrogen production is reduced. These reversible antiestrogen actions emphasize its medicinal importance . [14]

Immunomodulatory activity:

Piper betle leaf methanolic extract significantly modulates cellular immunological responses, nitric oxide production, interferon-γ receptor expression, and lymphocyte proliferation both in vitro and in vivo. Immunosuppressive potential is suggested by dose-dependent decrease of lymphocyte proliferation and antibody titer, suggesting potential use in cancer treatment and autoimmune illnesses. [14]

ECONOMIC IMPORTANCE:

In the Global market, the economic importance of betel leaf is largely influenced by the form and quality of its products. Betel leaf is marketed in various formulation forms as like powders, oils, capsules, pharmaceuticals, oral-care products, cosmetics, and food supplements. India exports betel leaves and its related products to countries including Bangladesh, Pakistan, Malaysia, Indonesia, generating foreign money. [15,16]

CONCLUSION:

The plant *Piper betle* L. is a considerable of ethnopharmacological, nutritional, and economic importance, supported by its high rich phytochemical constituent's. In Traditional medical systems such as Ayurveda, Unani, Siddha and various folk practices have long utilized betel leaf for the management of infections, inflammatory conditions, metabolic disorders, and oral health problems. Modern scientific studies shows that the plant possesses antimicrobial, antifungal, antioxidant, antidiabetic, anti-inflammatory, analgesic, antiallergic, anticancer, antihypertensive, and antilarval activities. These effects are largely attributed to phenolic compounds including chavibetol, chavicol, eugenol, hydroxychavicol, along with terpenoids, flavonoids and sterols.

The plant *Piper betle* is used in different sectors like pharmaceuticals, nutraceuticals, cosmetics, oral-care formulations, and functional foods.

Economically, *Piper betle* represents an important cash crop in South and Southeast Asia, contributing significantly to rural livelihoods and export markets. However, challenges related to cultivation practices, post-harvest handling, price fluctuations, and sustainability necessitate the development of improved agronomic techniques, standardized quality control, and regulated marketing systems. Future research should emphasize clinical validation of pharmacological claims, elucidation of molecular mechanisms of action, toxicity and safety profiling, and development of standardized extracts and formulations.

Overall, *Piper betle* L. stands as a promising natural resource with immense potential for integrated industrial and therapeutic exploitation. Harnessing its traditional knowledge base alongside modern scientific validation can facilitate the development of novel, safe, and effective products, thereby reinforcing its role in global healthcare and bio-based industries.

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