REVIEW ARTICLE

Unveiling the Therapeutic Potential of Caryota Urens: A Comprehensive Review

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ABSTRACT

Caryota urens L., commonly referred to as fishtail palm, is a tropical plant belonging to the Arecaceae family and is indigenous to Southeast Asia. This monocarpic palm is recognized for its distinctive bipinnate leaves and singular trunk. It has been traditionally valued for its therapeutic properties across diverse cultural practices. The various parts of the plant, including its roots, leaves, and fruits, have been employed in traditional medicine to alleviate ailments such as rheumatism, fevers, snake bites, diabetes, and diarrhea. Recent scientific inquiries have underscored the diverse pharmacological activities of *C. urens*, thereby confirming its traditional applications. The plant is replete with bioactive compounds, encompassing flavonoids, phenolic acids, saponins, and tannins, which collectively underpin its therapeutic potential. Noteworthy pharmacological properties are anti-inflammatory, antioxidant, antimicrobial, anti-diabetic, and other activities. *C. urens* exhibits potential for developing novel therapeutic agents, capitalizing on its extensive pharmacological properties and rich traditional medicinal legacy.

Key words: *Caryota urens*, diabetes, fishtail palm, kithul, medicinal plant, pharmacological activities

INTRODUCTION

Plants have long served as the basis for human medicine.[1] Classical examples of therapeutic drugs obtained from natural substances include quinine (from cinchona,[2] digitalis from foxglove,[3] salicylates from willow bark,[4] and ergot alkaloids from contaminated cereals such as rye).[5]

Medicinal plants have been gaining special interest in various diseases, such as diabetes, as an alternative mode of treatment[6-8] due to widespread accessibility, cost-effectiveness,[9] and safety, with minimal adverse effects compared to existing allopathic medicines.[10]

Medicinal plants, the most ancient form of healthcare products, play a crucial role in traditional medicine,[11] offering not only primary healthcare but also serving as pharmaceuticals. Ethnobotanical studies and traditional knowledge are the primary sources of information regarding plant-based drugs.[12]

Throughout the past 5,000 years, plant-based products have played a fundamental role around the world.[13] Ancient texts such as the Rig Veda have documented the use of ayurvedic plants and herbal formulations for treatment purposes. A study conducted by the WHO estimated that approximately 80% of individuals living in developing countries rely primarily on traditional drugs for healthcare.[14]

Different chemicals produced by plants, known as "phytochemicals," have been used as medicines.[15,16] Phytochemicals have been used for curing or managing many diseases, including the prevention of diabetes mellitus and its complications.[17] The traditional medicines are promising candidates,[18] and the research to extract the bioactive compounds has increased worldwide.[19] The traditional medicine industry is undergoing many developments, and the efficacy of medicinal plants is being recognized by more people.[20] Some compounds produced through biosynthetic pathways in the plant possess medicinal properties such as artemisinin (antimalarial),[21] curcumin (anti-inflammatory, anti-allergic, and anticancer),[22] resveratrol (antioxidant),[23] and paclitaxel (anticancer).[24]

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Diabetes mellitus has reached pandemic proportions globally, which requires lifelong treatment with lifestyle modification.[25] Diabetes mellitus is popularly known as diabetes, and the number of people with diabetes in 1980 was 108 million, while this number rose in 2014 to 422 million. Approximately 2 million deaths in 2019 were due to diabetes.[26] It will be the leading cause of mortality globally till 2030.[27] It is chiefly characterized by chronic hyperglycemia due to disturbed insulin secretion and resistance.[28,29] There is altered metabolism of glucose, proteins, and lipids, thus hampering glucose homeostasis.[30] Hyperglycemia causes complications such as diabetic nephropathy, retinopathy, various cardiovascular diseases (CVSs), including coronary heart disease, and lower limb amputation.[31,32] Diabetes is a major cause of these life-threatening diseases.[33]

Allopathic medicines are available for the effective treatment of diabetes; however, higher cost and adverse effects are two big challenges.[30,34] Several unexplored medicinal plants in India may be useful for the management of diabetes.[35] Many plants are described in Ayurveda literature to possess medicinal properties such as hypoglycemic effects. These plants need to be explored more efficiently.[36] With the growing evidence on the effectiveness of medicinal plants for diabetes mellitus, various medicinal plants are found to act by different targets of glucose metabolism, including an increase of glucose transporter type 4 and peroxisome proliferator-activated receptors expression, as well as the blockage of α-glucosidase, and also disrupting advanced glycation end-products formation, and antioxidant activity.[37]

Among these medicinal plants, palm fruits have attracted increasing attention because of their nutritional value and health benefits. They cover a wide range of bioactive compounds, mainly many carotenoids, important vitamins, essential dietary fibers, and particularly utmost importance of polyphenolic compounds.[38]

Kithul palm tree (*Caryota urens* L. family Areacaceae) is an underexplored tree. It is generally found in the Asian part of the continents[39] and reported in Ayurvedic medicine as well. Its synonyms are fish tail, toddy, and jaggery palm.[40]

It is highly prized for its ornamental and economic significance, as well as its diverse pharmacological properties. The various components of the plant have been common to traditional medicinal practices for years. Newer scientific inquiries have confirmed the traditional applications, thereby underscoring the potential of this plant in contemporary pharmacology.

The pharmacological potential of *C. urens* has garnered considerable attention from the scientific community in recent years. This comprehensive review aims to delve into the plant's various properties such as its traditional applications, structural and chemical composition, and the diverse pharmacological activities. By amalgamating traditional knowledge and contemporary scientific discoveries, this article furnishes a thorough overview of *C. urens* and their therapeutic capabilities.

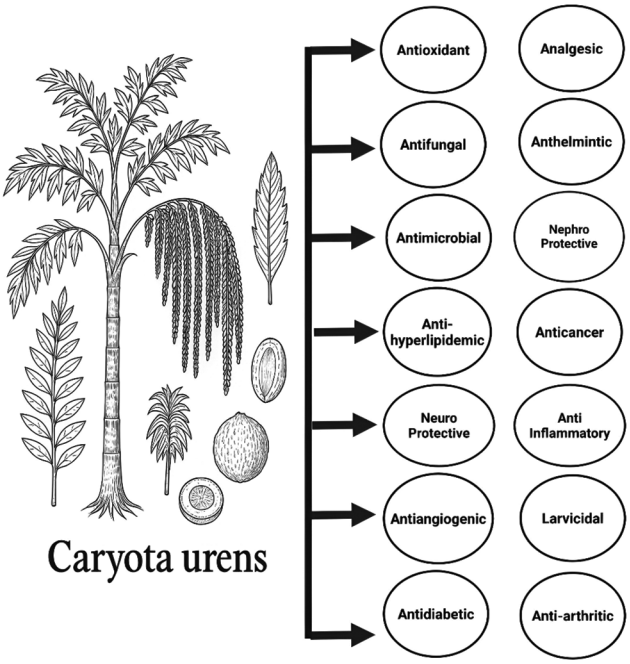
PLANT PROFILE OF *C. URENS*

C. urens is a palm species with substantial potential, despite its infrequent utilization. The Caryota genus encompasses 27 species that are extensively distributed across Asia. This plant exhibits medicinal properties and is employed in diverse treatments within the framework of the Ayurveda system, which is used in the Sri Lankan community.[41]

The nomenclature Caryota originates from the Greek term "karyon," signifying nut, about the fruit's characteristic shape. Conversely, urens originates from the Latin word "urens," meaning stinging and burning, alluding to its irritant properties. Previous research underscores the significance of *C. urens*, featuring promising compounds and pharmacological effects. Caryota trees are nutrient-rich, medicinal plant sources, possessing a range of bioactive constituents and essential components. Primarily prevalent in low-lying tropical Asia, these versatile and underappreciated palms offer medicinal value across all plant components. At present, they are recognized as a significant source for pioneering medicinal remedies against diverse ailments.[42] *C. urens* is a botanical species esteemed for both its ornamental and commercial properties. However, its potential remains underexplored.[12]

CLASSIFICATION OF *C. URENS* L.

Kingdom: Plantae
Sub-kingdom: Tracheobionta
Super-division: Spermatophyta
Division: Magnoliophyta
Class: Liliopsida
Subclass: Arecideae
Order: Arecales



Family: Areceae
Genus: Caryota L.
Species: *C. urens* L.[43]

Local names

- Sopari in Bengali
- Kitul palm, fishtail, toddy, jiggery, and Indian sago in English
- Mari in Hindi
- Mada, dirgha in Sanskrit
- Kitul in Sinhala
- Koondalpanai, konda panna, kundal panai, thippali, tippili in Tamil.[44]

Distribution

The species exhibits a wide distribution range encompassing Assam, Bangladesh, South-Central and Southeast Asia, China, India, Malaya, Myanmar, Nepal, Ogasawara-shoto, and Sri Lanka.[45]

Altitude

The trees thrive at altitudes reaching up to 1400 m above sea level.[46]

Flowering period

The flowering period extends from January to April.[47]

Habitat

The species inhabits both evergreen forests and plain areas.[47]

Trunk and bark

The Caryota Palm (*C. urens*) is an esthetically pleasing palm species capable of reaching a height of 20 m and a diameter of 0.3 m, featuring a sleek, cylindrical, and ringed trunk. Its mature wood exhibits robustness, density, and sustainability, making it suitable for various construction applications, notably in making structures for rafters, rooftops, partitions, fencing, and flooring.[48]

The tree displays a grayish trunk adorned with evenly spaced leaf-scar rings and boasts a 6-m-wide and 6-m-high leaf crown.[49]

Leaves

The bipinnate leaves measure approximately 3–4 m in length and are supported by around 50–60 cm long petioles. It exhibits a vibrant to deep green hue. The obdeltoid pinnae have pointed and jagged edges, extending 30 cm.[49]

The leaflets are wedge-shaped and obliquely truncated at the apex, with a tail-like process extending from the upper margin. The leaf sheaths exhibit a smooth texture and display fibrous netting.[50]

Flowers

The flowers of this plant exhibit monoecious characteristics, indicating the presence of both male and female reproductive structures. The fully developed spadix, reaching several feet in length, gracefully hangs around the palm, thus attracting attention. The tubular spathes, numbering three to five, are characterized by a single-sided split. The numerous flowers are arranged in threes, with the central and lowermost ones being female and developing late, while the side flowers are male.[50]

Each inflorescence comprises a blossom with a six-week lifespan, characterized by a three-meter-long spadix hanging from the tree and giving rise to a cluster of singular, white blossoms. Unisexual blooms within each inflorescence yield between 35000 and 40000 seeds.[51]

These trees are classified as monocarpic, indicating that their life cycle culminates with the flowering and fruiting process, after which the tree perishes.[49]

Male flowers

The male flowers are characterized by three round, heart-shaped sepals that exhibit an imbricate arrangement, signifying overlapping positioning. The petals possess a concave structure, a reddish hue, and a coriaceous texture. The flowers are also adorned with approximately 40 stamens, each featuring short, white filaments.[50]

Female flowers

The female flowers are characterized by broader sepals and shorter, greenish petals. Typically, three staminodes are positioned opposite the sepals. The ovary is superior, three-celled, and contains a single ovule. Furthermore, the stigma is sessile.[50]

Cultivation details

Temperature

The habitats of these plants predominantly exist in moist tropical climates where temperatures generally do not drop below 10°C, and the average annual precipitation exceeds 1,500 mm.[52]

Sunlight

Plants thrive under direct sunlight, yet they exhibit a preference for a moist, shaded environment.[52]

pH

The pH range is around 6–7.5 for this plant. It reaches full maturity within a span of 10–15 years, subsequently producing flowers for an additional 5 years or longer. The average daily yield per tree for sap, utilized in the production of wine and sugar, is approximately 20–27 L.[52]

Flowering

Upon the commencement of the flowering process, the inflorescence is stimulated to exude nectar. The inflorescence is subsequently shaped into a candle-like form and then delicately tapped to extract its alluring nectar, achieved by methodically trimming off the end of the "candle."[52]

Harvesting

The extraction of products is primarily derived from both wild and semi-wild species. Each trunk is almost capable of yielding 100–150 kg of starch and is commonly harvested for timber.[52]

Shape

The morphology of the plant is subject to variation depending on the prevailing growing conditions. Specimens cultivated in arid and infertile soils typically exhibit diminished stature and reduced leaf dimensions. Furthermore, light exposure significantly influences the plant's architecture, as specimens grown in full sun tend to display a more compact form.[46]

Soil

A soil mixture incorporating sand is utilized to facilitate optimal drainage, a crucial requirement as these trees thrives in arid conditions.[53]

Humidity

Fishtail palms necessitate a minimum of 50% humidity to flourish and maintain optimal health.[53]

Phytochemical analysis

The gas chromatography-mass spectrometry analysis confirms the presence of fatty acids, aliphatic and aromatic phenolic and carboxylic acids, some terpenoids, and caffeine.[41]

The following phytoconstituents are found in flowers

Glycosides, alkaloids, flavonoids, phenolics, saponins, lignin, tannin, serpentine, phytosterol, triterpenoid, fixed oil and fats, and mucilages.[54]

In fruits, a variety of phytochemicals such as phenolic and flavonoid compounds, oxalic and malic acid, and both organic and inorganic compounds and alkaloids have been identified.[55]

The fruit pulp is composed of organic acids, carbohydrates, phenols, flavonoids, steroids, and sterols.[56]

The immature fruit contains the following phytochemicals:[41]

Cyclopentanone	Phthalic acid	Stearic acid
1,8-Nonadien-4-Ol	11-Octadecanoic acid	Cyclopentaneun decanoic acid
Phenol, acide carbolique	Decylenic alcohol	3-Butenoic acid
2-methoxy-4-vinylphenol	Pyroglutamic acid	Palmitic acid
Pentadecanoic acid	(2E,6E)-Farnesol	Oleic acid
Pyrogallol1,3-dimethyl ether	1,5-Heptadiene	Hendecynoic acid

The fruit skin contains the following phytoconstituents:[41]

4-Flourobenzoyl	Hexanoic acid	Amyl nitrite
Cyclobutane	Isobutane	Aziridine
Isoxazolidine	Bis(trimethylsilyl) ester	Borazine
Nitrous acid	Isonitropropane	1-Butanol
1-Propanol	Oxetane	Nonadecanoic acid
Dodecanoic acid	8-Nonynoic acid	1-Propenyl-aziridine
Propanedionic acid	Levoglutamide	Caffeine
Oxalic acid	2.2-Bis(trimethylsilyl) styrene oxide	Cyclopentane undecanoic acid
		10-Undecynoic acid

In leaves, an array of phytochemical compounds is evident, encompassing alkaloids, terpenoids, saponins, steroids, glycosides, phenols, tannins, flavonoids, oxalic acid, phytosterol, and resins.[12]

The leaf also demonstrates the presence of various compounds, including:[41]

4-Hexen-2-one,3-Methyl-	Lignoceric acid	Aziridine
Hexanoic acid	11-Octadecenoic acid	Stearic acid
Dodecanoic acid	9,12-Octadeca dienoic acid	2-Oxabicyclo[3.2.1] octan-3-one
Nitrous acid	Linolenic acid	Cyclohexyl ester
N-Ethyl acrylamide	Pyroglutamic acid	Oleic acid
Butyl propyl ester	Palmitaldehyde	10-Undecenoic acid
Pentadecanoid acid	1,3-cyclohexane-1,3-D2-Diamine	8-Nonynoic acid
Benzoic acid	3,4-Hexanediol	

Uses

Economic importance

- The trunk of the plant contains a significant amount of starch. The shoots of the flowers yield a juice that can be condensed into a syrup with a high sugar content
- This plant is primarily recognized as a source of treacle, a form of liquid jaggery. Caryota treacle serves as a sweetening agent in both Sri Lankan and Western culinary practices
- The sap extracted from the inflorescence, known as toddy, possesses a comparatively robust potency when compared to toddy obtained from other palm species.[49]

Traditional uses

- The fibers derived from this plant are typically utilized in the production of ropes, brushes, brooms, and baskets. The pith of the plant serves as a valuable source for producing a highly nutritious "sago." Furthermore, the plant's terminal bud is considered edible, adding to its versatility and utility[50]
- The plant serves as an important source of nutrition for elephants in Cambodia, as they are fed with leaves and pulp
- Leaves, known for their robust fibers, are utilized for basketry within Cambodia
- The fruit is found to be enjoyable and sweet for consumption. Furthermore, Cambodians extract stalks from the plant to produce sugar, which can be further processed into wine.[49]

Medicinal uses

- The sap derived from the palm is employed in the management of urinary disorders and seminal weakness. In traditional medicine, a preparation composed of porridge derived from the *C. urens* flower has been historically utilized as a remedy for gastric ulcers and migraine headaches
- In addition, the bark and the seeds are used to treat boils, while the root is specifically designated for the treatment of tooth ailments[41]
- The high content of palmitic and oleic acid in Kithul seed oil makes it a valuable source of biofuels
- Furthermore, Kithul flour, characterized by a low gelatinization temperature, serves as an effective gelling agent, stabilizer, and thickener[42]
- The flowers of these trees were historically employed in ancient medical practices to alleviate hemicrania
- Traditional medical knowledge prescribed the use of tree flowers to enhance the growth of hair
- Furthermore, the roots of these plants were utilized to address tooth ailments
- Studies have shown that the skin of fruit and unripe fruit has antibacterial activity
- Moreover, the leaf extract is renowned for its notable antioxidant properties
- Notably, the root bark and terminal bud of these trees are utilized in the treatment of snake bites[56]
- The tender leaves exhibit a sweet and cooling nature, serving as an effective remedy for pitta aggravation
- The fruit pulp is notably beneficial for addressing hyperdipsia and fatigue
- Palm heart is locally utilized as flour and is particularly recognized for its role in managing diabetes and in traditional Ayurvedic remedies.[12]

Ornamental value

- The leaves of these plants can also be used to enhance floral decorations
- Caryota plants are commonly utilized as both indoor and outdoor ornamental flora in residential settings, large-scale hospitality establishments, and airport terminal structures
- In addition, the leaves of these plants serve as a valuable embellishment for floral displays.[44]

PHARMACOLOGICAL ACTIVITIES OF *C. URENS* L.

Anti-oxidant activity

Antioxidants possess the capability to effectively neutralize free radicals by impeding the oxidation process, chelating catalytic metals, and serving as oxygen scavengers.[41]

The implication of free radicals and consequent tissue damage in various diseases, among others, has garnered significant attention. Recent focus has centered on the identification of plants possessing antioxidant properties suitable for human consumption. Consequently, extensive research has been dedicated to exploring the potential of antioxidants, particularly those of natural origin, in inhibiting the production of reactive oxygen species (ROS) and exhibiting protective effects.[12]

The phytochemicals of this plant have been reported for their significant role as antioxidants.[57] In a conducted study, findings indicate that immature fruit extracts and other parts, such as leaves, exhibited notably higher antioxidant activity than those from fruit skin. Hence, we can say that *C. urens* extracts demonstrate substantial antioxidant potential.[41,58]

Methanolic extract of the leaf of *C. urens* was evaluated for antioxidant property through a series of methodologies, including 2,2-diphenyl-1-picrylhydrazyl (DPPH), hydrogen peroxide, and reducing power assays. Methanolic extract of the leaf of *C. urens* demonstrated a significant reduction,

yielding 266.6 µg/mL LC_{50}. These findings indicate the presence of phytochemical constituents within the plant extract capable of mitigating oxidative damage through the donation of hydrogen to free radicals.[12]

Various *in vitro* assays analyzed the antioxidant properties. Boiled and raw samples of dried methanolic extracts were utilized in the assays. The findings demonstrate that flour exhibits antioxidant activity against free radicals, electron-donating reducing activity, absorbance capacity, and metal ion-chelating capacity, indicating its potential as an antioxidant. The results indicate that *C. urens* flour possesses moderate antioxidant properties, potentially contributing to its purported traditional health benefits.[59]

Research was conducted to assess the antioxidant activity of various extracts obtained from *C. urens* aerial parts. Results revealed that the crude ethanol extract (CEE) exhibited the highest total antioxidant activity in comparison to the methanol fraction, ethyl acetate fraction, and chloroform fraction. Furthermore, CEE demonstrated the highest scavenging activity in both assays.[60]

The ethanolic extract derived from the flower exhibited inhibition percentages of 53.0%, 17.30%, and 44% for scavenging activity of hydrogen peroxide, DPPH, and reducing power, respectively. These outcomes signify the therapeutic potential of the flower extracts owing to their substantial free-radical scavenging capabilities.[48]

Methanolic extract of the seeds of *C. urens* underwent evaluation for its *in vitro* antioxidant power utilizing the ferric reducing antioxidant potential and 2,2′-azinobis(3-ethylbenzothiazoline-6-sulfonate) (ABTS) radical scavenging method. Notably, it demonstrated a substantial 90.5% inhibition during the ABTS assay. Moreover, the study revealed a corresponding ferric reducing antioxidant power (FRAP) value of 0.0713 ± 0.00106 mg/g.[43]

In a comprehensive research study, the polyphenols present in two varieties of palm fruits, namely jelly palm and fishtail palm, were meticulously characterized using LC-ESI-QTOF/MS, with a concurrent evaluation of their antioxidant potential. The ethanolic extracts of the fishtail palm fruits were subjected to assessment for polyphenol content. As a result, polyphenolic content in fishtail palm was quantified at 1.75 mg GAE/g ($p < 0.05$). Furthermore, the antioxidant powers of the fishtail fruits were determined through various methodologies encompassing total phenolic content, total flavonoid content, ABTS, FRAP, and DPPH. Various assays were employed to establish the free radical antioxidant activity of fruits of *C. urens*, yielding a FRAP antioxidant activity of 0.03 ± 0.01 µg AAE/g with $P < 0.05$.[38]

The antidiabetic properties of *C. urens* may be attributed to its potential to inhibit α-glucosidase and modulate inflammatory pathways as well as to mitigate hyperglycemia-induced oxidative damage. The effect of the methanolic extract was investigated through *C. urens* inflorescence in RAW 264.7 macrophages stimulated by lipopolysaccharide (LPS) and glucose-stimulated pancreatic cells. The findings revealed a production reduction of intracellular reactive species in pancreatic cells following the administration of the extract.[61]

Antimicrobial activity

Extracts derived from *C. urens* have exhibited antimicrobial activity against. This finding suggests that the plant may serve as a reservoir of natural antimicrobial agents with the potential to combat infections. Notably, certain studies have been enumerated in support of this claim.

The phytochemicals derived from this plant have been documented for their substantial antimicrobial properties.[57]

The antimicrobial activity of the methanolic extract of the leaf of *C. urens* was investigated against *Bacillus subtilis*, *Escherichia coli*, *Staphylococcus aureus*, and *Pseudomonas aeruginosa*. The antibacterial activity was conducted employing different concentrations, such as 25, 50, 75, and 100 µg/g of extract in a nutrient agar medium. Notably, the extract exhibited significant growth inhibition against *S. aureus*, with a highest zone of inhibition of 22 mm observed at 100 µg/mL. Furthermore, it displayed antimicrobial efficacy against all the tested bacterial strains, including *B. subtilis*, *E. coli*, *P. aeruginosa*, and *S. aureus*.[12]

The skin of unripe fruit of *C. urens* has antibacterial activity against (*E. coli*, *Vibrio cholerae*, *Salmonella* Typhi, *S. aureus*, and *Shigella flexneri*) in comparison to the leaf. The pronounced antimicrobial activity validates the efficacy of the traditional use of this herbal remedy.[41,58]

The ethanol extract derived from the flower demonstrates efficacy against *Clostridium septicum*, *Proteus mirabilis*, and *Proteus vulgaris*.[62]

Antifungal activity

The phytochemicals present in this plant have been documented for their significant role as an antifungal agent.[57] Three comprehensive studies were undertaken to investigate the antifungal properties of *C. urens*, all of which yielded positive results.

In the initial investigation, the antifungal efficacy was assessed against four fungal species, namely *Penicillium* sp., *Fusarium* sp., *Aspergillus niger*, and *Rhizopus* sp. Notably, the methanol leaf extract of *C. urens* demonstrated notable inhibitory activity against *Fusarium* sp., while exhibiting limited inhibition against *Penicillium* sp.[12]

During the second phase of the study, the *C. urens* leaves went through extraction and fractionation techniques by

various reagents such as carbon tetrachloride, chloroform, and n-hexane. The assessment of their efficacy was conducted through the implementation of the disc diffusion method. The comprehensive fraction exhibited potent antifungal effects against strains of *A. niger* and *Saccharomyces cerevisiae*. The findings demonstrated significant antifungal activity.[63]

During the third study, the ethanolic extracts derived from *C. urens* flowers exhibited significant resistance against six fungi (*Mucor*, *Aspergillus flavus*, *Aspergillus oryzae*, *Penicillium* sp, *Aspergillus nidulans*, and *A. niger*) as determined using the agar well-diffusion method. The observed antifungal activities are presumed to be due to flavonoids and phenolics present in the extract. Notably, *Mucor* demonstrated the highest inhibition, while *Penicillium* sp. exhibited the lowest inhibition among the six tested pathogens at a concentration of 25 µg/25 µL.[62]

Larvicidal activity

The development of plant-derived insecticides as a viable alternative to chemical insecticides is rapidly increasing. A study assessed the larvicidal activity of *C. urens* on *Aedes aegypti* through the methanolic extract of leaves of *C. urens*. The findings revealed a high larvicidal activity associated with the methanol leaf extracts of *C. urens*. This activity was supported by the presence of triterpenoids, steroids, and saponins in the methanol leaf extracts of *Caryota*, underscoring their efficacy as larvicides.[12,48]

In a recent study, it was observed that the synthesis of silver nanoparticles from *C. urens* exhibited notable efficacy against the mosquito *A. aegypti*. The study involved the application of varying concentrations of *C. urens* nanoparticles against different developmental stages of the *A. aegypti* mosquito. Furthermore, the study revealed that higher concentrations of *C. urens* nanoparticles demonstrated an increased deterrent effect on the oviposition behavior of the *A. aegypti* mosquito.[64]

Anti-inflammatory activity

According to research, extracts of *C. urens* significantly possess anti-inflammatory properties. This is primarily ascribed to the presence of bioactive compounds that effectively inhibit the production of pro-inflammatory cytokines.

The phytochemicals present in this plant are assumed to be responsible for the anti-inflammatory properties.[57]

The methanol leaf extract was assessed *in vitro* for anti-inflammatory action through the evaluation of its capacity to inhibit protein denaturation. The effect of the extract on the egg albumin denaturation was compared to that of diclofenac sodium, the reference drug. The highest observed inhibition % in *C. urens* was 68% at a concentration of 500 µg/mL. It has been documented that those plants containing phenols, terpenoids, and saponins have demonstrated anti-inflammatory activity.[12,48]

In a separate investigation, the therapeutic efficacy of CULHA (hydroalcoholic leaf extract of *C. urens*) against inflammatory ailments and the inhibition of nitric oxide (NO) production through inducible nitric oxide synthase were assessed. The CULHA, rutin, and umbelliferone displayed reductions of 61%, 30%, and 41%, respectively, due to significant inhibition of NO in lipo-polysaccharide-induced RAW 264.7 cells.[65]

In a separate investigation, the impact of a methanol extract from an inflorescence on LPS-stimulated RAW 264.7 macrophages was examined. The extract demonstrated a deduction in the overproduction of NO, IL-6, and L-citrulline levels. Moreover, an observed 5-lipoxygenase (IC_{50} of 166.1 µg/mL) inhibition occurred after treatment with the extract of *C. urens* inflorescences.[61]

Anti-diabetic activity

The products derived from *C. urens*, a plant commonly used in Ayurvedic medicine, have been recognized for their anti-diabetic properties. Some parts of *C. urens* demonstrate inhibition of glucosidase action. In addition, the low glycemic index of *C. urens* flour has proven to be advantageous for individuals managing diabetes.[42]

The phytochemicals derived from this particular plant have been documented for their notable contribution as an antidiabetic agent.[57] In a conducted study, the evaluation of *C. urens* fruit extracts in an in vitro bioassay targeting α-glucosidase inhibition at a concentration of 25 ppm demonstrated a 100% inhibition rate.[66]

In the context of an anti-diabetic experiment, the inhibitory effect on the alpha-amylase enzyme was assessed in *C. urens* flour (raw and boiled) at a 5 mg/mL concentration. The results demonstrated an alpha-amylase enzyme inhibition of 8.42% ± 0.97% for raw flour and 10.77% ± 2.64% for boiled flour.[59]

In a conducted study, it was determined that the inflorescences' extract exhibited a noteworthy response against yeast α-glucosidase (IC_{50} = 1.53 µg/mL).[42,67]

Anti-cancer properties

The study investigated the cytotoxic action of L-asp on the chronic myelogenous leukemia CML cell lines and peripheral blood mononuclear cell lines, yielding cytotoxicity or anti-cancer rates of 26% and 96% (IC_{50} = 23.03 µg/mL), respectively.[68]

A comparative analysis of the leaf and fruit metabolites of *C. urens* was conducted. Assessment of the plant's leaf crude extract revealed a substantial 4.5- to 5-fold induction of the phase II cytoprotective enzyme NQO1 compared to the control, indicating potential chemopreventive activity. In addition, two novel sulfated flavonols, kaempferol-3-O-sulfate-4′-O-rhamnosyl (1→6)-β-d-glucoside (F3) and quercetin-3-O-sulfate-4′-O-rhamnosyl (1→6)-β-d-glucoside (F1), showed the largest docking score as Nrf2 activators and KEAP-1 inhibitors, thus highlighting their positive action as lead compounds for chemopreventive drugs.[69]

Nephroprotective activity

A research study was conducted to analyze and evaluate the nephroprotective activity of Hyophorbe lagenicaulis leaves and *C. urens* flowers in mitigating nephrotoxicity induced by cisplatin and gentamicin. The experimental findings demonstrated a good impact of HLLE and CUFE as nutraceuticals, which were statistically significant.[70]

Neuroprotective effects

The plant's phytochemicals have been found to possess patented anti-Alzheimer's properties.[57] The impact of *C. urens* on memory and cognition in mice with Alzheimer's disease was evaluated. The study concluded that *C. urens* notably enhances memory in Alzheimer's disease.[51,58,71] Another study was carried out to assess the central nervous system activities of dried ethanolic leaf extract of *C. urens* at doses of 200 and 400 mg/kg. This evaluation utilized various models to measure the extract's effects on anti-convulsant activity, locomotor activity, anxiolytic activity, muscle relaxant activity, and antidepressant activity.[72]

Analgesic effects

The methanolic leaf extract of *C. urens* underwent a comprehensive assessment to explore its potential for providing pain relief. The outcome indicated the presence of various substances such as some phytosterols, important terpenoids, various tannins, unique flavonoids, and also some phenolic compounds in the *C. urens* extracts. These bioactive constituents are believed to be responsible for the observed analgesic effects.[58,73]

Anti-hyperlipidemic activity

In a study, the influence of treacle of *C. urens* on the dyslipidemia profile of Wistar albino rats was examined. Randox test kits were employed to assess the levels of total cholesterol, high-density lipoprotein, and triglycerides. Furthermore, the application of the Friedewald equation allowed for the determination of low-density lipoprotein content. The findings revealed a substantial beneficial impact of treacle on the serum lipid profile.[58,74]

Anti-angiogenic activity

A research study was carried out to investigate the effects of the ethanolic extract of *C. urens* on the regeneration ability of zebrafish fins. During the study, zebrafish were exposed to different concentrations of EECU and a standard drug, and the regenerated fin was calculated using microscopy and specialized software. The results revealed that the administration of EECU at regular intervals every other day hindered the regeneration of zebrafish fins over a 30-day period. It was due to the presence of specific plant-derived compounds in *C. urens*. The findings highlighted the noteworthy anti-angiogenic activity over the course of 30 days when compared to control groups and standard treatments.[75]

Anthelmintic activity

The extracts of *C. urens* L leaf show anthelmintic efficacy in both alcoholic and aqueous solvents on a test specimen *Pheretima posthuma*. Three earthworms of similar size were introduced into a 20 mL formulation containing 2 different concentrations of each crude aqueous and alcoholic leaf extract. The paralysis duration and time until death were measured for the worms. The results give positive anthelmintic activity of both the extract, alcoholic, and aqueous leaf extracts of *C. urens*, which manifested as dose-dependent paralysis and death times for the earthworms.[76]

Anti-arthritic activity

In a recent study, research was conducted to assess the activity of umbelliferone and rutin (active constituents of leaf hydroalcoholic extract of *C. urens*) in the control of rheumatoid arthritis (RA) by blocking tumor necrosis factor. Moreover, it was observed that mediated by ROS, oxidative stress plays a pivotal role in the onset and advancement of RA.[77]

CONCLUSION

C. urens, also known as the fishtail palm, is a botanical marvel with a multitude of ecological, economic, and cultural implications. Its striking fishtail-shaped leaves, coupled with its remarkable adaptability, make it an enchanting and highly functional addition to a variety of landscapes. Beyond its aesthetic appeal, this botanical wonder is deeply interwoven with traditional practices and local economies, emphasizing the critical need for its conservation to ensure its sustained prosperity both in its natural habitat and beyond.

C. urens holds great potential for the development of new therapeutic agents. Scientific research increasingly supports its traditional applications in managing inflammatory conditions, urinary disorders, and other ailments.

Despite the common perception of palm trees as having limited medicinal value, *C. urens* has been found to possess a broad spectrum of therapeutic benefits. Each part of the plant boasts distinctive medicinal properties, comprising analgesic, antiparasitic, antioxidant, anticancer, anti-inflammatory, and antibacterial activity.

Exploring the traditional methods of botanical preparation offers an intriguing opportunity for further interdisciplinary investigation across fields such as pharmacology, phytochemistry, and ethnobotany. While the pharmacological properties of this botanical wonder have been primarily studied *in vitro*, further research focusing on *in vivo* applications is essential. Continuous examination and comprehensive clinical trials are required to fully realize the potential benefits and applications of this versatile botanical specimen in contemporary medicine.

FUTURE PROSPECT

C. urens, an evergreen plant with numerous medicinal properties including antioxidants, antimicrobial agents, antidiabetic properties, anti-inflammatory agents, and larvicidal activity, remains underutilized in medicinal applications. Despite this, existing research has been limited to *in vitro* studies, highlighting the need for *in vivo* investigations to comprehensively understand its medicinal potential. Moreover, there is a critical need to identify and isolate novel endophytes from plant sources to evaluate their pharmaceutical properties and potentially discover new compounds with potent medicinal attributes. This underutilized plant presents an opportunity for significant advancement in the field of medicinal applications and warrants further exploration.

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