From Traditional Knowledge To Modern Medicine: *Cyperus scariosus* and Its Multifaceted Pharmacological Propertie

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Abstract

Due to their vast store of organic natural components, medicinal and aromatic plants like Cyperus scariosus play a significant role in both traditional and modern medicine. In poor nations where traditional medical practises are still relevant, these herbs are highly appreciated. The negligible side effects of medicinal plants, in contrast to manufactured drugs, make them helpful for treating a variety of illnesses. The Cyperaceae family includes *Cyperus scariosus*, sometimes referred to as Nut grass or Nagarmotha, which is well renowned for its medicinal properties.An vital component in Ayurvedic formulations, the plant's essential oil is extracted from the rhizomes and roots of the plant and has anti-inflammatory, antibacterial, and antifungal qualities. Its roots have a long history of use in medicine, including as a diaphoretic, tonic, and treatment for conditions including epilepsy, fever, and liver damage.. Because of its antibacterial, antifungal, and growth-regulating qualities, the essential oil of the plant is used for more than just perfumery. Additionally, it has potential for uses in analgesia, diabetes prevention, and hepatoprotection.Slender leaves, a July flowering and December fruiting period, and a fruit bearing season define C. scariosus. It has been shown to have anti-nociceptive characteristics, hypotensive and spasmolytic effects, hepatoprotective qualities, and antidepressant potential. The plant extract has also demonstrated hypoglycemic and hypolipidemic properties, making it advantageous for controlling hyperlipidemia and diabetes. Additionally, its antibacterial, antifungal, and antioxidant properties add to its therapeutic profile..

A thorough study of the plant's botany, traditional usage, phytoconstituents, therapeutic benefits, and clinical applications is still lacking, despite the fact that there has been much research on the chemical components and pharmacological properties of the plant. By providing information on C. scariosus and discussing its phytochemical investigations, pharmacological potentials, toxicity issues, and possibilities for further study, this paper seeks to close the knowledge gap.

1 INTRODUCTION

Both conventional and contemporary medicine depend heavily on medicinal and aromatic plants, which provide a great reservoir of organic natural products.. In many developing countries, traditional medicinal practices, which are considered alternative systems of healthcare, continue to fulfill essential health requirements. Unlike synthetic chemicals, medicinal plants are preferred due to their minimal adverse effects, making them valuable for treating a spectrum of ailments (Khan et al., 2009) [25].

The world of natural products offers a huge variety of chemical structures that serve as building blocks for molecules that may be improved by chemical processing or de novo synthesis to improve their functions. (Houghton, 1995) [19]. Within this spectrum, biologically active compounds like essential oils and various plant extracts stand out as promising disease-control agents, offering safety advantages over conventional alternatives (Tripathi and Dubey, 2004) [45].
The Cyperaceae family has several aromatic and therapeutic plants that include notable chemical compounds with biological functions. Cyperus scariosus, a versatile medicinal herb belonging to the extensive monocotyledonous According to Schultze-Motel (1964), the Cyperaceae family has over 3700 species in 70 genera [44]. The perennial, slender sedge C. scariosus is known by many names, including Nut grass, Nagarmotha in Hindi, Nagar musta in Sanskrit, Lawala in Marathi, Koraikkilangu in Tamil, and xiangfu/xiangfuzi in Chinese (Chopra et al., 1986) [8]. It is found throughout the country, often close to rivers and waterfalls.

Characterized by its delicate appearance and reaching heights of 45-75 cm, C. scariosus boasts sharp, pointed leaves measuring 0.3-0.85 cm in width. Blossoming in July and bearing fruits in December, its flowers can grow from 5 to 17.5 cm in length. This plant thrives in sunny, wet environments and does well on sandy and loamy soils, favouring Pacific Islands and coastal areas in particular.. With rapid growth, it forms an intricate network of roots and rhizomes that penetrate the soil up to 3-4 cm deep, releasing a pleasant aromatic fragrance.

The essential oil derived from the rhizomes and roots of C. scariosus serves as a key ingredient in numerous Ayurvedic formulations, renowned for its anti-inflammatory, antimicrobial, and antifungal properties. Folk traditions attribute the roots with a range of attributes, from being a cordial, tonic, and diaphoretic to aiding in addressing conditions such as epilepsy, fever, and liver damage (Said, 1982) [43]. Moreover, this plant finds application in fodder, while its tuberous rhizomes are utilized for culinary, medicinal, and perfumery purposes. It plays a role in treating diverse ailments including diarrhea, epilepsy, gonorrhea, liver damage, and syphilis, forming a significant component of indigenous medicinal recipes (Kritikar and Basu, 1918) [27].

In addition to having value in perfumery (Kahol et al., 1987) [21], extracted essential oil from the rhizomes and roots also has antibacterial (Lahariya and Rao, 1979) [29], antifungal (Deshmukh et al., 1986) [10], and plant growth-regulating (Kalsi et al., 1980) [24] qualities. Additionally, this oil has promise for analgesic and anti-diabetic effects (Alam et al., 2011). [2], [16], [16] hepatoprotective effects, hypotensive results, and spasmolytic activities.

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1.1 TAXONOMY, DISTRIBUTION AND MORPHOLOGY

This plant is a member of the Order Poales, Family Cyperaceae, Genus Cyperus, and Species scariosus of the Kingdom Plantae. Pantropical and warm temperate zones are home to the Cyperus genus. Cyperus scariosus is a common plant in India, especially in the states of Chhattisgarh, Bihar, Orissa, moist regions of Uttar Pradesh, Madhya Pradesh, and Bengal. Additionally, it may be found in the Pacific Islands, China, and South Africa.

Initially white, the plant eventually turns brown or black and emits a muddy odor. Stolons, measuring 10-20 cm in length, are densely packed with rhizomes that are bluntly conical and vary in size and thickness. These rhizomes are fleshy and white with scaly leaves when young, but become fibrous and wiry as they age.

Cross-sections of these rhizomes reveal distinct features. The outer layer comprises small tabular cells forming the epidermis, followed by a hypodermal sclerenchyma composed of 3-4 layers packed with brownish or blackish tannin deposits. A wide inner cortex zone contains parenchyma cells filled with elliptical starch grains measuring 12-15 µm wide at the broadest region and 4-6 µm at the narrowest. Many of these parenchyma cells also contain condensed natural reddish-brown material, consisting of a blend of terpenoids and alkaloids.

The lignified, tangentially elongated cells of a two-layered fake endodermis that contains the innermost cortex and the stele divide the two. Vascular fibres that are dispersed throughout the stele and ground parenchyma tissue that resembles cortical parenchyma make up its physical composition. Phloem is located at the centre of each concentric vascular thread, which is bordered by xylem. While an alkaloid-terpenoid complex is seldom seen in phloem cells, some of them do contain tannins (Adams et al. 2013).

The essential oil derived from C. scariosus primarily consists of sesquiterpenes, with prominent constituents including cyperene, rotundene, rotundenol, isopatchoula-3,5-diene, isopatchoul-3-ene, β-selinene, isopatchoulenol, and scariodione. Phytochemical investigations reveal that this plant is rich in various secondary metabolites, including polyphenols, flavonols, glycosides, alkaloids, saponins, and sesquiterpenoids.The extraction of essential oil from C. scariosus rhizomes is typically accomplished through steam distillation. In this procedure, dried and crushed rhizomes are passed via steam produced by a boiler. The pressure of the steam is carefully regulated based on the specific characteristics of the plant material. To preserve hygienic and quality requirements, the apparatus utilised for this distillation process, comprising the storage vessel, condenser, and receiver-cum-separator, is made of stainless steel (Sahu et al. 2010).

The resulting commercial oil from the rhizomes of C. scariosus is known as cyperiol. This oil is obtained through the hydro-distillation method, which involves the extraction of essential oil using water as a solvent. This oil is produced from the rhizomes of C. scariosus and is appreciated for its variety of secondary metabolites. contributing to its potential uses in various applications.

1.2 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 from the same species. Hikino *et al*. (1967) [18] isolated a sesquiterpene ketone cyperotundone 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 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 and rotundenol sesquiterpenes from *C. scariosus* and the structure was established by Paknikar *et al*. (1977) [38]. Two sesquiterpenoids hydrocarbon (-)-beta-selinene 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-enewhich on spectral characterization was found to be a tricyclic compound with an isopatchoulane type carbon skeleton. Longiverbenone , 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 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 , β-sitosterol and lupeol 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].

Table1: Major Compounds

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	

1.3 PHARMACOLOGICAL ACTIVITIES

According to studies and reports by several researchers, *Cyperus* contains a variety of chemical components, including mainly sesquiterpenoids, the majority of which may have pharmacological effect.

1.3.1.1 Anti-nociceptive activity

Alam et al. (2011) [2] investigated the anti-nociceptive effect of a methanol extract of C. scariosus leaves. Five groups of seven mice each were created by dividing the animals. Group I acted as the control group (10 mg/kg body weight, 1% Tween 80 in water). Group-II mice received aspirin at a dosage of 200 mg/kg body weight. Groups III to V received 50, 100, and 200 mg/kg of the extract orally, respectively, 30 minutes before to receiving an injection of acetic acid. Pain was generated in all groups by injecting 10 ml/kg of body weight of 1% acetic acid intraperitoneally. Each animal was given a 5 minute interval, after which the number of writhings was tallied for 10 minutes. The highest writhing inhibition with leaf methanol extract was reported to be reached at a dosage of 200 mg extract/kg body weight (p0.01), whereas the conventional aspirin induced a writhing inhibition of 56.74% (p0.001) at the same dose.

1.3.1.2 Hypotensive and Spasmolytic activity

When given intravenously, a hydro-methanolic extract of *Cyperus scariosus* produced hypotensive and bradycardic effects. These outcomes maintained in atropinized rats, demonstrating that the cardiovascular effects of the plant extract are not mediated by muscarinic receptor activation. It inhibited the spontaneous contractions of the rat uterus, rabbit jejunum, and guinea-pig paired atria in vitro experiments in a concentration-dependent (0.1–1 mg/ml) way. Additionally, it prevented guinea pig ileal contractions brought on by histamine or acetylcholine, showing a general spasmolytic effect. It reduced contractions elicited by norepinephrine (10 pM) and K+ (80 mM) at comparable doses (0.1–1 mg/ml) in the rabbit aorta. These findings suggest that Ca2+ channel blocker-like constituents may be present in Cyperus scariosus, which may account for the hypotensive effect shown in vivo. and the general spasmolytic activity ofplant may explain its folkloric use in diarrhea (Gilani *et al*. 1994) [15].

1.3.3.3 Hepatoprotective activity

We looked at the hepatoprotective properties of Cyperus scariosus' aqueous-methanolic extract against acetaminophen and CCl4's ability to cause liver damage. Acetaminophen therapy in mice resulted in complete mortality at a dosage of 1 g/kg, whereas pretreatment with a plant extract (500 mg/kg) decreased the death rate to 30% of animals. A dosage of 640 mg/kg of paracetamol caused an increase in the blood levels of the enzymes alkaline phosphatase, glutamate oxaloacetate transaminase, and glutamate pyruvate transaminase as well as liver

damage in rats. Rats pretreated with plant extract (500 mg/kg) had substantially decreased blood levels of ALP, GOT, and GPT (P 0.05). A same amount of plant extract (500 mg/kg) significantly reduced (P 0.05) serum enzymes caused by CC14 to increase and also stopped CC14's extension of pentobarbital sleeping time (Gilani and Janbaz 1995) [16].

1.3.3.4 Hypersentivity

By suppressing primary (26.8%) and secondary (29.7%) antibody titres and inhibiting cell-mediated delayed type hypersensitivity immune response (45.9%) at 600mg/kg dose phagocytosis both in vitro (37.4%) and ex vivo (37.8%), as well as delaying the time until graft rejection (45.8%), C. scariosus chloroform fraction significantly inhibits T cell responses in Balb/c mice in both humoral and When cyclosporine-A, a common T cell inhibitor, was administered to Balb/c mice at a dosage of 200 mg/kg, chloroform fraction dramatically p0.01 reduced CD8+/CD4+T cell surface indicators (14.0/25.3%) and intracellular Th1 cytokines, viz. IL-2(34.4%) and IFN- (34.7%). According to Bhagwat et al. (2009), C. scariosus did not substantially (p0.01) decrease the Th2 (IL-4) system. [3].

1.3.3.5 Antidepressant activity

In mice, C. scariosus oil's n-hexane extract showed antidepressant properties. Using the forced swim test and the tail suspension test on mice, antidepressant activity was assessed at two dose levels of 100 and 200 mg/kg, and the results were compared to those of the reference medication, imipramine, at 15 mg/kg.

Similar to the medication imipramine, C. scariosus n-hexane extract oil considerably (p 0.001) decreased the immobility period at both dosage levels at FST and TST. Due to an increase in the concentration of norepinephrine in synapses, the n-hexane extract of C. scariosus oil may exhibit antidepressant effect (Ramesh et al. 2012) [41].

1.3.3.6 Micro propagation

For in vitro regeneration, C. scariosus axillary bud explants were inoculated on SH media and supplemented with various amounts of Benzyl adenine, Kinetin, and Indole-3-butyric acid. After two weeks of culture inoculation, the greatest number of shoots were seen on media containing 1.0 mg/lt BA and 1.0 mg/lt Kn. The best outcomes were obtained when Kn 1 mg/lit was combined with Adenosine 1 mg/lit and Charcoal 500 mg/lit [44]. On SH medium with Kn 0.75 mg/lt+ADS 1.0 mg/lt+activated charcoal 500 mg/lt, efficient flowering of 80% was observed. On full strength SH medium supplemented with Kn1.5mg/lt+ADS1.0mg/lt+ activated charcoal 500mg/lt+5% coconut water, multiple shooting and multiple rooting were successful (Lavanya et al. 2005). [30].

1.3.3.7 Hyperglycemic inhibition

On mice, the ability of C. scariosus leaves to increase glucose tolerance was examined. Each of the six groups contained seven starved mice. The control group, Group I, got 10 ml/kg of 1% Tween 80 in water, 10 mg/kg of glibenclamide, and four different dosages of the methanol extract of C. scariosus leaves. Group II received the usual medicine, glibenclamide, in these amounts. All mice received an oral glucose dosage of 2 g/kg body weight after an hour, and blood samples were taken two hours after the glucose was given to the animals. The glucose oxidase technique was used to measure serum glucose levels. The results demonstrated that the activity of the methanol extract was dose-dependent. As compared to the control, the extract's dosage increase had a noticeable impact. The highest level of inhibition was seen at a dosage of 400 mg extract/kg body weight (46.86%), which was nearly as effective as the commonly prescribed medication glibenclamide (57.62%) at a dose of 10 mg/kg body weight. (2011) (Alam et al.) [2].

1.3.3.8 Hypolipidemic activity

Chawda et al. (2014) [7] examined the lipid-lowering and antioxidant effects of a hydroalcoholic extract of Cyperus scariosus Linn. root (HCS) in guinea pigs given a high cholesterol diet. Cyperus scariosus hydroalcoholic extract reduced serum lipid profiles and atherogenic indices in all dosages (P 0.05). Rosuvastatin raised serum AST and ALP levels while the greater dose of hydroalcoholic extract decreased serum AST, ALP, and LDH levels (P 0.05). On the liver histology of treated animals, there was a decrease in lipid buildup and an improvement in the hepatocytes, which may be related to the antioxidant activity of the extract that contained phenolic compounds.

1.3.3.9 Antioxidant activity

The scavenging of DPPH•, ABTS•+, NO, •OH, O2.-, and ONOO- by the 50% methanolic extracts of C. scariosus from various plant sections revealed the presence of considerable levels of polyphenols with exceptional antioxidant activity. It demonstrated substantial potential for scavenging free radicals and reducing oxidative DNA damage. The extracts exhibited very high levels of total phenolic content and total flavonoid content, both of which support their antioxidant effects, according to Kalim et al. (2010) [23]. Examine the ability of a 50% ethanol extract of C. scariosus to suppress T cells.

1.3.4 Antifungal activity

Six dermatophytes (Keratinomyces ajelloi, Microsporum gypseum, Trichophyton equinum, T. mentagrophytes, T. rubrum, and T. terrestre) were examined for their antifungal capabilities using essential oils from the leaves of 14 different plants. While oils from Murraya koenigii,

Thuj aorientalis, Mimusops elengi, and Cymbopogon martini var. motia were active against certain fungi, essential oil from Cyperus scariosus had strong activity against all dermatophytes (Deshmukh et al. 1986) [10]. The antifungal activity of fresh and distilled C. scariosus rhizomes from Uttar Pradesh (India) and Madhya Pradesh (India) was tested by Dubey et al. (2011) [12] against the phyto-pathogenic fungus Rhizoctonia solani. Fresh rhizomes from the U.P. and M.P. had the highest fungitoxicity, with ED50 values of 448 and 478 g/ml, respectively. Steam-distilled oil from these two states had ED50 values of 512 and 517 g/ml, respectively. The oil made from distilled rhizomes had the least amount of activity, with an ED50 of 1007 g/ml for up oil and 1032 g/ml for M.P oil.

1.3.4.1Antibacterial activity

Longiverbenone, a naturally occurring sesquiterpene, was isolated from an ethanolic extract of Cyperus scariosus rhizome utilising a solvent-solvent portioning and chromatographic method. The antibacterial activity of longiverbenone was tested using the disc diffusion method against eleven potential human pathogenic pathogens. The minimum inhibitory concentration (MIC) and minimum bactericidal concentration (MBC) were estimated using the broth macrodilution method (Rahman and Anwar 2008) [40].

1.3.4.2 Cytotoxic activity

The cytotoxic action of longiverbenone (lethal concentration 50%, LC50) was assessed in newly birthed brine prawns (Artemia salina). Here, it demonstrated moderate to good antibacterial effectiveness against the test pathogens. In tests against Vibrio cholerae, it has the lowest MIC (20 g/ml) and MBC (80 g/ml). According to Rahman and Anwar (2008), the isolated sesquiterpene's LC50 value for new-born brine prawns was 14.38 g/ml. [40].

1.3.4.3 Larvicidal and ovicidal activity

Elumalai et al. (2010) [13] studied the larvicidal and ovicidal activities of Cyperus scariosus essential oil against the fourth-instar larvae of S. litura. After 24 hours of exposure, the essential oil had a somewhat harmful impact on the lepidopteran armyworm pest. The shoot of C. Scariosus exhibited good larvicidal activity and a moderate ovicidal action (LC50 = 27.3, 29, 30.6, 31.2, LC95 = 43.6, 48.2, and 56 ppm).

1.4 ACUTE TOXICITY STUDY

Alam et al. (2011) conducted an acute toxicity test [2]. Nine groups of six animals each were created from the total number of animals. The control group was given 1% Tween 80 in normal saline at a dose of 2 ml/kg body weight. The leaf extract in methanol was given to the other groups at doses of 100, 200, 300, 600, 800, 1000, 2000, and 3000 mg/kg. Over the next eight hours and for up to 14 days, the animals were closely watched to determine whether any mortality took place. By the end of the 14-day monitoring period, no mortality was noted with any of the extract dosages. Another investigation on acute toxicity was carried out with albino rats. Different percentages of essential oils were given to overnight starved rats at 5000

1.5 PHYTOTOXICITY ACTIVITY

Khan et al. (2015) [26] studied the toxicological activity of the *C. scariosus* plant against maize (Zea mays) seeds. As compared to control, the C. scariosus methanolic extract demonstrated the least amount of stalk development and the most amount of root and stalk inhibition at 3 mg/ml. The sequence in which each

After 5 and 10 days, the C. scariosus plant's stalk and root growth may be expressed as follows: 3 mg/ml > 1.5 mg/ml > 0.75 mg/ml > 0.37 mg/ml. The methanolic extract's phytotoxic results revealed that, compared to other healing plants, maize (Zea mays) plant roots and shoot germination were inhibited, although not to a significant degree.

1.6 CONCLUSION

Cyperus scariosus, commonly known as C. scariosus, holds a prominent place in Indian Ayurvedic medicine, revered for its diverse pharmacological and traditional applications. This plant has garnered attention for its ethnomedical heritage, therapeutic properties, and pharmacological potential, leading to the development of nutraceuticals and pharmaceutical products aimed at combating various ailments. Particularly noteworthy are the volatile oils, flavonoids, phenolic acids, coumarins, steroids, and iridoid glycosides that make up the rhizomes and tubers of *C. scariosus*. Among these, the volatile essential oils, primarily composed of sesquiterpenoids, stand out as a significant component.

Hitherto, research on this plant species has concentrated on extract characterization, identification, and exploring the biological attributes of its extracts and essential oils. However, there exists a distinct need for more comprehensive investigations into the intricate chemical compounds present within these extracts and essential oils. Such studies hold the potential to unravel the precise metabolites responsible for the observed activities, thereby deepening our understanding of the plant's therapeutic potential.

In summation, the abundance of diverse phytochemicals within C. scariosus underpins its immense promise for integration into the pharmaceutical industry. This plant's multifaceted nature, coupled with its historical significance in traditional medicine systems, underscores its role as a source of valuable compounds that could contribute to the development of innovative pharmaceutical products.

ACKNOWLEDGEMENT : Authors are thankful to management DIBNS for providing necessary support.

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