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Phyto-pharmacotherapeutics of *Cyperus rotundus* Linn. (*Motha*): An overview

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Cyperus rotundus Linn. (Family: Cyperaceae), commonly known as *Motha* is a turf grass which grows everywhere including lawns . It has wide range of medicinal and pharmacological applications. It is used in traditional system of medicine and exhibits anti-inflammatory, anti-arthritic, antipyretic, analgesic, antidiabetic, antidiarrhoeal, cytoprotective, antmutagenic, antimicrobial, antioxidant, cytotoxic, apoptotic and various other activities. *Motha* is used in many Ayurvedic preparations. This paper provides an overview on phytopharmacological properties and multifaceted therapeutic benefits of the plant.

Keywords: Analgesic, Anti-arthritic, Anti-inflammatory, Cyperaceae, *Cyperus rotundus*, Gastroprotective, *Motha*, Nutgrass, Traditional medicine, Turf grass.

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Introduction

Cyperus rotundus Linn. (Family: Cyperaceae) is a multivalent plant widely used in traditional medicine around the world for treatment of various diseases (Plate 1). This plant is also known as Purple nutsedge or nutgrass (English), *Motha* (Hindi) or *Musta* (Sanskrit). *C. rotundus* is held in great esteem in Ayurveda, especially as a cure for gastrointestinal and joint ailments. This herb has been given special recognition in Ayurveda due to its multifaceted therapeutic benefits to cure various diseases. The studies conducted on animals and human subjects have shown that this widely growing medicinal plant has several pharmacological activities including anti-inflammatory, antidiabetic, antidiarrhoeal, antipyretic, analgesic activities, etc.[1-3]. In the present review, attempts have been made to provide state of art of scientific and clinical studies made on the use of *Cyperus rotundus* Linn. in the prevention and treatment of various ailments for better understanding of therapeutic potential of this medicinal plant.

Traditional uses

In Ayurveda, the roots and rhizomes of *C. rotundus* have been reported to possess multiple therapeutic actions: appetizer (*dipaniya*), digestive stimulant (*pacaniya*), anthelmintic (*krimighna*), diuretic (*mutra virecaniya*), scarifying/reducer of corpulence (*lekhanya*), purifyer of plasma (*rasa pacaniya*), antisaturative (*triptighna*), antipruriginous (*kandughna*), galactopurificator (*stanyashodana*), thirst restraining (*trishnagrahana*), etc. Hence,

Plate 1 — Tuberous root of *Cyperus rotundus* Linn.

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C. rotundus is recommended for use in several clinical conditions such as dyspepsia, thirst, fever, blood diseases, biliousness, dysentery, pruritis, pain, vomiting, epilepsy, ophthalmia, erysipelas, etc.[4-11].

Geographical source and chemical constituents

C. rotundus is indigenous to India, but now it is found in tropical, subtropical and temperate regions from Asia, South Africa, South America, etc.[6,12]. Different phytochemical studies on *C. rotundus* revealed the presence of alkaloids, flavonoids, tannins, starch, glycosides, furochromones, monoterpenes, sesquiterpenes, sitosterol, a fatty oil containing a neutral waxy substance, glycerol, linolenic, myristic and stearic acids[13-23]. Four chemotypes (H-, K-, M-O-types) of its rhizome essential oil from different parts of the world have been reported. The major compounds isolated from essential oil are: α-cyperone, cyperene, cyperotundone, cyperol, β-selinene, β-caryophyllene, valerenal, sugeonyl acetate, α-copaene, patchoulene, trans-pinocarveol, patchoulenenone, aristrol-9-en-3-one, selina-4, 11 diene, aristrol-9-en-8-one, kobusone, sugetriol, isokobusone, isocyperol, sugeonol and sitosterol[24-26]. Chemical structures of some important constituents are given in Figs 1-21.

Pharmacological activities

Pharmacological activities of *Cyperus rotundus* are summarized in Plate 2.

Anti-inflammatory

The alcoholic extract of *C. rotundus* showed highly significant (P<0.001) anti-inflammatory activity against the exudative and proliferative phases of inflammation in two animal models (carrageenin induced oedema and formaldehyde induced arthritis in rats). Its anti-inflammatory relative effect was higher than that of hydrocortisone (75.9% versus 47.3% in carrageenin-induced oedema model; 55.1% versus 35.6% in formaldehyde induced arthritis model)[2,3,27,28]. A highly potent anti-inflammatory fraction, eight times greater than that of hydrocortisone, was obtained by chromatographic separation from the petroleum ether extract[29]. This fraction was active also by the oral route (the oral to intraperitoneal relative efficacy was about one third) and had a safety margin about 3 times greater when compared with hydrocortisone. The active compound was identified as a triterpenoid.

Nitric oxide (NO) and superoxide (O^{2-}) are important mediators in the pathogenesis of inflammatory diseases, including arthritis. Seo *et al* reported that the methanol (MeOH) extract of rhizomes of *C. rotundus* could modulate NO and O^{2-} productions by murine macrophage cell line, RAW 264.7 cells. The extract inhibited NO production due to the suppression of iNOS protein, as well as iNOS mRNA expression, and also reduced the production of O^{2}(Ref. 30).

Clinical studies with 2% aqueous extract of *C. rotundus* showed anti-inflammatory activity in conjunctivitis (in human subjects)[31]. These actions could contribute to anti-inflammatory activity of *C. rotundus.*

Antipyretic

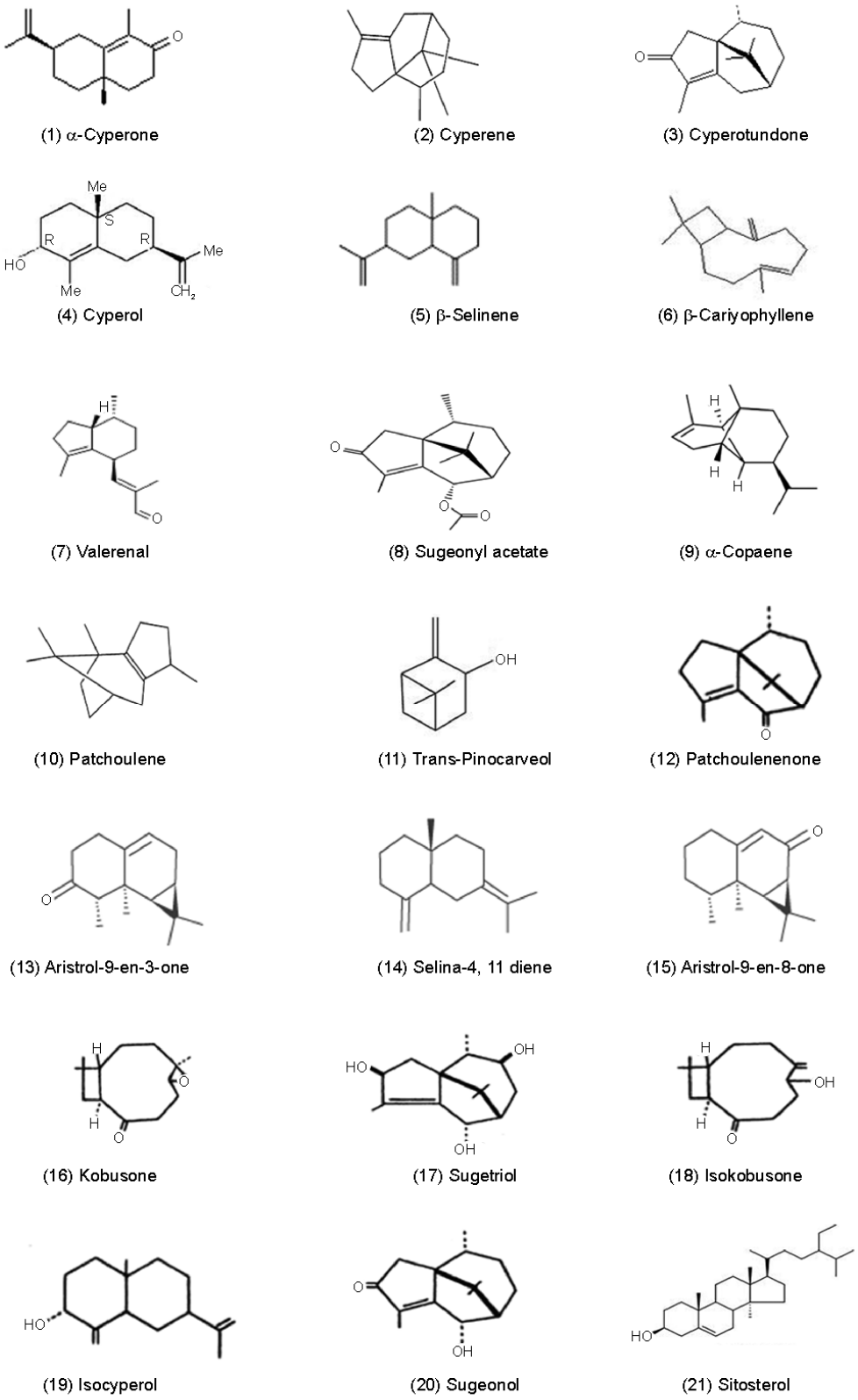
The alcoholic extract of *C. rotundus* showed highly significant (P<0.001) antipyretic activity against pyrexia produced in albino rats by the subcutaneous injection of suspension of dried Brewer's yeast in gum acacia in normal saline[3]. A specific fraction obtained by chromatographic method from the petroleum ether extract was found to posses a significant anti-pyretic effect similar to acetyl salicylic acid when used on the same animal model[29]. Thus presence of highly significant (P<0.001) anti-inflammatory and antipyretic activities in *C. rotundus* suggested that this herb would be a very useful remedy for arthritic conditions.

Analgesic and sedative

The total decocts of rhizomes of *C. rotundus* showed analgesic effects in the acetic acid writhing test[32]. The petroleum ether extract and essential oil of the plant are also reported to possess analgesic activity[29,33]. Further, the study conducted on isocurcumenol, a sesquiterpene isolated from *C. rotundus* has demonstrated that this compound acts as a benzodiazepine receptor agonist and thus, positively modulates GABAergic neurotransmission via enhancement of interaction of γ aminobutyric acid (GABA) with its receptor in animals. The benzodiazepine receptor is an important component of the GABA receptor complex. GABA being an inhibitory neurotransmitter, these findings provide a pharmacological explanation for the empirical use of *C. rotundus* as sedative[34].

Antiarthritic

Singh and his co-workers were first to discover anti-inflammatory, anti-pyretic and anti-rheumatic activity of *C. rotundus*[2,3,27,29,35]. A double blind trial of



Figs 1-21 — Chemical structures of some important constituents of *Cyperus rotundus* Linn.

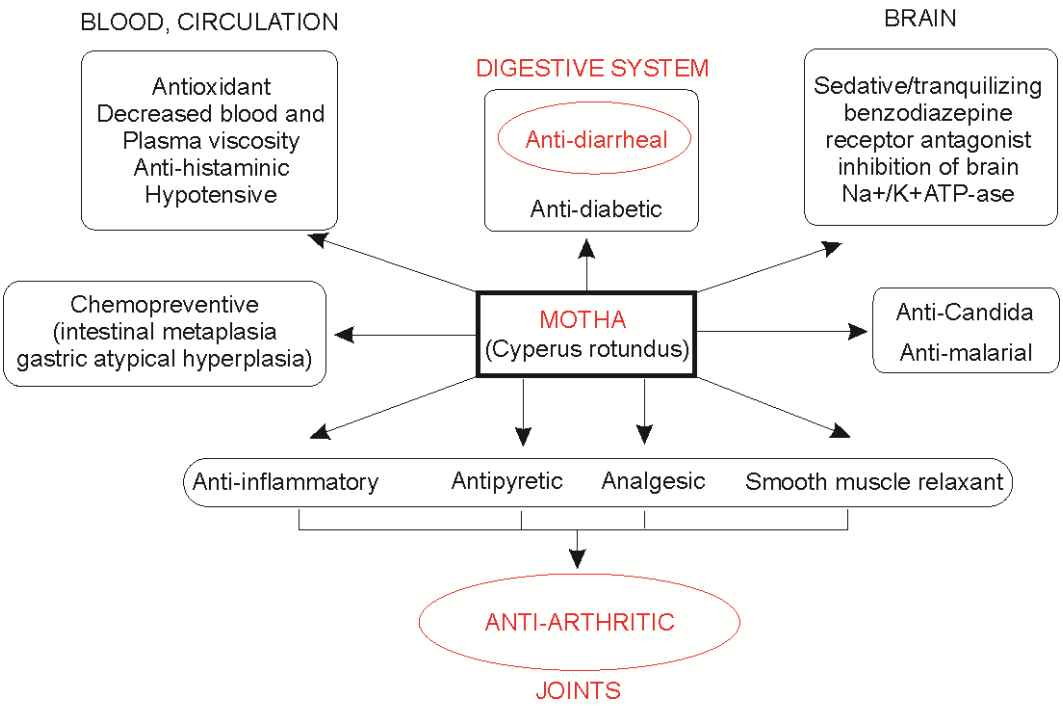


Plate 2 — Pharmacological activities of *Cyperus rotundus* Linn.

crude powder of *C. rotundus*, *Withania somnifera* and their combination (1:1) was carried out in 200 patients suffering from rheumatoid arthritis. Out of the 200 patients selected for the study 196 completed the trial of 3 months. Each group (including placebo group) consisted of 50 patients. Each patient received 500 mg capsule three times a day for three months. During this period biweekly general assessment based on global criteria (duration of morning stiffness, grip strength, articular index, consumption of escape analgesic, erythrocyte sedimentation rate, haemoglobin, rheumatoid factor titre, x-ray findings) was made. *C. rotundus* was more effective than *W. somnifera*, and when both drugs were combined, the response was better than the response of single drug. Also the patients' preference (against escape analgesic) was highest in the case of combined herbs[36].

The results of the clinical trial of *C. rotundus* in cases of arthritis showed beneficial effect in the treatment of patients with arthritis[37]. It has been found effective in the treatment of arthritis and the results of the studies were presented in IIIrd World Congress of Clinical Pharmacology & Therapeutics (IUPHAR), 1986, Stockholm, Sweden[38]. Clinical studies were conducted to evaluate the long term efficacy and tolerance of *C. rotundus* in rheumatoid and osteo-arthritis and significant results were obtained. A long term (3 years) clinical trial (3048 cases of rheumatoid arthritis and 1002 cases of osteoarthritis) was done for evaluating the efficacy of *C. rotundus*[39]. The study showed the following results in rheumatoid arthritis patients: (1) the highest percentage of subjects with good to excellent response was seen in fresh cases with active disease (73% of fresh cases, 56.3% of non corticoid drug treatment cases and 41.5 % of corticoid treated cases showed this therapeutic response); (2) the highest percentage of non response was seen in corticoid treated cases (20.28% of corticoid treated cases, 10.8% of non corticoid drug treated cases, and only 2% of fresh cases had no improvement). In osteoarthritis group, 70% cases (versus 18% of placebo subjects) showed a good to excellent response. The clinical data and results of this study were presented in the Xth International Congress of Pharmacology (IUHPAR), 1987, Sydney[39]. Further, we have designed a polyherbal formulation for the treatment of arthritis, using *C. rotundus* as the main ingredient, along with *W. somnifera* and *Ocimum sanctum* and carried out another clinical study including 570 cases of rheumatoid arthritis for the period of 10 months and the global criterion of rheumatic diseases were used for the assessment of the effect of Flexibility. In cases of rheumatoid arthritis 78% cases showed an excellent recovery and 74% cases of osteoarthritis showed excellent response

as judged by the global criteria[40]. No adverse reaction was observed in any subject participant to our study. No side effect has been reported with 8 g single dose, also. It is worthy to mention anecdotically that there are cases of rheumatoid arthritis on our record which have used *C. rotundus* powder for 10 to 25 years and have shown no side or toxic effect. Besides, no side effect was observed in our practice in any case of concomitant use of modern allopathic drugs (e.g. pain killers) with *C. rotundus*.

Other studies confirm our positive results in arthritic diseases. Biswas *et al*[41] showed that EazMov Plus, an Ayurvedic herbal preparation containing *C. rotundus*, *Tinospora cordifolia*, *Saussurea lappa*, *Picrorrhiza kurroa* and *Zingiber officinale* was effective in treatment of arthritic problems. 60 patients with OA (n=31), non-specific arthritis or rheumatoid arthritis were allocated randomly to take one capsule (50 mg) of either EazMov or Diclofenac three times daily after meals for 6 months. There was a definite improvement in parameters like severity of pain, morning stiffness with Eazmov. The clinical efficacy of EazMov was found to be significantly inferior to that of diclofenac regarding pain severity and disability scores, but safety profile and both hematological and biochemical parameters as well as Ritchie Articular index showed better effects with EazMov than Diclofenac.

Gastroprotective

C. rotundus extract protected against gastric mucosal injury induced by ischemia and reperfusion in rats. The mean ulcer index of rats treated with 200 and 100 mg/kg *C. rotundus* were significantly lower than that of control. The activities of glutathione-peroxidase and malondialdehyde were significantly affected by treatment of *C. rotundus*[42]. Cytoprotective effects of *C. rotundus* have been mentioned also in case of ethanol induced gastric damage in rats. Decoctions of *Rhizoma Cyperi* were given orally (1.25, 2.5, 4.0 g crude drug/kg) to rats 30 min before ethanol showed an ulcer inhibitory effect in a dose dependent manner. Pretreatment of rats with indomethacin (5 mg/kg) significantly reduced the gastric protective action of *C. rotundus.* The authors suggested that the gastroprotective action of *C. rotundus* is related to its inhibition of gastric motility and endogeneous prostaglandins[43].

Antidiarrhoeal

The methanol extract of its rhizome, given orally (250 and 500 mg/kg b.w.), showed significant antidiarrhoeal activity in castor oil induced diarrhoea in mice[44]. The decoction of tubers showed antigiardial activity, reduced bacterial adherence to and invasion of HEp-2 cells and affected production of cholera toxin (CT) and action of heat labile toxin (LT). The decoction of *C. rotundus* does not have marked antimicrobial activity and exerts its antidiarrheal action by mechanisms other than direct killing of the pathogen[45]. The methanol extract *Cyperus tegetum* Rox (MECT) showed significant antidiarrhoeal activity at the doses of 250, 500 and 750 mg/kg b.w. using castor oil and magnesium sulphate–induced diarrhoea models in mice. The extract, at the dose of 250, 500 and 750 mg/kg, retarded the intestinal transit of charcoal meal in mice as compared to the control. On the basis of these findings, it can be assumed that *C. tegetum* (another species) could be a potential source for novel 'lead' discovery for anti-diarrhoeal drug development[46].

Anti-emetic

The ethanolic extract of *C. rotundus* in the dose of 128.1± 11.6 mg/kg was found to protect 50% dogs against apomorphine induced vomiting[3].

Antispastic

Ethanolic extract of *C. rotundus* produced relaxation of rabbit ileum and spasmolytic effect against contractions induced by acetylcholine, barium chloride and 5-hydroxitriptamine, showing a direct relaxant action on the smooth muscle [3].

Tranquilizing activity

The ethanolic extract of *C. rotundus* showed potent tranquilizing activity in various tests: reduced the spontaneous motor activity, potentiated the pentobarbital narcosis and deranged the motor coordination, abolished the conditioned avoidance response in animals [3].

Anticonvulsant

Pretreatment with ethanolic extract of *C. rotundus* caused significant protection against strychnine and leptazol-induced convulsions in mice[47]. The ethanol extract of rhizomes (100 mg/kg, p.o.) reduced hind limb extension and duration of convulsion significantly, (P<0.001) which was comparable to standard drug Phenytoin (25 mg/kg, i.p.) and Diazepam (4 mg/kg, i.p.), respectively. These results suggest that the ethanol extract of its rhizomes is worthwhile to develop the potent phytoconstituent for treatment of epilepsy and the flavonoids present in

ethanol extract could be attributed for anticonvulsant activity[48].

Anti-obesity

C. rotundus preparations (powder in fine suspension, aqueous and alcoholic extracts) exhibited a lipolytic action and mobilized fat from the adipose tissues in rats, thus helping to reduce the obesity[49]. It was also demonstrated that administration of 45 or 220 mg/kg/day of it*s* tubers hexane extract for 60 days in Zucker rats induced a significant reduction in weight gain without affecting food consumption or inducing toxicity. *In vitro*, this extract was able to stimulate lipolysis in 3T3-F442 adipocytes suggesting that this medicinal plant contains activators of β-adrenoreceptors (AR). The binding assay performed on the rat β3-AR isoform, known to induce thermogenesis, demonstrated that tubers extract can consistently and effectively bind to this receptor. These data suggest that the effect on weight gain exerted by tubers extract may be mediated, at least partially, through the activation of the β3-AR[50]. A pilot study carried out on 30 obese people who were administered the powdered tuber of *C. rotundus* for 90 days, showed reduction in weight along with a decrease in serum cholesterol and triglycerides[51].

Hypolipemiant

Administration of *C. rotundus* extract restored the age associated change in serum lipids (total cholesterol, LDL cholesterol, HDL cholesterol, triglycerides and VLDL triglyceride level) to the level of young control rats. In young rats, treatment of *C. rotundus* significantly increased HDL cholesterol level[52].

Antidiabetic

Oral daily administration of 500 mg/kg of the extract (once a day for seven consecutive days) significantly lowered the blood glucose levels in rats with alloxan induced diabetes[53]. The scientists concluded that this antihyperglycemic activity can be attributed to its antioxidant activity as *C. rotundus* showed a strong 1,1-diphenyl-2-picryihydrazyl (DPPH) radical scavenging action *in vitro*. These results are convergent with *C. rotundus* potential to suppresses AGE formation and protein oxidation in a model of fructose-mediated protein glycoxidation[54]. Scientists concluded that, since non-enzymatic glycation has been shown to correlate with severity of diabetes and its complications, *C. rotundus* could be a candidate for targeting diabetic complications.

Anti-histaminic

The alcoholic extract of *C. rotundus* showed a weak capacity to protect guinea-pigs against bronchospasm induced by histamine aerosol[3].

Haemodynamic (hypotensive)

The alcoholic extract of *C .rotundus* produced gradual and persistent fall in blood pressure and stimulated the respiration. The responses of epinephrine and acetylcholine on blood pressure were not altered by the extract, but that of histamine was partially blocked[3].

Anticancer

C. rotundus ethanolic extract was found to have only weak to moderate anticancer activity (LC_{50}=2.528-4.939 mg/ml calculated from dose-dependent cell death) in a study which used neuro-2a cells for screening of plants with tumoricidal effects[55]. Other study showed that *C. rotundus* essential oil was very effective against L1210 leukaemia cells line. This result correlated with significantly increased apoptotic DNA fragmentation[56].

Antibacterial

Proteus vulgaris was sensitive to acetone extract (6 mg/disc) of *C. rotundus*, while other bacteria (e.g. *Escherichia coli, Pseudomonas aeruginosa,* etc.) were resistant to *C. rotundus* with 10 mg/disc (maximum dose tested). When compared with other herbs, *C. rotundus* had mild antibacterial activity in high doses[57]. A marked inhibitory effect of *C. rotundus* was observed against *Salmonella enteritidis*, *Staphylococcus aureus* and *Enterococcus faecalis* with total oligomers flavonoids (TOFs) and ethyl acetate extracts[58].

Antimalarial

Of 49 Tanzanian medicinal plants tested for *in vitro* antimalarial activity using multidrug resistant K1 strain of *Plasmodium falciparum*, tubers of *C. rotundus* were among three most active plants[59]. The most active antimalarial compounds isolated from *C. rotundus* extract included alpha-cyperone, autoxidation products of beta-selinene[60] and novel endoperoxide sesquiterpine, 10, 12-peroxycalamenene[61].

Hemorrheological changes

C. rotundus could improve all hemorrheological indexes such as blood specific viscosity, the plasma specific viscosity, erythrocyte electrophoresis, etc. in normal rats and "blood stagnating" rats. The "blood

stagnating" model was built with adrenaline and cold stimulation and is characterized by increased viscosity, thickness and liability to coagulate. The combination of *C. rotundus*, which is a Qi-regulating drug, and other two blood activating drugs (*Ligusticum chuanxiong* and *Paeonia veitchii*), display more favourable effect than single herbs or blood enriching drugs (*Astragalus membranaceus* and *Angelica sinensis*)[62,63].

Inhibitory activity on Brain Na^+/K^+-ATP-ase

Extract of *C. rotundus* showed high potent inhibitory activity on crude enzyme Na^+/K^+-ATP-ase from rat brain[64].

Anti-Candida

Essential oil from rhizomes of Brazalian *C. rotundus* showed anti-Candida activity, while the ethanolic extract was not effective at any concentration tested [65].

Antimetaplasic

A polyherbal Chinese formulation containing *C. rotundus* called Xiao Wei Yan (powder) has been used for its anti-metaplasic potential. Other herbs included in the formation were: *Smilax glabrae*, *Hedyotis diffusae*, *Taraxacum mongolicum*, *Caesalpinia sappan*, *Paeonia alba*, *Bletilla striata*, *Glycyrrhiza uralensis*, etc. 138 cases of intestinal metaplasia and 104 cases of atypical hyperplasia of the gastric mucosa of chronic gastritis diagnosed by biopsy were randomly divided into treated group and control group. The powder was taken orally 5-7 g three times daily for 2-4 months. After this period gastroscopic and pathological examination showed marked therapeutic effects for treated group when compare to control: the total effective rate of intestinal metaplasia was 91.3% (treated group) versus 21.3% (control group) and that of gastric atypical hyperplasia was 92.16% (treated group) versus 14.46% (control group)[66].

Discussion

C. rotundus commonly known as *Motha* is abundantly available and it provides good source of remedy to treat various ailments. It is cheapest and most abundantly available medicinal herb. It is a common turf grass growing wild in fields and it has got fragrant, black, tuberous roots which are used for inflammatory conditions. Tuberous roots grow in bunches deep underground and that is why it is very difficult to take out this herb from the soil, being a great nuisance for potato growers. Thus, everybody wishes to take out all tubers and throw it out from the field. It's rooting out helps farmer for better growth of potatoes and other vegetables. Hence it forms the most easily available and cheap source of medicinal herbs. Besides being medicine, a kind of khus scent is made out from the tubers of this herb. Thus in certain places like Kannauj in southern part of Uttar Pradesh, they produce a lot of khus (scent) from this. In our experiment we were surprised to find many pharmacological activities in this excellent herb with many medicinal values. While conducting pharmacological studies on various biological models Singh and Co-workers[2,3,27,29,35] reported for the first time this plant to possess very potent anti-inflammatory, analgesic and antipyretic activities. The anti-inflammatory activity was better than Prednisolone so far efficacy of the herb was concerned. Later, Singh and Co-workers during their clinical studies found potent anti-arthritic activity in the tuberous root powder of this plant[36]. In addition, this herb is used in more than hundred pharmaceutical preparations of Ayurveda to treat various kinds of ailments[67].

C. rotundus with a large number of biologically active phytochemicals has diverse variety of pharmacological properties, as described above, has been found effective in the treatment of chronic disorders. At our institute (International Institute of Herbal Medicine, Lucknow, U.P. India), we have developed a herbal formulation "Flexibility" with combination of three medicinal herbs namely *Motha* (*Cyperus rotundus*), Ashwagandha (*Withania somnifera*) and Tulsi (*Ocimum sanctum*). This herbal formulation helps to relieve the discomfort due to pain and inflammation especially in the joints and muscles (arthritic conditions), but also other type of inflammatory diseases. Hence, it was tried in a variety of arthritic conditions and was found to be very effective in rheumatoid, osteo- and peri-arthritis cases[38]. Its effects are excellent and no adverse reaction was observed in all the patients, who volunteered to take its powder. There are cases of rheumatoid arthritis on our record who have used mainly *C. rotundus* powder from 10 to 25 years duration and have shown no side or toxic effect of the powder. Besides, no adverse effect was observed in any case as an interaction with modern allopathic drugs (e.g. pain killers). Thus, it is compatible and

safe therapy for long-term use in human subjects as all non-steroidal anti-inflammatory drugs (NSAID) and steroids cause gastric problems like gastritis and peptic ulcers. *C. rotundus* as anti-inflammatory, antipyretic, analgesic is also an anti-ulcerogenic agent[28] and protects gastric mucosa.

Conclusion

Although the scientific studies on biological models and the clinical studies conducted in human subjects do prove the efficacy of *C. rotundus* in the treatment of various human diseases and its rhizomes powder alone or as 'Flexibility' have great value especially in the long-term management of arthritic, gastro-intestinal diseases and various inflammatory conditions, more systematic clinical studies and data projection are needed to further strengthen our contentions of its usefulness. Further, this study explores one of the cheapest and effective medicinal resources from this automatically growing plant all over India for use in thousands of arthritic condition patients where more than two percent world's population suffer from one kind or the other kinds of arthritis.

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