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Bioactive Compounds Of E. Alba And Their Role In Microbial Pathogen Control.

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ABSTRACT: Eclipta alba has been traditionally used in folk remedy, both Ayurveda and Siddha. The herb Eclipta alba contains many bioactive components such as coumestans i.e. wedelolactone and demethylwedelolactone, triterpenes, flavonoids, steroids, polypeptides, polyacetylenes and thiophene-derivatives. The plant is known to have some important pharmacological activities such as antimicrobial, antinociceptive, analgesic, antinflammatory, antiviral, hepatoprotective, immunomodulatory activity, etc. Traditionally, it is used as an immunomodulator, antioxidant, hair growth promoter, for rejuvenation, dehydration, and skin disorders. The reported uses include anticancer, hepatoprotective, antiulcer, antihyperlipedemic, anthelmintic, anti-inflammatory, analgesic, and antidiabetic activity[1].Th[e traditional knowledge with its holistic and systematic approach supported through experimental base can serve as an innovative and powerful discovery of natural 5α-reductase inhibitor. E. alba shows no signs of toxicity in rats and mice.

INTODUCTON: *E. alba*, commonly known as False Daisy or Bhringraj, is a medicinal plant from the Asteraceae family, widely distributed in warm temperate to tropical regions like India, China, Thailand, and Brazil.[2] *Eclipta alba* extract was evaluated for its antifungal activity in in vitro and in vivo against sorghum fungal pathogens *Fusarium thapsinum, Alternaria alternata, Epicoccum sorghinum,* and *Curvularia lunata*.*E. alba* has been used for the treatment of skin diseases, liver diseases, hair treatment and also as an antimicrobial, analgesic, anti-haemorrhagic, anti-hyperglycemic, and antioxidant agent [3] The safety of *E. alba* extract was confirmed by preclinical toxicology studies using acute oral toxicity, eye irritation tests, and dermal irritation on New Zealand white rabbits and Sprague dawley rats [4]Almost all parts of *E. alba* have been identified with medicinal properties, especially roots were employed as disinfectant for wounds, as laxative and ulcer treatment in livestock. Extract of *E. alba* have been used as tonic for blood vessel clearance in spleen and liver whereas antihepatotoxic activity have previously been reported in various studies to treat liver diseases [5]Shoot extract of *E. alba* was found effective as bronchodilator, anti-inflammatory and antimicrobial agent. *Eclipta alba* extract and its isolates were examined for their ability to inhibit HCV replicase (HCV NS5B) activity *in vitro* and HCV replication in a cell culture system carrying replicating HCV subgenomic RNA replicon.

Phytochemistry: Bioactive compounds

Eclipta alba (L.) contains wide range of active principles which includes coumestans, alkaloids, flavonoids, glycosides, polyacetylenes, triterpenoids. The leaves contain stigmasterol, a-terthienylmethanol, wedelolactone, demethylwedelolactone and demethylwedelolactone-7-glucosid.The roots give hentriacontanol and heptacosanol[44]. The roots contain polyacetylene substituted thiophenes.The aerial part is reported to contain a phytosterol, P-amyrin in the n-hexane extract and luteolin-7-glucoside, P-glucoside of phytosterol, a glucoside of a triterpenic acid and wedelolactone in polar solvent extract. The polypeptides isolated from the plant yield cystine, glutamic acid, phenyl alanine, tyrosine and methionine on hydrolysis. Nicotine and nicotinic acid are reported to occur in this plant.The bioactive compounds included in *E. alba* may differ depending on the environment, location of the sources, time of harvest, and period of storage [+++7]Inaddition, secondary metabolism, responsible for the synthesis of therapeutic phytochemicals in medicinal plants, is influenced by environmental and cultivation conditions. Consequently, these factors collectively contribute to the distinctive chemical profiles observed in *E. alba*.[8]

3 Evidence for Antimicrobial / Antifungal / Antiviral Activity

Eclipta alba is commonly known as Bhringaraja belonging to the Asteraceae family. The whole plant parts are used as hepatoprotective [9]

In the research of antimicrobial disease, understanding the disease mechanism and then selecting an appropriate protein structure to begin the drug design pipeline are essential, as it can explain the critical parameters required to clarify the action of bound ligands, which are drugs that can selectively inhibit the activity of the 3-hydroxydecanoyl-acyl carrier protein dehydratase (FabA) [10]

E. alba causes the disruption of the bacterial cell membrane which leads to the loss of bacterial cell viability.

4.Antifungal / agricultural pathogens

The current study was intended to explore the antifungal potential of *E. alba* in vitro on economically destructive sorghum grain mold pathogens, such as *F. thapsinum, A. alternata, E. sorghinum,* and *C. lunata*. We have also evaluated the effect of *E. alba* extract treatment on in vitro germination and seedling emergence in vivo, and disease incidence and growth parameters under greenhouse conditions. Further, the phytochemicals in antifungal fractions of *E. alba* extract were characterized by ultra-performance liquid chromatography (UPLC) coupled triple quadrupole mass spectrometry (UPLC-MS/MS) and ^{1}H-NMR.

3.4 Summary of pathogen-control potential

In summary, *E. alba* shows:

- Broad antibacterial potential (Gram-positive, Gram-negative, some resistant strains)
- Antifungal potential, including agricultural plant pathogens
- Some antiviral/anti-oomycete evidence
- Potential application not only in human pathogens but also in crop/plant pathogen control.
- **4. Mechanisms of action**
- While detailed mechanistic work is limited, several plausible mechanisms have been proposed based on compound class and experimental observations.

4.1 Membrane/cell wall disruption

Saponins (e.g., eclalbasaponin II) are amphiphilic and can insert into microbial membranes or cell walls, leading to increased permeability or lysis. In the antifungal sorghum-pathogen study, saponins along with wedelolactone were implicated in loss of pathogen cell viability. *E. alba* causes disruption of microbial cell membrane resulting in loss of microbial cellviability[11]

Saponin fractions of leaves of the plant exhibited antifungal potential against Aspergillus niger, Aspergillus fumigatus, Alternaria spp., Trichoderma spp and Aspergillus flavus. Hexane, ethyl acetate and ethanolic extracts of plant showed antifungal activities against Trichophyton mentagrophytes

4.2 Modulation of oxidative stress / host immune enhancement

- in fish, marked by a significant decrease in cortisol and elevated levels of superoxide dismutase (SOD) and catalase (CAT) levels in treated animals, as compared with the controls. We further demonstrated that the *A. invadans*-protective effect of methanolic leaf extract was caused by its immunomodulatory effect and is linked to the enhanced survival of fingerlings.
- NF-κB-mediated transcription, indicating that

wedelolactone is an inhibitor of IKK, whose activation is a critical step to activate NF-κB[12]

- **Proposed schematic**
- In essence: bioactive compounds from *E. alba* → interact with microbial membranes/enzymes/adherence factors + modulate host immunity/oxidative stress → reduction of microbial growth/infection.

5. Applications and prospects

5.1 Human health – antimicrobial agents

Given the promising antibacterial, antifungal and antiviral data, *E. alba* (or its purified compounds) could be explored as:

- Lead compounds for new antimicrobial drug development
- Adjunctive therapies (e.g., extracts or enriched fractions in synergy with existing antibiotics)
- Topical formulations (for skin/wound infections) given traditional usage
- Alternative/adjunct antiviral strategies (though still early)

5.2 Agricultural/plant pathogen control

This plant extract has been reported to possess immunostimulatory properties and reported to enhance the phagocytic index, antibody titer, and WBC count in higher vertebrates. Interestingly, the *E. alba* extract has shown promising results in aquaculture animals.

The ability to stimulate the defense system of vertebrates is considered to be central to controlling the pathogenesis of many microbial pathogens

Applications and Potential Development

 Herbal antimicrobial formulations: Standardised extract of *E. alba* could be developed into topical antimicrobials (skin/wound infections) or oral prophylactics (e.g., mouthwash) given its antibacterial/antifungal effects.

 Agricultural biocontrol: As seen in the sorghum pathogen study, *E. alba* methanolic extract reduced disease incidence in greenhouse/field trials. Thus, it could be developed as a botanical fungicide or seed treatment. **Synergistic adjuncts with conventional drugs**: Combining *E. alba* extracts with existing antibiotics may reduce required doses and delay resistance.

 Natural preservatives: The antibacterial/antifungal properties might permit use of *E. alba* extracts in food/ cosmetic preservation

Gaps in Current Research / Future Directions

- More studies on **minimum inhibitory concentration (MIC)/minimum fungicidal concentration (MFC)** for human pathogens (especially fungi like *Candida*, *Aspergillus*, and bacteria including MDR strains) are needed.
- Systematic correlation of chemical profile (via HPLC/GC-MS) with antimicrobial potency of *E. alba* extracts/fractions.
- Mechanistic work: e.g., transcriptomic/metabolomic profiling of microbes treated with *E. alba* extracts.
- Evaluation of **synergy** between *E. alba* extracts and commercial antimicrobials (antibiotics/antifungals).
- In vivo or ex vivo studies (animal models, wound models) of antimicrobial/antifungal effect of *E. alba*.
- Toxicology and safety: long-term toxicological, cytotoxicity studies to ensure safe use.

- Exploration of antiviral and antiparasitic potential (less well studied for *E. alba*).
- Industrial-scale extraction, formulation, stability studies.

Conclusion

- *Eclipta alba* emerges as a promising medicinal plant with a rich array of bioactive compounds—coumestans, saponins, flavonoids, among others—with documented antibacterial and antifungal activities against a variety of pathogens. this plant offers multiple research avenues—from phytochemical isolation and antimicrobial assays, to mechanistic studies and formulation development. With careful standardisation and safety evaluation, extracts or compounds from *E. alba* could contribute to novel antimicrobial therapies or biocontrol agents. Continued interdisciplinary research (phytochemistry + microbiology + formulation science) will be key to unlocking its full potential.

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