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AN IN-DEPTH REVIEW OF HYGROPHILA AURICULATA (SCHUMACH.) HEINE.

Botany

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ABSTRACT

Hygrophila auriculata (Schumach.) Heine., a medicinal herb widely used in Ayurveda and folk medicine, has garnered attention for its diverse pharmacological properties. Native to the Indian subcontinent, this plant is traditionally used to treat jaundice, inflammation, diabetes and kidney disorders. Rich in phytochemicals such as flavonoids, alkaloids, saponins, terpenoids and phenolics, it exhibits a broad spectrum of biological activities. This review critically evaluates the phytoconstituents and pharmacological effects of *H. auriculata*, highlighting antioxidant, antimicrobial, antihyperglycemic, nephroprotective and anticancer properties, as well as its emerging role in green nanotechnology. Gaps in current research and future directions for therapeutic exploitation are also discussed.

KEYWORDS

Hygrophila auriculata, Phytochemicals, Pharmacological properties, Nephroprotective effects, Green nanotechnology.

INTRODUCTION

Medicinal plants have long been central to traditional healthcare, offering remedies for various ailments and serving as a basis for modern drug discovery. *Hygrophila auriculata* (Schumach.) Heine. (syn. *Hygrophila spinosa*), from the family Acanthaceae, is one such plant of significant ethnopharmacological value. Known as "Neermulli" (Tamil), "Kulekhara" (Bengali) and "Ikshura" (Sanskrit), it is distributed across India, Bangladesh, Sri Lanka and Southeast Asia[22].

Traditionally, roots, seeds and leaves are used to treat inflammation, liver disorders, urogenital issues and general debility[5]. The plant is also revered in Ayurveda for its rejuvenating ("Rasayana") properties[9]. Recent research has identified a range of bioactive compounds, including betulinic acid, apigenin, stigmasterol, lupeol and caffeic acid derivatives, which underpin its therapeutic potential[19]. Modern studies confirm its antioxidative, anti-inflammatory, antimicrobial, antidiabetic, nephroprotective and anticancer activities[8].

PHYTOCHEMICAL CONSTITUENTS

H. auriculata (Schumach.) Heine. is a reservoir of diverse phytochemicals that contribute to its pharmacological efficacy. Major classes identified in various plant parts include alkaloids, flavonoids, phenolic acids, saponins, steroids, terpenoids and tannins[7].

ALKALOIDS AND STEROIDS

Alkaloids such as asteracanthine and asteracanthicine exhibit diuretic and aphrodisiac properties[25]. Steroidal compounds like stigmasterol and β-sitosterol are linked to anti-inflammatory and cholesterol-lowering effects[16].

FLAVONOIDS AND PHENOLIC COMPOUNDS

Flavonoids (apigenin, luteolin, quercetin) are prominent, known for antioxidant, anti-inflammatory and anticancer activities[25]. Phenolic acids (gallic, caffeic, ferulic) contribute to free radical scavenging[11].

SAPONINS AND TANNINS

Saponins, mainly in methanolic extracts, enhance immune response and show antimicrobial properties[7]. Tannins, identified via phytochemical screening, contribute to antimicrobial and wound-healing effects[17].

TERPENOIDS AND ESSENTIAL OILS

Terpenoids such as lupeol and betulinic acid, isolated from leaves and roots, show anticancer and hepatoprotective effects[19]. Essential oils contain mono and sesquiterpenes, though detailed profiling is limited[7].

OTHER BIOACTIVE CONSTITUENTS

Recent studies report novel aliphatic esters and diterpenes with cytotoxic activity[4] and phytoconstituents capable of mediating green synthesis of nanoparticles[13].

METHODS OF ANALYSIS

Phytochemical analysis employs TLC, HPLC, GC-MS and UV-Vis spectroscopy for compound isolation and structural elucidation[24].

TABLE-1
MAJOR PHYTOCHEMICAL COMPOUNDS IDENTIFIED

Phytochemical group	Key Compounds Identified	Reported Biological Activities
Alkaloids	Asteracanthine, Asteracanthicine	Diuretic, aphrodisiac
Steroids	Stigmasterol, β-sitosterol	Anti-inflammatory, cholesterol-lowering
Flavonoids	Apigenin, Luteolin, Quercetin, glycosides	Antioxidant, anti-inflammatory, anticancer
Phenolic Compounds	Gallic acid, Caffeic acid, Ferulic acid	Free radical scavenging (antioxidant)
Saponins	Not specified	Immunomodulatory, antimicrobial
Tannins	Not specified	Astringency, antimicrobial, wound healing
Terpenoids	Lupeol, Betulinic acid	Anticancer, hepatoprotective
Essential oils	Mono- and sesquiterpenes (general)	Not fully profiled; some reported bioactivity

Other Bioactive Constituents	Aliphatic esters, diterpenes, nanoparticle-mediating agents	Cytotoxic activity, green synthesis of nanoparticles

PHARMACOLOGICAL ACTIVITIES

ANTIOXIDANT ACTIVITY

Oxidative stress is implicated in many chronic diseases. Methanolic and aqueous extracts show strong DPPH radical scavenging, FRAP and lipid peroxidation inhibition[3]. Total phenolic and flavonoid content correlates with antioxidant capacity[12]. In vivo, extracts increase catalase, superoxide dismutase and glutathione peroxidase activity in liver tissues[27].

ANTIMICROBIAL ACTIVITY

Methanolic and ethanolic extracts exhibit broad-spectrum antibacterial and antifungal activity, notably against *Staphylococcus aureus, Escherichia coli and Aspergillus species*[26,7]. The activity is attributed to flavonoids, saponins and essential oils[20].

ANTIHYPERGLYCEMIC AND ANTIDIABETIC ACTIVITY

Experimental studies in diabetic models show significant antihyperglycemic effects[7]. Oral administration of dried flower powder reduces alloxan-induced blood glucose in rats[2].

ANTI-INFLAMMATORY AND ANALGESIC ACTIVITY

Root and leaf extracts show anti-inflammatory activity in carrageenan-induced paw edema and cotton pellet-induced granuloma models[1]. Analgesic effects are observed in acetic acid-induced writhing and hot-plate models[21].

NEPHROPROTECTIVE EFFECTS

Methanolic extracts reverse gentamicin and cisplatin-induced nephrotoxicity in rats, restoring serum creatinine, urea and electrolyte balance[14]. Histopathology confirms renal tissue repair.

HEPATOPROTECTIVE AND CARDIOPROTECTIVE ACTIVITIES

Extracts normalize liver enzyme markers and lipid profiles in models of CCl_4- and paracetamol-induced liver injury[6,10]. Cardioprotective effects are observed in doxorubicin-induced cardiotoxicity models[15].

CYTOTOXIC AND ANTICANCER PROPERTIES

Methanolic extracts show cytotoxicity against breast and liver cancer cell lines, likely due to apigenin and betulinic acid[19]. Silver nanoparticles synthesized from leaf extracts exhibit selective cytotoxicity[13].

TABLE-2 SUMMARY OF PHARMACOLOGICAL ACTIVITIES

Pharmacological Activity	Extract/Constituents	Key Findings & Mechanisms
Antioxidant	Methanolic, aqueous extracts; flavonoids, phenolics	Strong DPPH, FRAP, lipid peroxidation inhibition; high TPC/TFC correlates with antioxidant capacity; in vivo increases in catalase, SOD, GPx
Antimicrobial	Methanolic, Ethanolic, Butanol Extracts; Flavonoids, Saponins, Essential Oils	Broad-spectrum antibacterial (e.g., S. aureus, E. coli, B. subtilis, P. aeruginosa); antifungal (Aspergillus spp., Trichoderma); MIC as low as 0.125 µg/mL
Antihyperglycemic/ Antidiabetic	Dried flower powder, methanolic extract	Significant reduction in blood glucose in diabetic rats; mechanisms: increased glucose uptake, α-glucosidase inhibition
Anti-inflammatory/ Analgesic	Root, leaf extracts	Reduced paw edema, granuloma; analgesic in writhing and hot-plate models; dose-dependent, comparable to NSAIDs
Nephroprotective	Methanolic leaf extract; flavonoids, triterpenoids	Reversed gentamicin/cisplatin nephrotoxicity; restored serum markers; renal tissue repair
Hepatoprotective /Cardioprotective	Methanolic, n-butanol extracts	Normalized liver enzymes, bilirubin, lipid profiles; reduced cardiac mortality and improved markers in doxorubicin models
Cytotoxicity/ Anticancer	Methanolic extract, AgNPs; apigenin, betulinic acid	Cytotoxicity against breast/liver cancer cell lines; AgNPs from extracts selectively toxic to cancer cells

GREEN SYNTHESIS OF NANOPARTICLES IN NANOTECHNOLOGY

H. auriculata (Schumach.) Heine. extracts are used for green synthesis of silver, zinc oxide and iron oxide nanoparticles, leveraging phytochemicals as reducing and capping agents[13]. Characterization confirms spherical nanoparticles[23]. Green-synthesized nanoparticles show potent antibacterial, antifungal, antioxidant and cytotoxic effects. They offer promise for enhanced drug delivery and reduced toxicity.

FUTURE POTENTIAL

Further research is needed on nanoparticle-based drug delivery systems and hybrid therapeutics.[13]

TOXICOLOGICAL STUDIES AND SAFETY PROFILE

Despite extensive traditional use, comprehensive toxicological evaluations are limited. Acute and sub-chronic toxicity studies in rodents indicate a high safety margin for aqueous and methanolic extracts at therapeutic doses, with no significant adverse effects observed[6].

CONCLUSION

Hygrophila auriculata (Schumach.) Heine. is a promising medicinal plant with a diverse phytochemical profile and multiple pharmacological activities. Its applications in traditional medicine are supported by modern research and its potential in nanomedicine is emerging. Future research should focus on clinical trials, molecular mechanisms and the development of standardized, safe and effective formulations.

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