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A review on phytochemistry and pharmacological activities of *Cyperus scariosus*

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Abstract
Cyperus scariosus R. Br. (Family Cyperaceae), is an important medicinal plant in Indian System of Medicine found wildly in different parts of the country. It is pestiferous perennial, delicate slender sedge wildly used for extraction of essential oil. Phytochemical studies have shown that the essential oil consists of polyphenol, flavonol, glycoside, alkaloid, saponins, sesquiterpenoids as major chemical components of this herb. The essential oil of rhizomes of *C. scariosus* have pleasant aromatic odour and possess various biological activities such as anti-inflammatory, anti-microbial, anti-fungal, antioxidants, growth regulating properties, analgesis, antidiabetic, hypotensive and splasmolytic. The phytochemical and pharmacological activities of *C. scariosus* have supported its traditional as well as prospective uses as a valuable ayurvedic plant. This review covers the phytochemistry and pharmacological activites of the plant and its essential oil.

Keywords: *Cyperus scariosus*, Essential oil, Pharmacological activities**,** Phytochemistry

Introduction
Medicinal and aromatic plants are widely used as medicine and constitute a major source of natural organic compounds. The traditional medicinal methods, recognized as alternative system of medicine, still play an important role to cover the basic health needs in the developing countries. The medicinal plants due to their least side effects as compared to synthetic chemicals are used for the treatment of various diseases (Khan *et al*. 2009) [25]. Natural products offer an untold diversity of chemical structures, serving as lead molecules, the activities of which can be enhanced by chemical manipulation or *de novo* synthesis (Houghton 1995) [19]. Naturally occurring biologically active compounds such as, essential oils and several plant extracts are less hazardous and represent a rich source of potential disease-control agents (Tripathi and Dubey 2004) [45]. A great number of aromatic and other medicinal plants of family cyperaceae contain chemical compounds that exhibit biological properties. *Cyperus scariosus* is a valuable multipurpose medicinal herb of large cosmopolitan family of monocotyledons comprising about 3700 species within 70 genera (Schultze-Motel 1964) [44]. It is commonly known as Nut grass, Nagarmotha in Hindi and Nagar musta in Sanskrit, Lawala in Marathi and Koraikkilangu in Tamil and xiangfu/xiangfuzi in Chinese (Chopra *et al*. 1986) [8]. *C. scariosus* is pestiferous perennial, delicate slender sedge found wildly in various parts of the country, around rivers, waterfall especially in damp or marshy areas. *C. scariosus* is perennial, with height of approximately 45-75 cm, leaves are sharp, pointed and 0.3-0.85 cm wide. Flowering is seen in July and fruits are formed in December and length of flowers is 5-17.5 cm. The plant requires sun and moist conditions, though it grows in sandy as well as in loamy soil moist fields, particularly in Pacific Islands and along coastal regions. *C. scariosus* grows rapidly and fills the soil with its tangle of roots and rhizomes occur 3-4 cm deep in soil and possess pleasant aromatic odour, the essential oil mostly used as anti-inflammatory, anti-microbial and anti-fungal agent is also forms as one of the ingredients in several ayurvedic formulations (Lavanya *et al.* 2014) [30]. Plant roots have a folkloric reputation as a cordial, tonic, desiccant, emmenagogue, diaphoretic and vermifuge (Said 1982) [43]. It is also used as fodder, yielding culms, tuberous rhizomes are used for edible, medicinal and perfumery purposes. It is used to treate a variety of diseases including diarrhea, epilepsy, fever, gonorrhea, liver damage, syphilis and act as an important ingredient of several prescriptions used in indegenoius system of medicine (Kritikar and Basu 1918) [27]. The essential oil obtained from rhizomes and roots of the plant has its value in perfumery (Kahol *et al*. 1987) [21] and is also known to possess antibacterial (Lahariya and Rao 1979) [29], antifungal (Deshmukh *et al*. 1986) [10]. as well as plant growth regulating properties (Kalsi *et al*. 1980) [24], analgesis and anti-diabetic activity (Alam *et al*. 2011) [2], haptoprotective activity (Gilani and Janbaz 1995) [16], hypotensive and splasmolytic activity

(Gilani *et al*. 1994) [15]. Since the last two decades, various attempts have been made to investigate the chemical constituents and pharmacological activities of *C. scariosus.* Unfortunately, no review has been published on such an extensively investigated medicinal plant including such aspects as its botany, traditional uses, phytoconstituents, therapeutic activities, and clinical application. This article aims to provide up-to-date information on the advances in the phytochemical investigations, pharmacological potential, toxicity, and future prospects of *C. scariosus.*

2. Taxonomy, Distribution and Morphology

It belongs to Kingdom- Plantae, order -Poales, Family - Cyperaceae, Genus -Cyperus and species - *scariosus*. The genus Cyperus is pantropical extending into warm temperate regions. In India, *Cyperus scariosus* is widely distributed especially in Chhattisgarh, Bihar, Orissa, in damp places in Uttar Pradesh, Madhya Pradesh and Bengal (Chopra *et al*. 1986, Jain 1991) [8, 20]. It is also found in South Africa, China and Pacific Islands. The color of this plant is initially white, eventually turning brown or black and has the muddy odor. Stolons are 10-20 cm long crowded with a number of rhizomes that are bluntly conical and vary in size and thickness. They are initially white, fleshy with scaly leaves and later with increase in age become fibrous and wiry. These rhizome show a typical swelling outline in transverse sections having no cork and consists of an outer layer of epidermis made up of small tabular cells followed by a hypodermal sclerenchyma (3-4 layers) packed with brownish or blackish tannin deposits. Within this sclerenchymatous zone there is a wide zone of inner cortex whose parenchyma cells are filled with starch grains which are elliptical and having 12-15 µm width in the broadest region and 4-6 µm in the narrowest region. Most of the cortical parenchyma cells are also packed with condensed natural reddish-brown color with a mixture of terpenoids and alkaloids. The innermost cortex is separated from the stele by a two layered false endodermis with lignified and tangentially elongated cells. The stele is a mixture of scattered vascular strands and ground parenchyma tissue, the latter showing all features of cortical parenchyma. Each vascular strand is concentric with phloem in the center and xylem surrounding it. Some of the phloem cells also contain tannin, but rarely alkaloid-terpenoid complex (Adams *et al*. 2013) [1].

3. Phytochemical investigation

The essential oil of *C. scariosus* constituted of mostly sesquiterpenes, such as cyperene, rotundene, rotundenol, isopatchoula-3,5-diene, isopatchoul-3-ene, β-selinene, isopatchoulenol and scariodione. Phytochemical studies show that the major chemical components of this herb are polyphenol, flavonol, glycoside, alkaloid, saponins and sesquiterpenoids.

3.1 Essential oil: *C. scarious* is rich in secondary metabolites. Extraction of essential oil from the rhizome is carried out by steam distillation by passing steam generated by a boiler through dried crushed rhizome. The pressure of steam is controlled according to the nature of plant material. The tank, condenser and receiver-cum-separator are made-up of stainless steel (Sahu *et al*. 2010) [42]. The commercial oil of Cyperus is known as cyperiol is obtained from the rhizomes of *C. scariosus* by hydro-distillation.

3.2 Phytochemical characteristics

As compared to *C. rotundus*, little information is available on the chemical composition of *C. scariosus*. The essential oil was found to contain bicyclic and tricyclic sesquiterpenes (Naves and Ardizio 1954) [31]. Dhingra and Dhingra (1957) [11] reported that the essential oil of *C. scariosus* contains a bicyclic ketone, a tricyclic tertiary alcohol and a tricyclic sesquiterpene hydrocarbon. Nerali *et al*. (1965) [35] reported the isolation of a new sesquiterpene ketone isopatchoulenone (I) which was structuraly similar to patchoulenone from *C. scariosus*. Nigam (1965) [37] isolated a sesquiterpene ketone, cyperenone (I), from the same species. Hikino *et al*. (1967) [18] isolated a sesquiterpene ketone cyperotundone (I) from the three species of the Cyperus genus (*C. rotundus*, *C. scariosus* and *C. articulatus*). Neville *et al.* (1968) [36] isolated a ketone and from spectral data established that the ketones isolated by the earlier investigators were one and the same and proposed a new name, isopatchoul-4 (5)-en-3-one (I). Nerali *et al*. (1967) [33] isolated two sesquiterpene alcohols, cyperenol (II) and patchoulenol (III) from the alcoholic fractions of the essential oils of the tubers. Nerali and Chakravarti (1969) [32] established the structure and stereochemistry of scariodione, from the oil of *Cyperus scariosus* Nerali *et al*. (1970) [34] isolated rotundene (IV) and rotundenol (V) sesquiterpenes from *C. scariosus* and the structure was established by Paknikar *et al*. (1977) [38]. Two sesquiterpenoids hydrocarbon (-)-beta-selinene (VI) and the new compound isopatchoula-3,5-diene (VII) was isolated from the essential oil of *C. scariosus* rhizome (Gopichand *et al*. 1978) [17]. Uppal *et al*. (1984) [46] isolated a new hydrocarbon, isopatchoul-3-ene (VIII) which on spectral characterization was found to be a tricyclic compound with an isopatchoulane type carbon skeleton. Longiverbenone (IX), a naturally occurring sesquiterpene was isolated from ethanolic extract of *C. scariosus* rhizome by solvent-solvent partioning and chromatographic technique (Rahman and Anwar 2008) [40]. Sahu *et al*. (2010) [46] isolated a new compound, 2, 3-diacetoxy-19-hydroxy-urs-12-ene-24-O-β-D-xylopyranoside (X) from tubers of *C. scariosus*. The preliminary phytochemical investigation of hexane and chloroform extracts of *C. scariosus* rhizomes chromatographed on silica gel led to the isolation of stigmasterol (XI), β-sitosterol (XII) and lupeol (XIII) as major constituents (Kakarla *et al*. 2015) [22]. Bhatt *et al.* (1981) [4] studied the phytoconstituents of the leaves of *C. scariosus* and isolated a phenolic glycoside, which on acidic hydrolysis gave an aglycone along with glucose and rhamnose. The aglycone was identified as leptosidin and the structure of the new glycoside was assigned as leptosidin 6-*O*-β-D-glucopyranosyl-*O*-α-L-rhamnopyranoside. Two glycosides, leptosidin-6-O-[β-D-xylopyranosyl (14)-β-D-arabinoside (Bhatt *et al*. 1984) [6] and stigmasta-5, 24 (28)-diene-3 β-O-α-L-rhamnopyranosyl-O-β-D-aabinopyranoside were also isolated from the leaves (Bhatt *et al*. 1982) [5].

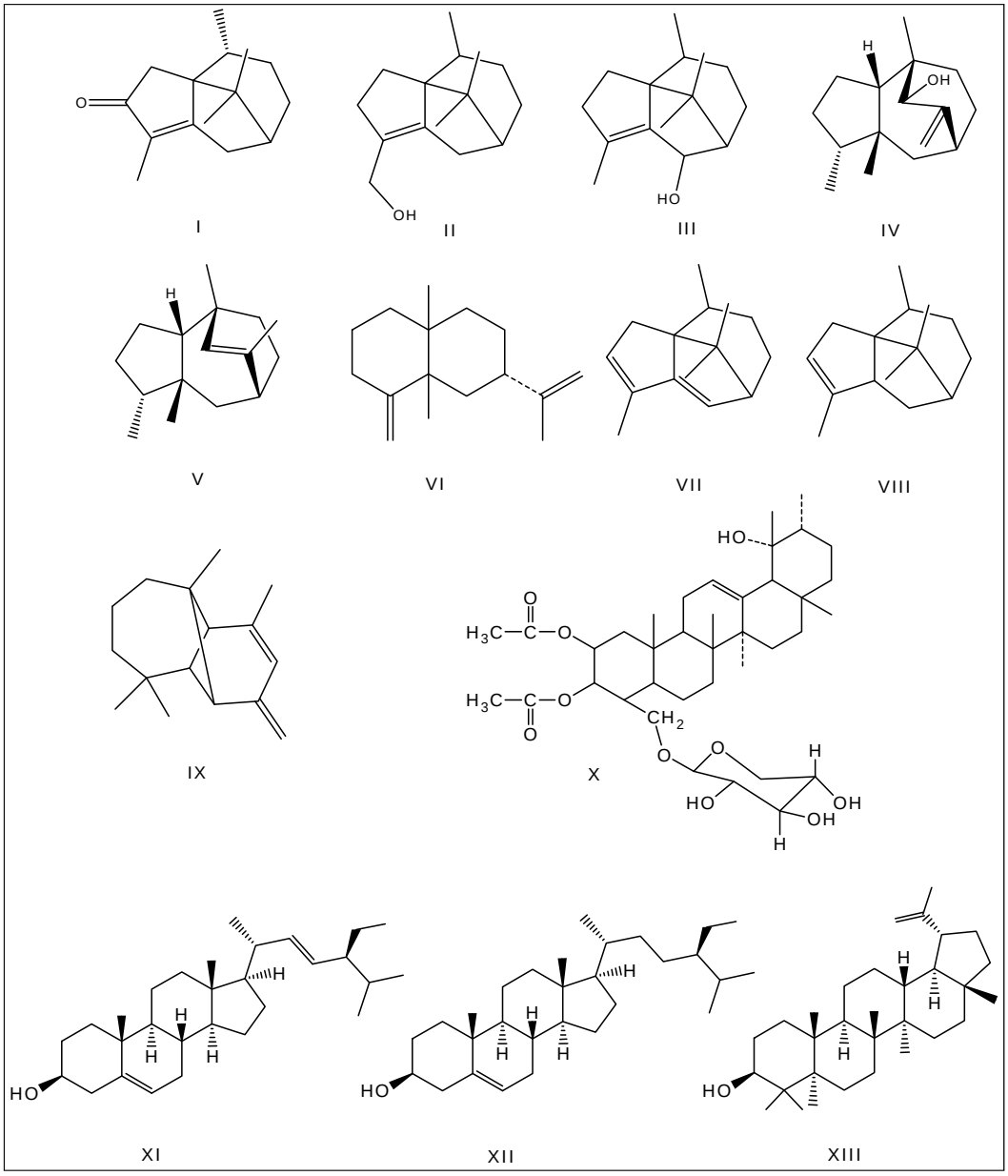

Fig 1: Compounds isolated from the *C. scariosus*

Table 1: GCMS analysis of hydro distilled essential oil of *C. scariosus* from India

Sr. no.	Major compounds	Percentage	Reference
1	Isopatchoul-4(5)-en-3-one	16.5	Garg *et al* 1990 [14]
	Cyperene	15.75	
	Patchoulenone	7.60	
	Rotundone	5.10	
	Rotundene	4.75	
	An unidentified sesquiterpenoid	7.20	
2	Cyperene	13.91	Pandey and Chowdhury2002 [39]
	Caryophyllene oxide	12.45	
	Iso-patchoul-4 (5)-en-3-one	12.25	
	Trans-pinocarveol	7.24	
	Rotundene	5.76	
	Eudesma-4(14)-11-diene	4.55	
	Rotundone	4.32	
	α-gurjunene	3.53	
	Guaiazulene	3.21	
3	Camphene	11.26	Chowdhury *et al* 2005 [9]
	α-pinene	8.84	
	Copaene	7.6	
	caryophyllene oxide	7.15	

	Myrtenal	6.41	
4	Cyperene	30.60	Dubey *et al* 2011 [12]
	α- Humulene	10.66	
	Valencene	6.18	
	β-caryophyllene oxide	3.84	
	Longifolendehyde	4.11	
	Zierone	6.54	
5	Cyperene	19.84	Dubey *et al* 2011 [12]
	α- Humulene	7.12	
	Valencene	5.43	
	β-caryophyllene oxide	3.73	
	Longifolendehyde	4.59	
	longiverbenone	5.89	
	Zierone	10.68	

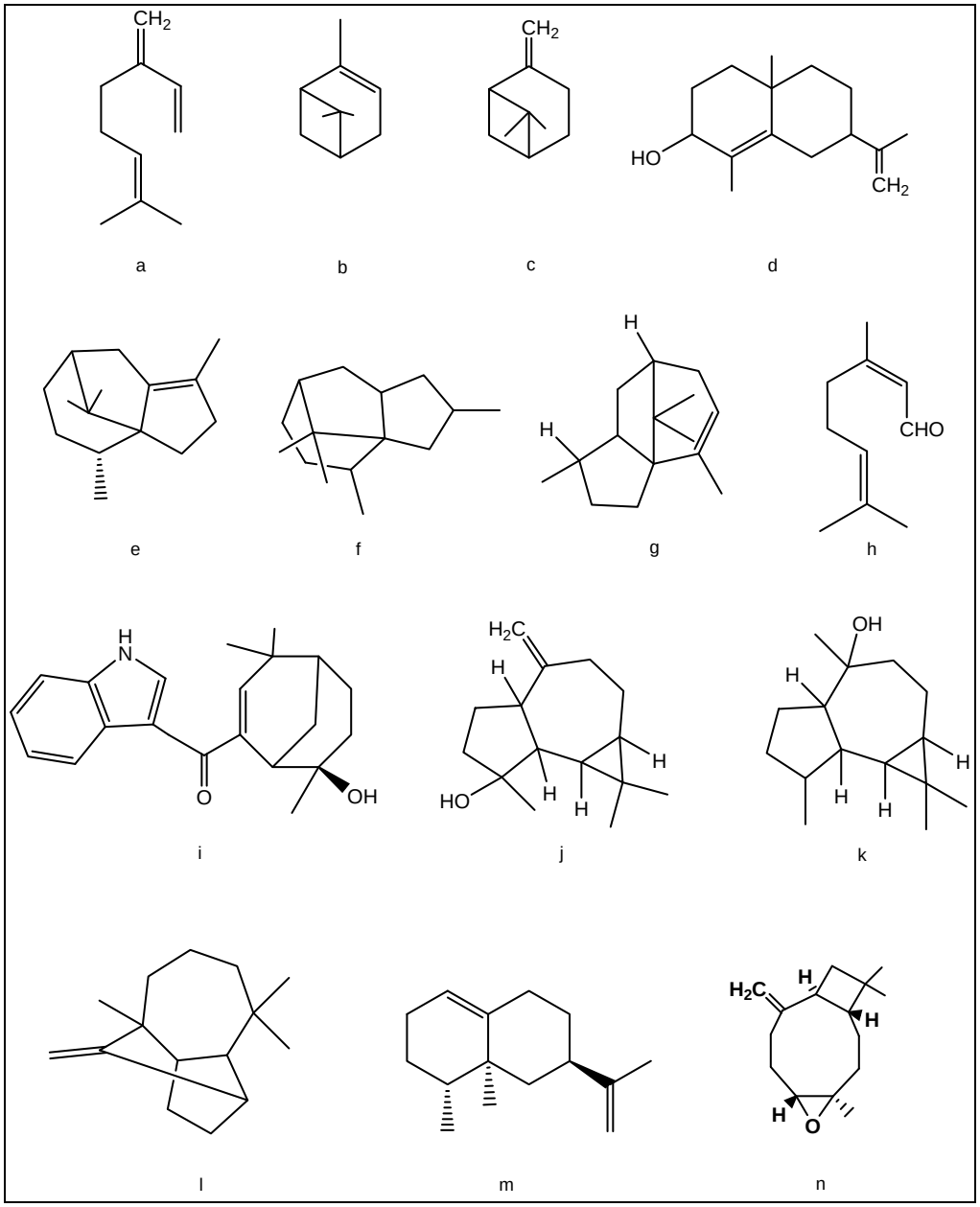

Fig 2: Compounds identified by GCMS. a) Myrecene b) α-pinene c) β-pinene d) cyperol e) cyperene f) patchoulane g) patchoulene h) citral i) aristolone j) spathulenol k) sesquiterpene alcohol l) longifolene m) Valencene n) Caryophyllene oxide

3.3 Effect of Geographical Climatic Conditions on Yield, Carbon Isotope Composition and Chemical Composition

Kumar *et al*. (2016) [28] studied the essential oil of rhizome of *C. scariosus* (13 accessions) from five states of India. The essential oil yield in all the thirteen accessions showed significant variation and results are depicited in Table 2. Stable carbon isotope composition analysis of nagarmotha rhizome essential oil was performed on the Isotope Ratio Mass Spectrometry (IRMS) of Therm-Fisher Scientific (Germany).

Table 2: Oil content from Nagarmotha rhizome accessions collected from different places of India

No.	Place	State	Oil content (%) hydro-distillation	Carbon isotope (d 13C/12C)
1	Badarpur	Orissa	0.26±0.020	-12.84±0.10
2	Padampur	Orissa	0.20±0.035	-12.79±0.12
3	Chhattarpur	Madhya Pradesh	0.50±0.025	-12.52±0.26
4	Khajuraho	Madhya Pradesh	0.38±0.030	-13.18±0.56
5	Panna	Madhya Pradesh	0.38±0.035	-12.60±0.18
6	Tilakgram	Madhya Pradesh	0.58±0.025	-14.26±0.12
7	Tikamgarh	Madhya Pradesh	0.27±0.005	-12.24±0.08
8	Ujjain	Madhya Pradesh	0.27±0.03	-11.53±0.89
9	Raipur	Chhattisgarh	0.47±0.026	-15.97±1.66
10	Mahasamudra-I	Chhattisgarh	0.34±0.03	-13.56±0.33
11	Mahasamudra-II	Chhattisgarh	0.42±0.040	-13.43±0.19
12	Kolkata	West Bengal	0.24±0.026	-14.46±0.78
13	Sitapur	Uttar Pradesh	0.39±0.030	-16.17±0.69

The distilled oil was analysed for estimation of its chemical composition using GC-MS. Wide variation was observed in the chemical composition of the nagarmotha oils of different accessions (Table 3).

Table 3: Variation in percentage of major compounds of different regions in india

No.	Place	State	Cyperene	Caryophyllene oxide	Longiverbenone	Longifolene
1	Badarpur	Orissa	7.87	10.17	12.71	15.18
2	Padampur	Orissa	22.54	2.42	3.96	6.95
3	Chhattarpur	Madhya Pradesh	11.89	4.29	9.38	10.35
4	Khajuraho	Madhya Pradesh	16.20	7.76	5.38	12.63
5	Panna	Madhya Pradesh	10.89	5.21	10.28	20.43
6	Tilakgram	Madhya Pradesh	5.77	10.38	6.89	14.18
7	Tikamgarh	Madhya Pradesh	19.90	5.92	7.37	17.90
8	Ujjain	Madhya Pradesh	12.61	6.58	6.54	10.98
9	Raipur	Chhattisgarh	24.17	2.65	3.68	5.95
10	Mahasamudra-I	Chhattisgarh	16.63	6.74	9.15	13.62
11	Mahasamudra-II	Chhattisgarh	15.03	8.98	7.65	9.81
12	Kolkata	West Bengal	17.09	6.89	6.56	14.50
13	Sitapur	Uttar Pradesh	15.25	5.38	7.61	17.51

4. Pharmacological activities

Cyperus has numerous chemical constituents, manly sesquiterpenoids most of which may show pharmacological activity as investigated and reported by many workers

4.1 Anti-nociceptive activity

Anti-nociceptive activity of methanol extract of *C. scariosus* leaves was examined by Alam *et al*. (2011) [2]. Mice were separated into five groups containing seven mice each. Group-I served as control (1% Tween 80 in water, 10 mg/kg body weight). Aspirin was administered to Group-II mice at a dose of 200 mg/kg body weight. Groups-III to V was given 50, 100 and 200 mg/kg body weight of the extract, respectively orally 30 min before acetic acid injection. In all groups, pain was induced through intraperitoneal administration of 1% acetic acid at a dose of 10 ml/kg body weight. A period of 5 minutes was given to each animal and then, the number of writhings was counted for 10 min. It was found that with methanol extract of leaves, the maximum inhibition of writhing (46.62%) was obtained at the dose of 200 mg extract/kg body weight (p<0.01), whereas the standard, aspirin caused 56.74% (p<0.001) writhing inhibition at the same dose.

4.2 Hypotensive and Spasmolytic activity

Intravenous administration of hydro-methanolic extract of *Cyperus scariosus* (3-10 mg/kg) produced hypotensive and bradycardiac effects. These effects remained unaltered in atropinized animals indicating that cardiovascular effects of the plant extract are not mediated through activation of muscarinic receptors. *In vitro* studies, it suppressed the spontaneous contractions of guinea-pig paired atria, rat uterus and rabbit jejunum in a concentration-dependent (0.1-1 mg/ml) manner. It also inhibited histamine or acetylcholine-induced contractions of guinea-pig ileum indicating non-specific spasmolytic action. In rabbit aorta, it inhibited norepinephrine (10 pM) as well as K^+ (80 mM)-induced contractions at similar concentrations (0.1-1 mg/ml). These data indicate that *Cyperus scariosus* contains Ca^{2+} channel blocker-like constituent(s) which may explain hypotensive effect observed *in vivo* and the general spasmolytic activity of plant may explain its folkloric use in diarrhea (Gilani *et al*. 1994) [15].

4.3 Hepatoprotective activity

The aqueous-methanolic extract of *Cyperus scariosus* was investigated for hepatoprotective activity against acetaminophen and CCl_4-induced hepatic damage. Complete mortality was observed at a dose of I g/kg in mice on treatment with Acetaminophen while pretreatment with plant extract (500 mg/kg) reduced the death rate to 30% of animals. Acetaminophen at a dose of 640 mg/kg resulted in rise in serum levels of alkaline phosphatase (ALP), glutamate oxaloacetate transaminase (GOT) and glutamate pyruvate transaminase and produced liver damage in rats. Pretreatment of rats with plant extract (500 mg/kg) significantly lowered ($P < 0.05$) the respective serum ALP, GOT and GPT levels. The same dose of plant extract (500 mg/kg) was able to significantly prevent ($P < 0.05$) $CC1_4$-induced rise in serum enzymes and also prevented CC14-induced prolongation in pentobarbital sleeping time (Gilani and Janbaz 1995) [16].

4.4 Hypersentivity

C. scariosus chloroform fraction inhibits T cell responses in Balb/c mice in both humoral and cell mediated immune responses on p.o administration significantly p<0.01 by suppressing primary (26.8%) and secondary (29.7%) antibody titres and also inhibited cell mediated delayed type hypersensitivity immune response (45.9%) at 600mg/kg dose phagocytosis both *in vitro* (37.4%) and ex vivo (37.8%) and delayed the graft rejection time (45.8%), thus confirming marked immunosuppression. Chloroform fraction significantly p<0.01 suppressed CD8+/CD4+T cell surface markers (14.0/25.3%) and intra-cellular Th1 cytokines, viz IL-2(34.4%) and IFN-γ (34.7%) compared to cyclosporine-A, a standard T cell inhibitor 53.6% which was given to Balb/c mice at 200 mg/kg dose. *C. scariosus* did not show significantly p<0.01 suppress Th2 (IL-4) system (Bhagwat *et al*. 2009) [3].

4.5 Antidepressant activity

The n-hexane extract of *C. scariosus* oil exhibited antidepressant activity in mice. With two dose levels at 100 and 200mg/kg antidepressant activity was screened using forced swim test and tail suspension test in mice and results were compared with standard drug (imipramine) at 15mg/kg. *C. scariosus* n-hexane extract oil significantly p<0.001 reduced the immobility time in both dose levels at FST and TST which is similar to standard drug imipramine. The n-hexane extract of *C. scariosus* oil may show antidepressant activity due to increase of nor epinephrine level in synapses (Ramesh *et al*. 2012) [41].

4.6 Micro propagation

C. scariosus axillary bud explants inoculated on SH medium, supplemented with different concentrations of Benzyl adenine, Kinetin and Indole-3-butyric acid for *in vitro* regeneration. Maximum numbers of shoots observed on media containing1.0mg/lt BA and 1.0mg/ltKn after 2 weeks of culture inoculation. Kn 1 mg/lit with Adenosine 1mg/lit and Charcoal 500mg/lit gave best results in rooting from shoots [44]. Efficient flowering 80% was recorded on SH media with Kn 0.75mg/lt+ADS 1.0mg/lt+activated charcoal 500 mg/lt. Multiple shooting and multiple rooting was effective on full strength SH medium supplemented with Kn1.5mg/lt+ADS1.0mg/lt+ activated charcoal 500mg/lt+5% coconut water (Lavanya *et al*. 2005) [30].

4.7 Anti-hyperglycemic activity

Glucose tolerance property of *C. scariosus* leaves was determined on mice. Six groups of fasted seven mice each were made. Group-I served as control and received 1% Tween 80 in water, 10 ml/kg of body weight and, Group-II received standard drug (glibenclamide, 10 mg/kg of body weight) and the other four groups received four different doses of the methanol extract of *C. scariosus* leaves. After a period of one hour, a dose of 2 g/kg of body weight of glucose were orally administered to all mice and after two hours of the glucose administration blood samples were collected. Serum glucose levels were measured by glucose oxidase method. The results revealed that the methanol extract exhibited dose-dependent activity. The increase in dose of the extract showed significant effect as compared to the control. The maximum inhibition effect was found with the dose of 400 mg extract/kg body weight (46.86%), which was close to that of the standard drug glibenclamide (57.62%) at 10 mg/kg body weight dose. (Alam *et al*. 2011) [2].

4.8 Hypolipidemic activity

Chawda *et al*. (2014) [7] studied the lipid-lowering and antioxidant activities of a hydroalcoholic extract of *Cyperus scariosus* Linn. root (HCS) on guinea pigs fed with a high cholesterol diet. Both doses of hydroalcoholic extract of *Cyperus scariosus* decreased serum lipid profile and atherogenic indices ($P < 0.05$). The higher dose of hydroalcoholic extract also reduced serum AST, ALP, and LDH levels and rosuvastatin increased AST and ALP levels ($P < 0.05$). In treated animals, decreased lipid accumulation and improvement in hepatocytes was observed on histology of the liver and it may be due to the antioxidant activity of extract contained phenolic compounds.

4.9 Acute toxicity study

Acute toxicity test was carried out by Alam *et al*. (2011) [2]. Animals were divided into nine groups and each group contained six animals. The control group was given 1% Tween 80 in normal saline (2 ml/kg body weight). The other groups received 100, 200, 300, 600, 800, 1000, 2000 and 3000 mg/kg of the methanol extract of leaves. For the next 8 hours the animals were remained under close observation and were sustained up to 14 days for any mortality to take place. No mortality was observed with any of the extract doses till the end of the observation period of 14 days. Other Acute toxicity study using albino rats was done. Overnight fasted rats were administered with different fractions of essential oils at5000 mg/ kg, p.o.After 24 hrs no mortality was found.250, 5 00, and 750 mg/ kg, p.o. doses were selected for the further study.

4.10 Phytotoxicity activity

Khan *et al*. (2015) [26] studied the phytotoxicity activity of *C. scariosus* plant against maize (Zea mays) seeds. The results showed that methanolic extract of *C. scariosus* showed minimum stalk growth and maximum stalk and root inhibition using 3 mg/ml as compared to control. The order of effect of *C. scariosus* plant on stalk and root growth after 5 and 10 days may be written as; 3mg/ml > 1.5mg/ml > 0.75mg/ml > 0.37mg/ml. The phytotoxic results obtained from the methanolic extract showed that inhibition of the germination of roots and shoots of the maize (Zea mays) plants occurred but not to a significant level as compared to the other medicinal plants.

4.11 Antioxidant activity

The 50% methanolic extracts of *C. scariosus* obtained from different plant parts contained significant amounts of polyphenols with superior antioxidant activity as evidenced by the scavenging of DPPH·, ABTS·+, NO, ·OH, O2.- and ONOO-. It showed significant potential for preventing oxidative DNA damage and radical scavenging activity. The extracts showed significantly high total phenolic Content and total flavonoid contents which contribute to their antioxidant activities (Kalim *et al*. 2010) [23]. Investigate the T cell inhibition potential of 50% ethanol extract of *C. scariosus*

4.12 Antifungal activity

Essential oils from leaves of 14 plants were tested for their antifungal properties against 6 dermatophytes (*Keratinomycesajelloi, Microsporum gypseum, Trichophyton equinum, T. mentagrophytes, T. rubrum* and *T. terrestre*). Essential oil from *Cyperus scariosus* showed high activity against all the dermatophytes, while oils from *Murraya*

koenigii, Thuj aorientalis, Mimusops elengi and *Cymbopogon martini* var.*motia* were active against some of the fungi (Deshmukh *et al*. 1986) [10]. Dubey *et al*. (2011) [12] carried out the antifungal activity of steam distilled essential oil, hexane extract of fresh and distilled *C. scariosus* rhizome from Uttar Pradesh (India) and Madhya Pradesh (India) against the phyto-pathogenic fungus *Rhizoctonia solani***.** The ED_{50} of steam distilled oil of U.P. and M.P. was recorded as 512 and 517 µg/ml respectively, while fresh rhizomes from U.P. and M.P. showed the highest fungitoxicity with ED_{50} of 448 and 478 µg/ml respectively. The oil obtained from distilled rhizomes showed least activity with ED_{50} of 1007 µg/ml in case of up oil and 1032 µg/ml in case of M.P. oil.

4.13 Antibacterial activity

Longiverbenone is a naturally occurring sesquiterpene isolated from ethanolic extract of *Cyperus scariosus* rhizome by solvent-solvent portioning and chromatographic technique. The antibacterial activity of longiverbenone was evaluated against eleven potential human pathogenic bacteria using disc diffusion method. Minimum inhibitory concentration (MIC) and minimum bactericidal concentration (MBC) were determined by broth macrodilution method (Rahman and Anwar 2008) [40].

4.14 Cytotoxic activity

Cytotoxic activity (lethal concentration 50%, LC_{50}) of longiverbenone was determined on new borne brine shrimp (*Artemia salina*). It showed moderate to good antibacterial activity against the test organisms tested herein. It exhibited the lowest MIC (20 µg/ml) and MBC (80 µg/ml) against *Vibrio cholerae*. The LC_{50} of the isolated sesquiterpene was found to be 14.38 µg/mlagainst new borne brine shrimp (Rahman and Anwar 2008) [40].

4.15 Larvicidal and ovicidal activity

The larvicidal and ovicidal effects of *Cyperus scariosus* essential oil was investigated against the fourth-instar larvae of *S.litura* by Elumalai *et al*. (2010) [13]. The essential oil showed moderate toxic effect on lepidopteran agricultural pest of armyworm after 24hr of exposure. The shoot of *C. Scariosus* showed good larvicidal activity (LC_{50} = 27.3, 29, 30.6, 31.2, LC_{95} = 43.6, 48.2, 56 and 51.4 ppm) and moderate ovicidal effect.

5. Conclusions

C. scariosus is a very popular medicinal herb in Indian Ayurvedic medicine systems with various pharmacological and traditional uses. Due to its various ethnomedical, pharmacological and therapeutic properties this plant species has been used to develop nutraceuticals and pharmacological products and indicating its effectiveness against several diseases. The rhizomes and tubers of *C. scariosus* contain varying concentrations of volatile oils, flavonoids, phenolic acids, coumarins, steroids, and iridoid glycosides. The volatile essential oil mainly consists of sesequiterpenoids. So far, this plant species investigations have been limited to the extraction, identification and biological properties of extracts and essential oil. Therefore, more diverse studies on the chemical compounds present in the extracts and essential are needed to study to characterize the metabolites responsible for these activities. In conclusion, due to presence of several phytochemicals, *C. scariosus* has a great potential for use in pharmaceutical industries.

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