https://doi.org/10.48047/AFJBS.6.Si4.2024.2097-2106

African Journal of Biological Sciences

Insights in Medicinal Value of Aquatic Plants Eichhornia Crassipes, Ipomoea Aquatica, and Hydrilla Verticillata: Potential Therapeutics in Drug Design and Discovery

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Article History
Volume 6, Issue Si4, 2024
Received: 30 May 2024
Accepted : 15 June 2024
Doi:
10.48047/AFJBS.6.Si4.2024.2097-2106

ABSTRACT

Plants play a pivotal role in human medicine, offering a vast array of bioactive compounds with therapeutic properties. As the main producers in most water habitats, aquatic plants are crucial. Though the aquatic habitat is rich in plant species, little research has been done on their medicinal potential. Some studies studied aquatic flora's ethno-medicinal, economic, and edible functions. Aquatic plants contain unique biological properties that could be used in agriculture, ornamentation, nutraceuticals, horticulture, and medicine. Aquatic plants, such as Eichhornia crassipes, Ipomoea aquatica, and Hydrilla verticillata, possess valuable effects like antimicrobial, antitumor, and antioxidant effects. Despite their potential, aquatic plants have often been undervalued, and more work required to fully explore their medicinal properties in various regions. In this review aquatic plants from India which is calmed to cure various diseases in Indian system of medicine. Moreover, the present review highlights the therapeutic potential of above three aquatic plants, urging researchers to evaluate their medicinal effectiveness and consider their applicability in medical fields.

Keywords: Aquatic plants, Eichhornia crassipes, Ipomoea aquatica, Hydrilla verticillata, Phytochemistry, Therapeutic potential

INTRODUCTION

Plants are rich in bioactive chemicals that treat human illness. Traditional medicine systems have long relied on plants for remedies, and many modern pharmaceutical drugs originate from plant-derived compounds(Prasathkumar et al., 2014). Plants offer immunomodulatory, anti-inflammatory, antimicrobial, and antioxidant effects, combating infections, alleviating inflammation, and protecting against oxidative stress. Herbal medicine and phytotherapy utilize plant-based preparations for various health conditions, while plant-based diets provide essential nutrients for overall wellbeing(Adegbola et al., 2017).However, caution is necessary, as not all plants are safe or effective, and scientific research and clinical trials are essential to validate plant-based treatments under professional guidance(Parveen et al., 2015).

Aquatic plants with medicinal value play animportant role in traditional and modern medicine, as they contain bioactive compounds like alkaloids, flavonoids, and polyphenols, offering benefits as

antimicrobial, antioxidant and anti-inflammatory effects(Arya et al.,2022).These plants have been used for generations in traditional healing systems and are being researched for their potential to treat various diseases. They show promise in wound healing, gastrointestinal, respiratory, and cardiovascular health, liver protection, urinary tract health, pain management, and even potential anticancer effects (Shedoeva et al.,2019). However, caution and further scientific investigation are necessary to ensure safe and effective use, and consultation with healthcare professionals is essential when considering their medicinal applications (Alotaibi et al.,2017).
Hydrilla verticillata (Hydrilla) is an aquatic weed with a potential medicinal value. While it is considered problematic in some areas due to its aggressive growth, it contains phytoconstituents as flavonoids, terpenoids and alkaloids. These shows diverse properties like antimicrobial, antiviral, antifungal, and antioxidant properties(S PP et al.,22).Ponds, lakes, channels, wetlands, and rivers all have aquatic plants. They are typically considered weeds and unproductive. India has several aquatic plant species, however medical research is few. This review illuminates the therapeutic potential of commonly available aquatic plants in different regions of India, providing valuable insights for researchers assessing the medicinal efficacy of these plants and their extracts or isolated components(Sharifi-Rad et al.,2018).

Eichhornia Crassipes

Phytochemistry of plants

Flavonoids: Flavonoids are phenolic chemicals found abundantly in plants; they are bioactive and have several medicinal applications (Jayanthi et al.,2011,Nyananyo et al.,2007) (Table 1).

Alkaloids: Alkaloids are nitrogen-containing compounds found in many plants. Water hyacinth has been reported to contain alkaloids, but their specific types and potential effects on human health are still being studied.Alkaloids were found in waterhyacinth phytochemically (Lata et al.,2010,Muthunarayanan et al.,2011, Jayanthi et al,2011). TLC qualitative separation of alkaloids showed that the shoot and rhizome contain cytisine and tomatine, whereas the shoot includes codeine, thebaine, and quinine and the rhizome nicotine (Lata et al.,2010).

Glycosides: Glycosides consist of a glucose unit attached to an aglycone. Several glycosides are used therapeutically, while others are recognised to have pharmacological properties with extraordinary therapeutic promise. Waterhyacinth stigmatic exudates contain soluble free fatty acids,fructose, sucrose andsugars (Kandasamy et al., 1983,Ahmed et al.,1982) Waterhyacinth heteropolysaccharide contains D-xylose, L-galactose, and Larabinose (Muthunaravanan et al.,2011).

Tannins: Tannins are astringent polyphenolic chemicals. They may aid water hyacinth's therapeutic properties.

Phenolic Compounds: Phenolic compounds have the potential to replace bioactive agents in the pharmaceutical and medical industries, where they can be used to improve health, prevent disease, and treat existing conditions. Pyrogallol, 4-methylresorcinol, catecho, 2-methylresorcinol, and resorcinol are some of them. E. crassipes leaf, petiole, and flower extracts contained numerous phenolic acids. caffeic, salicylic acids, gentisic, p-hydroxybenzoic, chlorogenic, p-coumaric, vanillic, ferulic, syringic, protocatechuic, and gallic (Lata et al.,2010,Ahmed et al.,1982; Surendraraj et al.,2013).

Terpenoids:Squalene, a hypo-cholesterolemic terpenoid, was found in E. crassipes plant(FiletoPerez et al.,2015). Only Mexican plants contain this chemical. Lenora et al.'s GC-MS analyses (Lenora et al.,2017) found camarolide, a pentacyclic triterpenoid, in the aerial plant's methanol extract.

Therapeutic importance

South American water hyacinth is now distributed worldwide. Water hyacinth, which grows quickly and chokes water bodies, has various therapeutic and useful uses:

Phytoremediation: Water hyacinth is known for its ability to absorb and accumulate pollutants from water bodies. It is used in phytoremediation processes to remove excess nutrients, other contaminants and heavy metals from polluted waters, thus helping to improve water quality.

Wastewater Treatment: Due to its high rate of nutrient uptake, water hyacinth can be used as an efficient and cost-effective method for treating wastewater. It helps in reducing nutrient loads and improving the overall health of aquatic ecosystems.

Table 1 - Studies based on Eichhornia crassipes

Title	Parts	Solvent	Findings	Reference
Anti-Inflammatory Activity of Eichhornia crassipes	Root	Ethyl acetate and water	Evidence of the extracts' potent pain-relieving properties comes from the percentage inhibition they elicit from anti-inflammatory action.	Jayanthi et al., 2016
Antimicrobial activity of Eichhornia crassipes	Leaves	Acetone, ethyl acetate, ethanol, n-Butyl alcohol and methanol	The infections found in chicken were significantly reduced by the n-Butyl alcohol extract, one of six extracts that were evaluated.	Kayathri et al., 2015
Antibacterial activity of Eichhornia crassipes	Leaves	Ethanol	Potentially useful medicinally due to their antimicrobial characteristics, the phytochemical substances are also powerful inhibitors of the AprX enzyme.	Kumar et al., 2018
Antifungal, antimicrobial activities of Eichhornia crassipes	Leaves	Acetone, ethanol, methanol and n-Butyl alcohol	The most effective antifungal and antimicrobial agent against some plant pathogens was the n-Butyl alcohol extract.	Haggag et al., 2017
Cytotoxic and antioxidant properties of water hyacinth against cancer cell	Leaves	Methanol	There are a variety of chemicals, including alkaloids and terpenoids, which have distinct antioxidant and anticancer effects.	Aboul-Enein et al., 2010
Antimicrobial activity of Eichhornia crassipes	Leaves	Ethanol, methanol and water	The plants extracts of Eichhornia crassipes has potent antimicrobial activity against pathogens.	Joshi et al., 2013
Aanticancer activity of Eichhornia crassipes	leaves, roots and stems	Ethanol, methanol and water	All plant parts showed anticancer property.	Mtewa et al., 2018
Antioxidant activity of Eichhornia crassipes	Leaves, petiole, root	Methanol	All plant parts showed antioxidant property.	Tulika et al., 2017

Ipomoea Aquatica

Phytochemistry of plants

Ipomoea aquatica is a green vegetable grown in various Asian nations. It's a Convolvulaceae plant with excellent nutritional value. Ipomoea aquatica phytochemical contents have been studied in various phytochemistry research (Table 2).

Polyphenols: Ipomoea aquatica contains flavonoids phenolic acids, and tannins. Antioxidant polyphenols protect the body against oxidative stress (Anonymous et al.,1959).

Carotenoids: Carotenoids are pigments responsible for the bright colors in fruits and vegetables. Ipomoea aquatica contains carotenoids like β-carotene, lutein, and zeaxanthin. These compounds act as antioxidants and are essential for maintaining eye health(Prasad et al.,2005).

Alkaloids: Some studies have reported the presence of alkaloids in I aquatica. Alkaloids are nitrogenous compounds found in many plants, and their presence in water spinach may contribute to its potential pharmacologic properties. β carotene,glutamine, β-sitosterol and alanine, hentri-acontane were identified in I. aquatica(Tofern et al.,1999).

Therapeutics potential

Many Asian countries eat water spinach, also known as Chinese spinach, a semi-aquatic plant. Ipomoea aquatica has medicinal and culinary purposes. Ipomoea aquatica has therapeutic benefits:

Rich in Nutrients:Water spinach is full of vitamins (A, C, K, and B vitamins) and minerals (iron, calcium, magnesium, and potassium). Water spinach is a healthy addition to a balanced diet(Candlish et al.,1987).

Antioxidant Properties:The body can scavenge free radicals with antioxidants, and it has been hypothesised that this ability is one of the factors that contributes to the preventive impact of plant-based meals against diseases such as type 2 diabetes, cardiovascular disease, and cancer.

Anti-inflammatory Effects:Inflammation is the body's normal defensive reaction to harmful substances and unpleasant experiences. Many undesirable consequences are linked to the use of the medications used in conventional anti-inflammatory treatment. The use of therapeutic herbs has historically been accepted as safe and cheap.

Table 2 - Studies related to Ipomoea aquatica (Water Spinach)

Title	Parts	Solvent	Findings	References
Nutritional and medicinal properties of Ipomoea aquatica	-	-	I. aquatica was nutritional plants and useful in malnutrition.	Gangopadhyay et al., 2021
Antioxidant and hepatoprotective potential of Ipomoea	Whole Plant	Ethanol	One possible explanation for I. aquatica's preventive action against TAA-induced liver damage is that it modulates detoxifying enzymes and has antioxidant and free radical scavenging	Alkiyumi et al., 2012

aquatica			properties.	
Antidiabetic activity of Ipomoea aquatica	Whole Plant	Methanol	When administered orally to rats with diabetes, fractions IA6-1 and IA9-2 shown promising antidiabetic benefits.	AB et al., 2017
Potential wound healing activity of Ipomoea aquatica	Leaves	Ethanol	I. carnea leaves possess wound healing effects.	El-Sawi et al., 2017
Assessment of antimicrobial activity of Ipomoea aquatica	Leaves	Ethanol & Aqueous	The plants shows potent inhibitor against the aquatic microbes.	SAPTIANI et al., 2016
Antioxidant activity of Ipomoea aquatica	Whole Plant	Hexane & Methanol	Ipomoea aquatica has potential antioxidant activity.	Shah et al., 2021
Evaluation of diuretic activity of Ipomoea aquatica	Whole Plant	Methanol	The amount of urine and electrolyte excretion were both enhanced to a greater extent than with fursemide, the gold standard diuretic.	Mamun et al., 2003
Neuroprotective effects of Ipomoea aquatica	Leaves	Alcohol	Ipomoea aquatica demonstrated a significant activity at 400 mg/kg.	Dwivedi et al., 2023

Hydrilla verticillata

Phytochemistry of plants

Flavonoids: Hydrilla verticillata has been reported to contain various flavonoids, such as apigenin, luteolin, quercetin, and kaempferol. Flavonoids are known for their antioxidant properties and may have potential health benefits(Tubac et al.,2005) (Table 3).

Tannins:Hydrilla verticillata has been found to contain tannins, which are polyphenolic compounds known for their ability to bind and precipitate proteins. Tannins may play a role in the plant's defence mechanisms(Manna et al.,1999).

Saponins: Saponins are glycosides with a soap-like structure (Boyd et al.,1969).

Terpenoids:Hydrilla verticillata contains terpenoids, which are a diverse group of natural compounds. Some terpenoids may have biological activities and contribute to the plant's defence against herbivores and pathogens(Easely et al.,1974).

Sterols: Sterols, such as β-sitosterol, are lipid-based compounds found in plants (Aquat et al.,1997). Theyhave structural and physiological roles in the plant.

Alkaloids: Some studies have reported the presence of alkaloids in Hydrilla verticillata. It contains antioxidants, saponin, amino acids, β-carotene, polysaccharides, detoxifying agents, micro and macronutrients.

Therapeutic potential

Some potential pharmaceutical applications and investigations have been explored, particularly related to its phytochemical composition and biological activities. Here are some areas of pharmaceutical interest related to Hydrilla verticillata:

Wastewater Treatment: Hydrilla verticillata has been used in phytoremediation to treat polluted water bodies. Its ability to absorb and accumulate nutrients, heavy metals, and other contaminants from water makes it a useful tool in improving water quality and restoring ecosystems(Dhanasekaran et al.,2010).

Bioenergy Production: Hydrilla verticillata fast growth rate and high biomass yield make it a potential feedstock for bioenergy production. It can be used to produce biogas or bioethanol through anaerobic digestion or fermentation processes, contributing to renewable energy sources.

Table 3 – Some of the reported work on Hydrilla verticillata

Title	Parts	Solvent	Findings	References
CNS activities of the aq. Extract of Hydrilla verticillata	Whole Plant	Distilled Water	The aq. Extract enhanced the anticonvulsant activities and reduced different behavioural reflexes. This paper shows that aq. extract of H. verticillata exhibited strong CNS depressant activity.	Zhu et al., 2015; Mahajan et al., 2020
Antioxidant activity of Hydrilla verticillata extracts	Whole Plant	Ethyl Acetate, Petroleum Ether, Choloroform, Benzene, Ethanol & Aqueous	The antioxidant activities of these extracts are closely identical in magnitude and comparable to those of the standard antioxidant compounds used.	Pal et al., 2018
Biogas production from Hydrilla verticillata biomass	–	–	The authors provided an overview of the development, harvest, and management of H. verticillata, as well as its contemporary uses and applications.	Jain et al., 2019
Nutritional evaluation of Hydrilla verticillata	–	–	This micronutrients possess good nutritive value.	AB et al., 2017
Antimicrobial activity of Hydrilla verticillata extracts	Whole Plant	Hexane & Methanol	There were phytoconstituents such as alkaloids, saponins, tannins, steroids, flavonoids, glycosides, triterpenoids, and polyphenolic compounds in the n-hexane extract, and there were also phytoconstituents in the methanolic extract of H. verticillata.	Behera et al., 2023
Anti-Adipogenesis Activity of Hydrilla Verticillata	Whole Plant	Ethanol	The aquatic plant H. verticillata has been found to have anti-adipogenesis properties, according to researchers.	Zhen et al., 2020

Conclusion

In conclusion, Eichhornia crassipes, Ipomoea aquatica, and Hydrilla verticillata exhibit promising potential for pharmaceutical and other applications. The abundant availability and diverse properties of these plants make them valuable candidates for sustainable solutions in various fields, including medicine, agriculture, and energy production. This comprehensive review highlights the potential therapeutic applications and other uses of Eichhornia crassipes, Ipomoea

aquatica, and Hydrilla verticillata. These aquatic plants have been studied for their bioactive compounds, medicinal properties, and potential as alternative energy sources and agricultural resources. Further research and exploration are needed to fully understand and harness their therapeutic benefits and other practical applications. It is needed to optimize the processes and enhance its nutrient values for large-scale utilization in agriculture.Overall, these aquatic plants hold promise for pharmaceutical, agricultural, and energy-related applications. However, further work is needed to understand and exploit their therapeutic benefits and practical uses effectively.

Acknowledgements
Authors are thankful to the institute for providing all facilities.

Declarations
Conflict of interest
There is nothing to disclose for this paper.

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