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SIGNIFICANCE OF *CYPERUS ROTUNDUS* (NAGARMOTHA), A NOXIOUS WEED IN AYURVEDA

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ABSTRACT: It is a very old practice of using herbal plants for the maintenance of health. The demand for herbal remedies has been increased rapidly over the past few years. This is due to the beneficial health impacts of herbal products on the living systems. *Cyperus rotundus*, commonly called as nagarmotha, purple nutsedge or nutgrass, is a perennial grass that belongs to Cyperaceae family. It is a cosmopolitan weed plant found in almost every corner of the tropical, subtropical, and temperate regions. It is a widely used plant in traditional systems of medicine, especially in Ayurveda and folk systems around the world, for its useful remedial properties in indigestion, constipation, dysentery, abdominal distention, cholera, skin diseases, diabetes, furuncle infections, sprains and bruises, fever and stomach ache, etc. It exhibits extraordinary therapeutic properties like antioxidant activity, antidiabetic activity, anti-inflammatory, antiplatelet, antimalarial, anti-diarrheal, anti-allergic, anti-tumor, analgesic activities, hepato-protective. The present review aims to provide information related to phytochemistry, traditional uses in Ayurveda and folk medicinal system, and therapeutic properties of *Cyperus rotundus*.

INTRODUCTION: Humans rely completely on mother nature as it has been served as the primary source of numerous medicines for thousands of years^{1, 2}. It has gifted us several important medicinal plants, which are the extraordinary source of traditional and modern drugs. Therefore, the plant kingdom is entitled to “the treasure house of potential drugs”^{3, 4}. Phyto-chemicals present in them are medically important because these exhibit biological properties and served as chemical entities for synthetic drugs.

They have a major role in the nutraceutical and cosmetic industry in Global and domestic markets⁵⁻¹². Plant-based products are called herbal / botanical drugs, phytomedicines, etc. These have several advantages over synthetic drugs, such as they are easily available, safe, less expensive and exhibit negligible adverse impacts on the living systems¹³⁻¹⁵. According to WHO, herbal medicines are categorized as raw plant materials, processed plant materials and medicinal herbal products¹⁶.

Secondary metabolites are major organic compounds present in the medicinal plants having definite, suitable and compatible physiological action on the living system, which cause negligible side effects¹⁷⁻¹⁹. The estimated reports of WHO conclude that 80% of the population of the world relies mainly on herbal medicines²⁰⁻²⁴. As per WHO, around 20,000 important medicinal plants

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are known to exist in 91 countries, including 12 mega biodiversity countries²⁵. Asia represents a long history of utilization of medicinal plants for treating human ailments. These are used to treat chronic as well as infectious diseases²⁶. World biodiversity centers include India, which has a very rich history of using medicinal plants for various purposes, especially for health-related problems. More than 45000 different plants have been found in different regions of India; therefore, it is considered as the Botanical garden of the world²⁷.²⁸. These medicinal plants are majorly promoted by traditional systems of medicines²⁹.

Herbal medicines are also mentioned in classical Indian texts such as Rigveda, Ayurveda, Charak Samhita, and Sushruta Samhita³⁰. In India, the most ancient traditional medicine system is Ayurveda which focuses on treating diseases as well as it prevents the occurrence of illnesses. Almost 600 medicinal plants are being used in Ayurvedic practices^{31, 32, 33}.

In Europe, herbal medicines contribute a lot to the pharmaceutical industry³⁴. In an ancient encyclopedia of traditional Chinese medicine named *Materia Medica's* compendium, more than 1,000 different plant species are described³⁵. Medicinal plants are being used in health maintenance practices in China for many years³⁶.³⁷. The major importers of Traditional Chinese Medicine are Japan, Hong Kong, Korea and Singapore.

These countries take 66% share of China's total herbal drug export³⁸. Traditional medicines are served as the primary healthcare system in South Africa and West Africa^{39, 40}. Swazi and Nigerian population still solely depends upon traditional herbal medicines^{41, 42}. Turkey has rich plant diversity. Around 10,500 different plant species are known to exist within the borders among which 30% are indigenous to Turkey^{43, 44}.

Approximately 600 medicinal plants and 900 herbal drugs have been described by Dioscorides⁴⁵. Medicinal plants are used in almost all cultures around the world. One such important medicinal plant is *Cyperus rotundus* **Fig. 1**, commonly called Nagarmotha motha or musta in India and globally known as purple nutsedge.

It belongs to Cyperaceae family⁴⁶. The word *Cyperus* have originated from a Greek name of the genus called "Kuperos or Cypeiros" which means sedge, whereas the species name *rotundus* is a Latin word that means round and thus *rotundus* refers to the tuber^{47, 48}. Genus *Cyperus* has 600 different species found throughout the world⁴⁹.

This medicinal plant was used as an herbal medicine in ancient times. Its medicinal importance was described by Dioscorides (c40–90 AD) and Pliny (23–70 AD)⁵⁰. In ancient Egypt, *Cyperus rotundus* tubers were used in embalming and perfumes⁵¹. *C. rotundus* is consumed as a vegetable in Yelka. Its tubers and seeds are edible parts. Tubers are consumed either raw or cooked. The dried form of tubers is consumed as cereal⁵²⁻⁵⁶.

Rhizomes and tubers are mostly used in traditional systems of medicine of India, China, and Japan against inflammatory diseases, stomach-related problems, and irritable bowel^{57, 58}. It has a wide variety of phytochemicals present in it. The essential oil extracted from *C. rotundus* exhibits antibacterial activity⁵⁹.

It is associated with therapeutic properties like antioxidant activity, antidiabetic activity, anti-inflammatory, antipyretic and analgesic activities, hepatoprotective *etc.*⁶⁰⁻⁶⁵

Apart from its therapeutic uses, it has been called the world's worst weed because it destroys the crops like sugar cane, corn, cotton, rice, and many vegetables in many countries⁶⁶. Vernacular names and taxonomic classification of *C. rotundus* is given in **Table 1** and **2**, respectively.



FIG. 1: CYPERUS ROTUNDUS

TABLE 1: VERNACULAR NAMES OF *CYPERUS ROTUNDUS* ^{67,68}

English	Coco grass, Nut-grass, Nutsedge, Purple nut-grass, Purple nutsedge
Hindi	Nagarmotha, Korehi-jhar, Motha, Mutha
Sanskrit	Chakranksha, CharukesaraAbda, Ambuda,
Urdu	Saad kuf
Arabic	Soad, Soadekufi
Bengali	Nagarmotha, Moothoo, Musta,
Burma	Vomoniui
Gujarat	Nagaramothaya
Malaya	Mushkezamin
Turkish	Topalak
Telugu	hadra-muste, Gandala, Kaiivartakamuste.
Germany	Nußgras, Rundeszypergras
Japanese	Hamasuge
Thailand	Yahao mu, Yakhon mu
Nepalese	Mothe
Chinese	Hsiang-fu, Suo cao.
Arab	Suadkuf
Italian	Ciperoorientale, Ciperorotondo.
Spanish	Castañuela, Cebollín
Persian	Mushkzer-e-zameen
Portuguese	Junça, Junca-aromatica

TABLE 2: TAXONOMIC CLASSIFICATION OF *CYPERUS ROTUNDUS* ⁶⁹

Taxonomic Rank	Taxon
Kingdom	Plantae
Division	Angiosperms
Class	Dicots
Subclass	Commelinids
Order	Poales
Family	Cyperaceae
Genus	<i>Cyperus</i>
Species	<i>rotundus</i>
Common names	Nut-grass, Nagarmotha.

Morphology of *Cyperus rotundus*: *Cyperus rotundus* is a dark green grass-like perennial, monocotyledonous bisexual herb that attains a height of up to 40 cm. It consists of underground tuberous roots/rhizomes which are fragrant. The tubers 1- 3.5 cm long and are achromatic in color from the outside whereas reddish-white from inside. There are multiple buds present on each tuber. Below the ground, it forms a vast network of basal bulbs, fibrous roots.

The stem of this plant is nodosely thickened at the base, which suddenly transformed into a wiry rhizome, whereas it is sub solitary, triquetrous at the top. Rhizomes and tubers are born in the manner of the chain. The leaves are 2-6 mm wide and are mostly basal and dark green in color. A prominent midrib is present over the leaves surface, which is somewhat tapered at the tips.

Leaves are long, which overlapped the stem. A compound umbel is present where flowers are borne in clusters that are 25mm long. The spikes are short, ovate, 2.5 cm long, 2–3 mm wide and are loosely spicate of 3–8 spikelets. Spikelets are flattened in shape. It is 12–30 flowering plant. The rachilla is winged. The inflorescence is 10cm long and is compound or simple with 3–9 primary branches. The seeds are present in the form of trigonous nuts ⁷⁰⁻⁷⁴.

Geographical Distribution of *Cyperus rotundus*:

It is a native plant of India found up to a height of 2000 meters, but there are some beliefs regarding its origin like it is believed that this plant originated in northern and eastern regions of Australia ⁷⁵. This global species grows mainly in tropical, subtropical and temperate regions of the world such as Asia, South Africa, South America, etc. ⁷⁶⁻⁷⁸

It is found in 92 countries like Afghanistan, Iran, Iraq, Saudi Arabia, Yemen, Palestine, Lebanon, Syria, Turkey, Armenia, Azerbaijan, Russian Federation, Kazakhstan, Kyrgyzstan, Turkmenistan, Uzbekistan, China, Japan, Korea, Taiwan, India, Nepal, Pakistan, Sri Lanka, Myanmar, Thailand, Vietnam, Indonesia, Malaysia, Philippines, Austria, Switzerland, Albania, Bulgaria, Croatia, Greece, Romania, Serbia, Slovenia, France, Portugal, Spain, Marshall Islands, Micronesia, Northern Mariana Islands, USA, Mexico, Brazil, Bolivia, Colombia, Ecuador, Peru, Argentina, Algeria, Egypt, Libya, Morocco, Tunisia, Western Sahara, Chad, Djibouti, Eritrea, Ethiopia, Somalia, Sudan, Kenya, Tanzania, Uganda, Burundi, Equatorial Guinea, Gabon, Rwanda, Zaire, Benin, Burkina Faso, Cote D'Ivoire, Ghana, Guinea, Mali, Mauritania, Niger, Nigeria, Senegal, Sierra Leone, Togo, Angola, Malawi, Mozambique, Zambia, Zimbabwe, Botswana, Namibia, South Africa, Swaziland ⁷⁹. It grows rapidly and single species can produce up to 40,000 kg/hectare of underground plant material. It grows well in light (sandy) and medium (loamy) soils of acid, neutral and basic nature. It prefers moist or wet soil ⁸⁰. It grows mainly in fields, farmlands, neglected areas, wastelands, grasslands, forest edges, roadsides, sandy or gravelly shores, riverbanks, rice and sugar fields, watercourse, irrigation canal banks, in disturbed areas and lawns/turf ⁸¹.

Phytochemistry of *Cyperus rotundus*: *C. rotundus* contains several phytochemical constituents of various classes like fat, gum resins, carbohydrates, essential oils alkaloids, saponins, flavonoids, terpenoids, mono- and sesquiterpenes, albuminous matters, fibers, and ash⁸²⁻⁸⁶.

Sesquiterpenes: *C. rotundus* possess diverse skeletons of sesquiterpenes such as patchoulane, rotundane, eudesmane, guaiane, cadinane and caryophyllene types. Patchoulane type sesquiterpenes such as patchoulane-1 (cyperene-3, 8-dione), patchoulane-2 (14-hydroxy cyperotundone), patchoulane-3 (14-acetoxy cyperotundone), patchoulane-4 (3 β -hydroxy-cyperenoic acid), patchoulane-5 (sugetriol-3, 9-diacetate) is present in *Cyperus rotundus*. Whereas eudesman-6 and 7 are known to be present in this plant. Other eudesman (15–21 and 23–24) are present in this plant [87,88]. Two novel sesquiterpenes named isocyperotundone (1) and 1,4-epoxy-4-hydroxy-4,5-seco-guain-11-en-5-one (2) are reported to be present in this plant⁸⁹.

Flavonoids: Flavonoids like vitexin, orientin, cinaroside, quercetin 3-O- β -D-glucopyranoside, and myricetin 3-O- β -D-glucopyranoside, isnagin, khellin, ammiol, isorhamnetin, and tricetin, luteolin 3'-methyl ether, Luteolin 7, 3'-dimethyl ether, Luteolin 5, 3'-dimethyl ether, luteolin 4'-glucoside, Luteolin 7-diglucoside, tricetin 5-glucoside, kaempferol are present in *Cyperus rotundus*. A novel flavonol derivative is discovered in this plant named as cyperaflavoside (myricetin 3,3',5'-trimethyl ether 7-O- β -D-glucopyranoside)^{90,91}.

Steroids: Steroidal glycoside, sitosteryl-(6'-hentriacontanoyl)- β -D-galactopyranoside, sitosterol, stigmasterol, sitosterol glucoside, stigmasterol glucoside, chrysoeriol, kaempferol, luteolin, quercetin, rutin and khellol -D-glucopyranoside are known steroids which are present in *Cyperus rotundus*^{92,93}.

Phenylpropanoid: *Cyperus rotundus* tuber and rhizomes consist of phenylpropanoid compounds such as p-coumaric acid, ferulic acid, isoaragoside, chionoside A, helioside C^{94,95}.

Phenolic Compounds: p-Hydroxybenzoic acid, protocatechuic acid, vanillic acid, ellagic acid,

salicylic acid, protocatechuic acid, caffeic acid and p-coumaric acid are some known phenolic compounds present in *Cyperus rotundus* tubers and aerial parts^{96,97}.

Iridoides, Benzodihydrofurans, and Miscellaneous: Rotunduside A, rotunduside B, 6-O-p-Coumaroylgenipin gentiobioside, 1-[2,3-Dihydro-6-hydroxy-4,7-dimethoxy-2S-(prop-1-en-2-yl)benzo-furan-5-yl]ethanone, 2S-Isopropenyl-4,8-dimethoxy-5-methyl-2,3-dihydrobenzo-[1,2-b;5,4-b']difuran, 2S-Isopropenyl-4,8-dimethoxy-5-hydroxy-6-methyl-2,3-dihydrobenzo[1,2-b;5,4-b']difuran, 1 α -Methoxy-3 β -hydroxy-4 α -(3',4'-dihydroxyphenyl)-1,2,3,4-tetrahydronaphthalin, 1 α ,3 β -Dihydroxy-4 α -(3',4'-dihydroxyphenyl)-1,2,3,4-tetrahydronaphthalin, 4,7-Dimethyl tetralone, n-Butyl- β -D-fructopyranoside, Ethyl- β -D-glucopyranoside all these compounds fall under this category of phytochemicals⁹⁸⁻¹⁰⁰.

Essential Oils with their Percentage: *Cyperus rotundus* contains good amount of essential oils in it, for example it contains α -pinene 2.87, cyclopentene-3-ethylidene-1-methyl 0.24, sabinene 0.43, β -pinene 2.13, p-cymene, 0.18, 1-limonene 0.28, 8-cineole 0.36, trans-pinocarveol 7.92, terpinen-4-ol 0.59, citronellal 0.76, 4,4-dimethyl-tricyclo-(3,2,1) octan-6-one 1.56, p-cymen-8-ol 1.96, 1- α -terpineol 1.45, cis dihydrocarvone 0.38, myrtenol 1.86, verbenone 1.55, 1- β -4,4-trimethylbicyclo (3,2) hept-6-en-2-ol - 1.05, trans-carveol 0.48, carvone 1.95, carvenone 0.32, α -cubebene 0.40, dihydrocarvylacetate 0.93, α -copaene 3.02, isolongifoline 1.66, cyperene 7.83, trans-caryophyllene 3.08, dihydroaromadendrene 1.47, aromadendrene-epoxide 2.51, naphthalene, 1,6-dimethyl-4-(1-methyl ethyl) 1.09, α -silenene 0.55, cis-calamenene 0.42, trans-calamenene 0.57, elema-1,3,11 (13)-trien-12-ol 0.64, caryophyllene-oxide 2.86, caryophylla-2(12), 6(13) dien-5-one 1.95, cyclohexane, 1,1,2-trimethyl,3,5 bis-1-methyl ethyl) 0.97, isopropyl, 4 α β , 8 α β -dimethyl 3.69, longiverbenone 1.09, 10-epi- α -cyperone 1.00, (+) oxo- α -ylangene 9.35, (+) α '-cyperone 9.07, caryophyllenol 2.11, vulgarol A 1.13, vellerdiol 0.77, aristolone 3.54, vulgarol B 0.98, ledenoxide 1.34, dimethyl-7-isopropenyl-bicyclo-Dec-1-en-3-one 2.95, longifolinaldehyde 0.27 and longipynocarvone 2.95¹⁰¹.

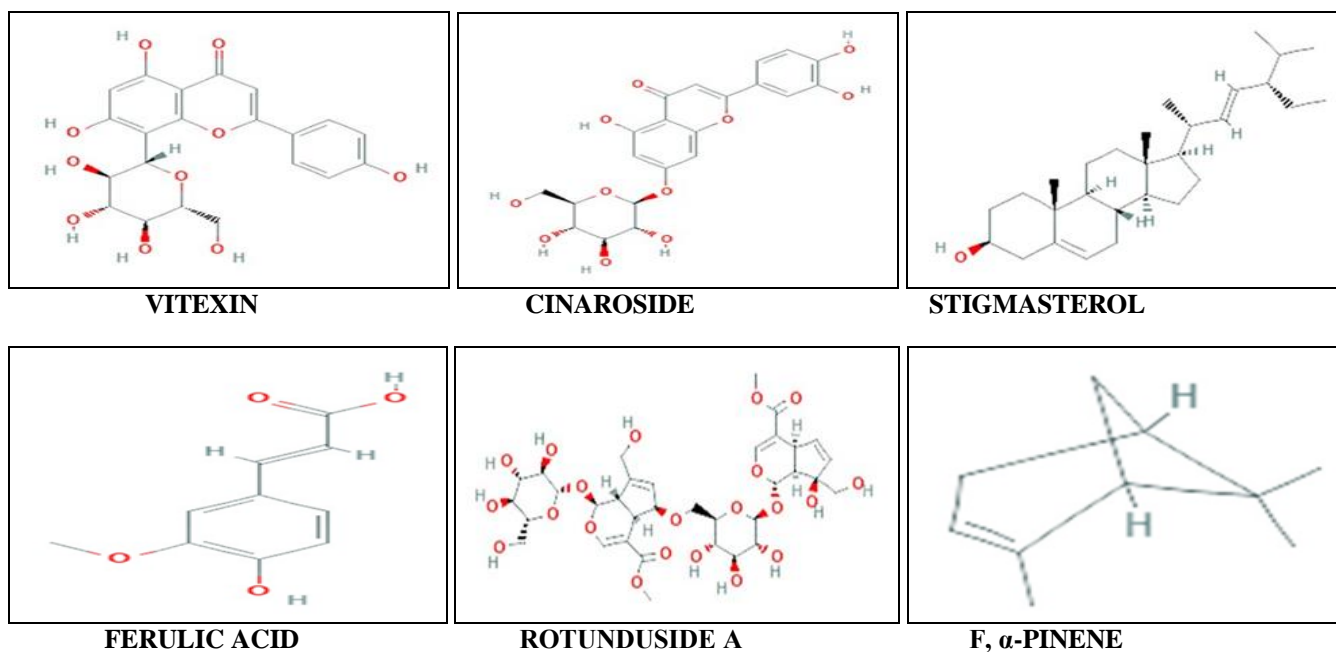


FIG. 2: CHEMICAL STRUCTURES OF SOME OF THE PHYTOCHEMICAL CONSTITUENTS OF *CYPERUS ROTUNDUS*

Traditional and Modern View of *Cyperus rotundus*:

A. Ayurvedic View: Ayurveda works on three body components/doshas of the body *i.e.*, Kapha (water & earth), pitta (fire), and Vata (space & air). An equilibrium between these three doshas is important for a healthy and balanced life^{102, 103}. *Cyperus rotundus* is an important medicinal plant that holds a significant place in Ayurveda due to its extraordinary therapeutic properties. It is Kapha-pitta hara *i.e.*, it balances the kapha and pitta dosha of the body¹⁰⁴. In Ayurveda, it is used as an astringent, diaphoretic, diuretic, analgesic, antitussive, sedative, stimulant, stomachic, vermifuge, tonic and antibacterial agent¹⁰⁵. Rasapanchak of *Cyperus rotundus* is given in **Table 3**.

TABLE 3: RASAPANCHAK OF *CYPERUS ROTUNDUS* AS PER AYURVEDA¹⁰⁶

Sanskrit/English	Sanskrit/English
Virya/Potency	Sita/Cold
Vipak/Metabolic property	Katu/Pungent
Guna/Physical property	Laghu/Light, Ruksha/Dry
Rasa/Taste	Katu/Pungent, Tikta/Bitter, Kasaya/Astringent

Properties of *Cyperus rotundus* as per Ayurveda:¹⁰⁷⁻¹⁰⁹

Dipaniya: appetizer.
Pachana: digestive stimulant.

Krimighna: anthelmintic.

Mutra virecaniya: diuretic agent.

Lekhanya: fat reducing properties.

Rasa pacaniya: plasma purifier.

Triptighana: antisaturative.

Kandughna: antipuriginous/anti-itching.

Satanyasodana: galactopurifier.

Trishnagrahana: thirst restraining properties.

Jwarhara: anti-pyretic.

Atisarghana: anti-diarrheal.

Satmikaran: anti-poisonous and enhances strength.

Uses of *Cyperus rotundus*:

Abhyanttar nadi sansthan: treats epilepsy and other brain disorders.

Paachan sansthan: treats in digestion, vomiting, irritable bowel syndrome, and enhances metabolism.

Rakatwah Sansthan: treats blood-related disorders.

Swasan Sansthan: treats cough and asthma.

Mootarwah Sansthan: treats oligourea.

Prajanan Sansthan: treats amenorrhea, puerperal disorders and disorders related to lactation.

Taapkram: treats fever and dehydration.

Nagarmotha is used in panchakarma against kushtha roga (skin problems like psoriasis), and female infertility¹¹⁰⁻¹¹².

Some important formulations of *Cyperus rotundus*:

- Amrutadivati and Shrugyadishaarkar: These polyherbal formulations are known for their effective use in TamakaShwasa (a respiratory issue)¹¹³⁻¹¹⁴.
- Shirishadi: It is used as anti-asthmatic agent and hypoglycemic drug. It also has anti-microbial properties^{115, 116}.
- Mustadi Kwatha: It used against diabetes mellitus, problems related to urinary system and nutrition¹¹⁷.
- DarvyadiKwatha: It is used against diabetes and asrigdara (abnormal menses)^{118, 119}.
- Herbal shampoo: Nagarmotha is an ingredient in polyherbal shampoo, promoting hair growth and has anti-dandruff properties¹²⁰.
- VidangadiLauha: It is used for the treatment of anemia, obesity, amavatarheumatoid arthritis, prameha diabetes, etc.¹²¹
- Kanakabindvarishta: It is an important Ayurvedic polyherbal formulation that has been described in Charaka Samhita. It is used against kushtharoga (Skin related problems)^{122, 123}.
- Mustadiyapanavasti: It is beneficial for bones, muscles and eyes. It increases digestive fire. It helps to get relief from the pain of groins, thighs, sacral region, and abdomen. It is used to treat abnormal menses¹²⁴.
- Shwas-Kasadi Gutika: It is used against Kasa (cough)¹²⁵.

B. Folk View: *C. rotundus* is one of such plants which have a rich history of its utilization in different folk cultures around the world. For instance, the rhizomes of *C. rotundus* are traditionally used by many Asian countries against

stomach-related problems, bowel disorders, and inflammatory diseases^{126,127}. In the Nanded District of Maharashtra, people use root juice for the treatment of ulcers and urinary disorders¹²⁸. In Mandi, Himachal Pradesh, the tubers of *C. rotundus* are used against diseases like cough, epilepsy, malarial fever, cholera. Tubers are used as stomachic tonic and diuretic. The root paste is used to treat wounds and sores, while the root extracts are used as anti-inflammatory, anti-pyretic, and analgesic¹²⁹. This plant is consumed as a tonic in some areas of Madhya Pradesh¹³⁰.

The tribal people of harda district, Madhya Pradesh, use tuberous powder to treat dysentery¹³¹. In Sirohi district of Rajasthan, people use root nodules/rhizomes to treat stone and rheumatism. They use roots to make agarbatti sticks¹³². The rhizome powder is used to purify mother's milk in Jalgaon district Maharashtra¹³³. In the Buldhana district of Maharashtra, people chew the leaves against snake bites. They use leaf extract against acidity. Dried root powder is used to treat cold and cough¹³⁴. People of Hingoli district, Maharashtra, treat acne and dandruff by root powder of *C. rotundus*¹³⁵. In Tarai region, Kumaun Himalaya people use tubers to treat problems related to stomach and bowel¹³⁶. In the Jhabua district of Madhya Pradesh, people treat urinary disorders by tuberous roots of this plant¹³⁷. In Bijnor, people use plant extracts as diaphoretic and astringent. They use a paste of *C. rotundus* roots, ginger, and honey to treat dysentery¹³⁸. In Bilaspur district, Chhattisgarh people treat diarrhea, anorexia, blood disorder by using *C. rotundus*¹³⁹. In Hamirpur, Himachal Pradesh, people use it as anti-inflammatory, antipyretic and analgesic. They use this plant to heal wounds, skin diseases, diarrhea, stomach related disorders and also use against scorpion sting¹⁴⁰. In Bihar, this plant is used to enhance digestion, reduce obesity and fat levels¹⁴¹. In Ranchi rheumatism, inflammations, dysuria and obesity are traditionally treated by using *C. rotundus* rhizome¹⁴². The Warli tribe of Dahanu, Maharashtra, uses tuber paste to improve lactation¹⁴³. Leaves and roots are used to treat stomach-related issues in the Northern hill region of Chhattisgarh¹⁴⁴.

C. Modern View: There are several advantages of herbal drugs over synthetic drugs, such as they are

less expensive, harmless, safe, and easily available. The market demand for herbal drugs/products is increasing rapidly, due to which the quality of herbal drugs is being compromised because of the association of factors like contamination, adulteration, and misidentification¹⁴⁵⁻¹⁴⁷. Due to conflict in vernacular names and scientific names of the medicinal plants, the cases of misidentification occur¹⁴⁸. Another ultimate reason for the degradation of herbal drugs is intentional adulteration by using various materials such as orthodox drugs, inferior products, foreign particles, etc.¹⁴⁹⁻¹⁵¹. The most common contaminants induced in herbal drugs/products are mercury, arsenic, and lead, cadmium, copper and thallium, pesticides, microbes and mycotoxins¹⁵²⁻¹⁵⁸. In the market, the commonly available forms of herbal products are powders, capsules, and extracts. Alterations are usually done either before or during the processing of herbal drugs, i.e., adulterants and contaminants are induced in the raw/crude form of the plant extracts. These alterations can be prevented and detected out by proper quality analysis and standardization protocols, so they cause no adverse effects on consumer health¹⁵⁹⁻¹⁶¹. These protocols maintain the quality of the herbal products¹⁶². The most reliable technique used in today's time is the standard DNA barcode. This technique significantly works on the identification of species¹⁶³.

Therapeutic Uses of *Cyperus rotundus*: *Cyperus rotundus* is known for its extraordinary therapeutic activities. Some of its important therapeutic properties are described below.

Anti-diarrheal: Uddin *et al.*, studied anti-diarrheal properties of *Cyperus rotundus* on castor oil-induced diarrhea in mice models. It was revealed from the study that methanolic extract on oral administration at the dose of 250 and 500 mg/kg b.w. exhibited potent anti-diarrheal activities¹⁶⁴.

Anti-bacterial: The anti-bacterial activity of *Cyperus rotundus* was studied by Jabier *et al.* They use some gram-positive and gram-negative bacterial species *viz.* *Cyperus rotundus* oil exhibited maximum inhibitory actions against gram-positive bacteria as compared to gram-negative bacteria¹⁶⁵. The anti-bacterial activity of this plant was studied by Parekh *et al.*, against

many bacterial species. It was observed that the ethanolic extract of this plant showed significant anti-bacterial activity against all the used bacterial species. While the aqueous extract was active against *Vitis vinifera* L. this study supports the use of *Cyperus rotundus* as anti-bacterial agent¹⁶⁶.

Anti-diabetic: Singh *et al.*, evaluated the anti-diabetic potential of *Cyperus rotundus* on Swiss mice models. Diabetes was induced artificially in the models by using streptozotocin. It was found that ethanolic extract at the dosage of 250 and 500 mg/kg body weight exhibited antidiabetic activity. Also it helped in improving body weight. The elevated levels of biochemical parameters such as SGPT, SGOT, cholesterol, and triglyceride were reduced after the administration of ethanolic extract which confirms its use as anti-diabetic agent¹⁶⁷.

Anti-oxidant: Yazdanparast conducted a comparative *in-vitro* study to check the anti-oxidant potential of *Cyperus rotundus* against standard antioxidants such as butylated hydroxytoluene, tocopherol, L-ascorbic acid, and catechin. The hydroalcoholic extract of this plant showed significant reduction capability and free radical scavenging against 1,1-diphenyl-2-picrylhydrazyl (DPPH) and superoxide anions, and it showed a moderate effect on nitric oxide. The study concluded that *Cyperus rotundus* can be used as an antioxidant¹⁶⁸.

Lactogenic: Badgujar *et al.*, studied the lactogenic behavior of *Cyperus rotundus* on female rat models. The aqueous extract of the plant on oral administration at the dosage of 300 and 600 mg. significantly increased the milk production in lactating rat models at the rate of 23% and 40%. The extract increased the stimulation of prolactin synthesis. It significantly increased the size of mammary glands. It was also observed that pups gained weight during the experimental period, which supports its use as a lactogenic¹⁶⁹.

Antinociceptive: Imam *et al.*, studied the antinociceptive activity of hydromethanol extract of *Cyperus rotundus* in mice models. Nociception was induced in the models by two methods *i.e.* thermal (hot plate and tail immersion) and chemical (formalin). The extract was administered at the doses of 50, 100, and 200 mg/kg; p.o. For

comparison, morphine sulphate (5 mg/kg, i.p.) and diclofenac sodium (10 mg/kg, i.p.) were used. In thermal-induced nociception, hydromethanol extract helped in increasing the latency period at all doses. Whereas in chemical-induced nociception, the extract significantly decreased the paw licking activity. From this study, it can be concluded that *Cyperus rotundus* exhibits anti-nociceptive activity¹⁷⁰.

Anti-inflammatory: As per the study report of Rocha et al., ethanol extract of *Cyperus rotundus* is associated with anti-inflammatory activity. They conducted the study on mice models. Arachidonic acid (AA) and 12-O-tetradecanoylphorbol-13-acetate (TPA)- were administered in the models for inducing skin inflammation. The extract significantly helped reduce ear edema and cellular infiltrate in acute and chronic skin inflammation models on topical application. It also effectively decreased the keratinocyte hyperproliferation induced by TPA¹⁷¹.

Hepatoprotective: Hepatoprotectivity of *Cyperus rotundus* was evaluated by Kumar et al., in rat models. Models were administered with carbon tetrachloride for inducing liver damage. It was observed that ethyl acetate extract of *Cyperus rotundus* exhibited hepatoprotective actions such as it lowered down the serum levels of glutamic oxaloacetic transaminase, glutamic pyruvic transaminase, alkaline phosphatase and total bilirubin¹⁷².

Wound Healing: Puratchikody et al., studied the wound healing property of *Cyperus rotundus* in rat models. Models were categorized into three categories on the basis of type of wound i.e., the excision wound rat models, the incision wound rat models, and dead space wound models.

Alcoholic extract of tuber parts in the form of ointments was examined against the wounds. The response comparison of extract ointment with the standard drug nitrofurazone ointment (0.2% w/w NFZ) showed a considerable difference in wound contracting ability, wound closure time, and tensile strength¹⁷³.

Anti-allergic: Jin et al., studied the anti-allergic behavior of *Cyperus rotundus* in *in-vitro* and *in-vivo*. The findings suggested that sesquiterpenes

are associated with anti-allergic activity. Sesquiterpenes were associated with the inhibition of 5-lipoxygenase-catalyzed leukotrienes production in rat basophilic leukemia (RBL)-1 cells¹⁷⁴.

Anti-tumor: As per the report of Kilani et al., a study conducted on L1210 leukemia cells line, essential oil of *C. rotundus* tuber is associated with anti-tumor activity. It was found that essential oil was very effective against L1210 leukemia cells line¹⁷⁵.

Analgesic: *C. rotundus* exhibits potential analgesic activity. It is well supported by Pal et al. A study was conducted on mice models in which writhes and stretches were induced by a 1.2% acetic acid solution. Ethanol extract of *C. rotundus* significantly reduced the number of writhes and stretched¹⁷⁶.

Neuroprotective: Lee et al., investigated the neuroprotective effect of *C. rotundus* in an experimental *in-vitro* model of Parkinson's disease. It was found that a rhizome extract of *C. rotundus* named cyperi rhizome showed significant neuroprotective activity against 6-hydroxydopamine (6-OHDA)-induced neuronal damage¹⁷⁷.

Anti-viral: As per the reports of an experimental study conducted by Soltan et al., hydroalcoholic extract of *C. rotundus* has effective anti-viral potential against herpes simplex-1 virus¹⁷⁸.

Diuretic: Akperbekova et al., suggested that drugs from and galenicals from the roots of *Cyperus rotundus* growing in Azerbaijan, exhibits diuretic effect¹⁷⁹.

Antihypoxic: Jebasingh et al., studied the antihypoxic effect of *Cyperus rotundus* in rat models. Models were administered with sodium nitrite to induce hypoxia injury.

It was observed that ethanol extract at particular doses of 200 and 400 mg/kg exhibited significant protective actions against the cognitive impairments and the locomotor activity and muscular coordination defects¹⁸⁰.

Anti-malarial: Weenen et al., studied the antimalarial property of 49 Tanzanian plants. It was

found that *Cyperus rotundus* tuber extract significantly exhibited antimalarial activity¹⁸¹.

Anti-platelet: As per the reported study conducted by Seo *et al.*, to check the antiplatelet behavior of *Cyperus rotundus*, it was observed that eight components of *C. rotundus* rhizome viz. 4-cymene, (+)-nootkatone, b-pinene, 1,8-cineole, limonene,

valencene, caryophyllene oxide, coumarin, (+)-nootkatone exhibited a significant inhibitory effect on platelet aggregation induced by arachidonic acid (AA) and collagen, thrombin¹⁸².

Reported pharmacological and therapeutic properties associated with *Cyperus rotundus* (Nagarmotha) are given in **Table 4**.

TABLE 4: REPORTED THERAPEUTIC USES OF CYPERUS ROTUNDUS (NAGARMOTHA)

Sr. No.	Extract	Method	Property	References
1	Methanolic extract	<i>In-vivo</i> -mice	Anti-diarrhoeal	164
2	Oil	<i>In-vitro</i>	Antibacterial	165,166
	ethanolic extract	<i>In-vitro</i>		
3	Ethanolic extract	<i>In-vivo</i> - mice	Anti-diabetic	167
4	Hydroalcoholic extract	<i>In-vitro</i>	Anti-oxidant	168
5	Aqueous extract	<i>In-vivo</i> - female rats	Lactogenic	169
6	Hydromethanol extract	<i>In-vivo</i> - mice	Antinociceptive	170
7	Ethanol extract	<i>In-vivo</i> mice	Anti-inflammatory	171
8	Ethyl acetate extract	<i>In-vivo</i> - rats	Hepatoprotectivity	172
9	Alcoholic extract	<i>In-vivo</i> - rats	Wound healing	173
10	Sesquiterpenes	<i>In-vivo</i> and <i>in-vitro</i>	Anti-allergic	174
11	Tuber essential oil	<i>In-vitro</i>	Anti-tumor	175
12	Ethanol extract	<i>In-vivo</i> - mice	Analgesic	176
13	Cyperus rhizome	<i>In-vitro</i>	Neuroprotective	177
14	Hydroalcoholic extract	<i>In-vitro</i>	Anti-viral	178
15	Ethanol extract	<i>In-vivo</i> - rats	Anti-hypoxic	180
16	Tuber extract	<i>In-vitro</i>	Antimalarial	181
17	Rhizome extract	<i>In-vitro</i> and <i>ex-vivo</i>	Antiplatelet	182

CONCLUSION: Medicinal herbs are playing a vital role in healthcare systems since ancient times. They are being used to treat various ailments. These plants are the promising source of discoveries of new drugs. These herbs are the central part of all the medicine systems because they exhibit significant therapeutic properties. *Cyperus rotundus* is one of the important medicinal herbs which is in use to treat a number of diseases since ancient times. It is primarily used in Ayurveda and other traditional systems of medicines. It is commonly used against dysentery, cold, cough, cholera, diarrhoea, irritable bowel syndrome. It is used in many traditional polyherbal formulations. It has wide range of phytochemical constituents like saponins, flavonoids, sesquiterpenes, steroids etc. It exhibits biological properties like anti-inflammatory, antipyretic and analgesic activities, hepatoprotective, antimalarial activity, etc. This wonder herb can be a good and reliable source of new drugs.

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