

Pharmacological and ecological aspects of *Chlorophytum borivilianum* Sant. and Fern.: a review.

Aspectos farmacológicos y ecológicos de *Chlorophytum borivilianum* Sant. y Fern.: una revisión.

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ABSTRACT

Chlorophytum borivilianum; Sant. and Fern. is one of the important medicinal herb belonging to family Liliaceae. Traditionally known as 'Safed Musali' in the Indian drug market. An efficacy of its tuberous roots has been assessed for the treatment of few sexual disorders in males. Also, phytochemical evaluation revealed the richness of alkaloids, saponins, carbohydrates, steroids, vitamins, proteins etc. Apart from the aphrodisiac properties mostly confined to the roots; the efficacy of this important medicinal herb needs to be investigated for other attributes especially on human model. In India as well as across the world; from the pharmacological point of view; this plant serves as valuable medicinal herb with a great potential to cure many diseases. However; this plant has been categorized as critically endangered plant according to IUCN red data list. Due to overexploitation, authentic identification and standardization as well as lack of ecological and conservation perspective; the species number of genus *Chlorophytum* is found to be decreasing consistently. Also, documentation of such ethnobotanicals and knowledge of traditional medicines can be significant contribution towards sustainable utilization of indigenous therapeutic plants.

Keywords: *Chlorophytum borivilianum*, ecological, pharmacological.

RESUMEN

Chlorophytum borivilianum; Sant. y helecho. Es una de las hierbas medicinales importantes que pertenece a la familia Liliaceae. Conocido tradicionalmente como "Safed Musali" en el mercado de drogas de la India. Se ha evaluado la eficacia de sus raíces tuberosas para el tratamiento de algunos trastornos sexuales en los machos. Además, la evaluación fitoquímica reveló la riqueza de alcaloides, saponinas, carbohidratos, esteroides, vitaminas, proteínas, etc. Además de las propiedades afrodisíacas que se limitan principalmente a las raíces; Es necesario investigar la eficacia de esta importante hierba medicinal para determinar otros atributos, especialmente en el modelo humano. Tanto en la India como en todo el mundo; desde el punto de vista farmacológico; esta planta sirve como una valiosa hierba medicinal con un gran potencial para curar muchas enfermedades. Sin embargo; esta planta

ha sido clasificada como planta en peligro crítico según la lista roja de datos de la UICN. Debido a la sobreexplotación, la identificación y estandarización auténticas, así como la falta de una perspectiva ecológica y de conservación; Se ha descubierto que el número de especies del género *Chlorophytum* disminuye constantemente. Además, la documentación de dichos elementos etnobotánicos y el conocimiento de las medicinas tradicionales pueden ser una contribución significativa hacia la utilización sostenible de plantas terapéuticas autóctonas.

Palabras clave: *Chlorophytum borivillianum*, ecológico, farmacológico.

INTRODUCTION

Traditional and herbal medicines have been utilized since ancient times and accounts for about 70-80% of population on a global basis. According to the World Health Organization; about 80-95% of population of developing as well as developed countries; uses herbal and traditional medicines or crude plant extracts; as a home remedies for their routine ailments. (Khan and Ahmad, 2019; Siddaramu *et al.*, 2022). India shows diverse topographic and climatic conditions that supports unique habitat for variety of medicinally important plant species. (Naveen *et al.*, 2022). Today; the demand for many natural crude therapeutic drugs are increasing all over the world. Recently; ethno-ecological survey of medicinal herbs is being carried out by different states. (Tandon and Shukla, 1995). The center of origin of *C. borivillianum* is tropical and subtropical Asia. (Chakraborty and Aeri, 2009). Earlier, it has been reported that, about 300 species of *Chlorophytum* are distributed across the world; especially tropical and subtropical regions of Africa which are most probably; the centers of origin of genus *Chlorophytum*. (Geetha and Maiti, 2002; Bansal, 2018). Currently; 23 species of genus *Chlorophytum* reported across the different regions of India. (Chandore and Yadav, 2019). Also, *C. borivillianum* is categorized as critically endangered status according to IUCN Red data list. (Bhat *et al.*, 2018; Gowthami *et al.*, 2021).

C. borivillianum is herbaceous plant belonging to the family Liliaceae, commonly known as 'Safed musali' is highly valuable medicinal plant in India and Indian system of Ayurveda. It is a multipurpose herb useful in maintaining better human health and gynecological disorders. (Nalawade *et al.*, 2022). Also, its commercial utilization is found to be rapidly expanding due to the presence of high medicinal properties in its different parts especially tuberous roots. During the last couple of decades; many endangered medicinal plant species; due to the lack of authentic identification and standardization; are being used as alternative resource which creates scarcity and eventually leads in adulteration. In this context; comparative morpho-anatomical and phytochemical evaluation of *Chlorophytum* species is essential. (Parveen and Singh, 2018).

Pharmacological Perspective:

Traditionally; tubers are also being used in the treatment of few other ailments like rheumatism. Also, leaves can be used in various culinary preparations. However; tubers have been most commonly used for its aphrodisiac properties lack of libido, male impotency, oligospermia. (Meena and Rao, 2005). The major biochemical constituent of *Chlorophytum borivillianum* are carbohydrate (42%), Protein (10%), fibers (20% to 30%) Saponins (2% to 17%) and alkaloids (15% to 25%). Also, primary saponin and alkaloids have been found to be the rich source of over 25 alkaloids,

vitamins, steroids, potassium, calcium, magnesium, phenol, resin, mucilage and polysaccharides. High quality of simple sugars mainly sucrose, glucose, fructose, xylose, mannose, and galactose and more recently; Stigmasterol, furostanol, chlorophytoside as well as polysaccharide fraction etc. have been isolated. (Thakur *et al.*, 2011; Rungsung *et al.* 2013). Arsenic induced toxicity in *C. borivilianum* and its impact on reproductive system has been studied by Sharma *et al.*, 2012. The presence of various vital bioactive compounds and medicinally important secondary metabolites like alkaloids, glycosides, steroids etc. have been confirmed in many earlier phytochemical studies as well as by chromatographic and spectrophotometric analyses. (Vyas *et al.*, 2020).

C. borivilianum; recognized worldwide as 'herbal viagra', and 'Indian ginseng' in India; found significant in curing stress induced weakness and other such ailments. (Sharma and Muzumdar; Singh *et al.*, 2012, Giribhau *et al.*, 2014; Thakur and Dixit, 2016). Similarly; the root extract of *C. borivilianum* have found to be helpful in prevention of sperm count and impairment in sperm characteristic and morphology. (Kothari; Thakur *et al.*, 2004). Traditionally; it is used as health promoting tonic along with anti-oxidant, anti-pyretic, anti-viral, anti-mutagenic, anti-tumors, antifungal activity. (Bhat *et al.*, 2008, Deore and Khadabaddi, 2007; 2008; 2010; Akki and Patil 2006; Singh *et al.*, 2012). Few researchers have reported that the human disorders such as renal and pulmonary cancer can be better managed by herbal drugs like 'Safed Musali.' Singh *et al.*, Saxena *et al.*, 2012).

Pharmacological evaluation has been attempted by many workers which revealed few inherent medicinal properties such as aphrodisiac, immunomodulatory activity and anti-aging properties. (Kothari, 2004; Singh *et al.*, 2008; Chakraborty, 2012). Traditionally; the tuberous roots of *C. borivilianum* are being used in the manufacturing of crude herbal drugs. It has been shown to work very well in curing impotency. (Sharma and Muzumdar, 2012; Desale, 2013; Giribhau *et al.*, 2014; Bhat *et al.*, 2018). Many ethnic communities across the different states of India like Rajasthan ("Meena"), Mizoram ("Mizo"), Maharashtra ("Thakur"), Madhya Pradesh ("Korku" and "Bharia") have been found to be enjoying the health, vitality and longevity by using 'Safed musali' in their health care system. (Patil, 2010; Jagtap *et al.*, 2009; Meena and Rao, 2010; Deshwal and Trivendio, 2011). Indigenous people in the states like Maharashtra have found to be utilizing the root tubers of *C. borivilianum* for the variety of medicinal purposes and have initiated its cultivation; which indicates its socio-economic importance. (Patil, and Patil, 2000; 2001).

In earlier research; it was reported that *C. borivilianum* is medicinally significant especially in rejuvenation. (Miraj *et al.*, 2020, Verma *et al.*, 2020). Also, studies have indicated that the root extraction is better equip testicular cell against the different oxidative stresses. (Vyas *et al.*, 2022). *C. borivilianum* consist of many useful secondary metabolites helping in sexual problems mostly stigmasterol (Pratiwi *et al.*, 2021), Saponin (Khan *et al.*, 2022). Recent studies have identified nine compounds including 5-methylhex-2-y, pentadecyl ester (23.69).9, 10- anthracenedione (19.02). (Vyas *et al.*, 2020).

Most of the pharmacological investigations and studies conducted previously lack critical assessment and substantial scientific evidences. Also, all the studies merely highlighted the toxicity, quality and the commercial utilization of *Chlorophytum borivilianum*; which is insufficient to gather comprehensive information so as to focus on the existing lacunae and future research. (Khanam *et al.*, Ashraf *et al.*, 2013).

Tubers and other body parts like leaf and stem of *C. borivilianum*; are rich in alkaloids, glycosides, tannins, and saponin enriched fraction etc. These have been assessed for nutritional as well as cytotoxic, hemolytic properties. (Somanath,2008; Singh *et al.*, 2022). Few works have focused antidiabetic, anti-oxidant, anti-stress, anti-helminthic and anti-larvicidal property of *C. borivilianum*. (Sharma *et al.*, 2017). Recently; the use of *C. borivilianum* as a dietary supplementation is found effective as heat stress ameliorator in dairy cows. Similarly; in rat model; this vital herb has been shown to possess antimicrobial, antimutagenic, antioxidant, antiulcer, properties. (Devi *et al.*, 2021). Different plant parts of *C. borivilianum* have been used to evaluate the medicinal properties, pharmacological and physiological response in various experiments conducted on animals mostly rats, cows as well as human beings. (Table 1).

Characterization of enzymes responsible for Saponin biosynthesis has been attempted by few researchers (Karla *et al.*, 2013). The seeds of *C. borivilianum* are quite dormant and their viability is low, which necessitates its *in vitro* regeneration and its large scale cultivation for agricultural and commercial purposes. Also, the presence of secondary metabolites irrespective of topographical and climatic conditions; can be enhanced through micropropagation and *in vitro* culture techniques which can be considered as novel approach in bioprospecting of phytopharmaceuticals. (Purohit *et al.*, 1994; Jha and Bansal, 2018; Kaushal *et al.*,2021).

ECOLOGICAL PERSPECTIVE

The genus *Chlorophytum* is originated from the tropical and subtropical Africa and about 300 species are distributed predominantly in tropical and subtropical forests up to 1500 m altitude (Nayar and Sastry, 1988; Oudhia, 2001; Raghavendra *et al.*, 2005).

It is evident that, the plant species in which reproductive parts (fruit, flower, and seed) as well as vegetative parts (leaves, roots, rhizome etc.) are harvested for commercial purposes; are more endangered in comparison; than any other plant species. Commercially; it is one of the important crop with high level of ethno-medicinal properties, low risk, and high returns can be fetched within a short period of one year. (Manjunatha *et al.*, 2008).

The decline in the number of species and extinction of some species of genus *Chlorophytum*, is largely due to the ecological disturbances, cultivation/harvesting practices by unskilled labor leading to poor natural regeneration, over exploitation for commercial purposes etc. (Mishra, 2011). Naturally, seed setting in most of the flowering plant species occurs by adopting variety of pollination mechanisms. Likewise; there are different insect pollinators which play an important role in pollination biology. (Shivanna *et al.*, 2001). The pollinators of *C. borivilianum* include diverse group of insect species that transfer pollen in flowering plant. Interaction between plants and pollinators is valued for increasing food production and maintaining ecosystem function to support biodiversity. (Gomez *et al.*, 2007; Ollerton,2017, Celep *et al.*, 2020).

C. borivilianum is small annual herbaceous plant which is grows wild as well as cultivated in different regions of India. Indigenous tribal people mostly collect its tubers for economic and medicinal purposes. It is one of the important ethno-medicinal herb utilized by tribal population in several districts of Maharashtra as well as different states in India. (Khairnar and Gadekar, 2019). Moreover; the studies evaluating the role of bioactive phyto-

constituents of *C. borivilianum* in nectar formation, pollinators and other fundamental ecological processes, global change etc. are being attempted by few workers. (Stevenson *et al.*, 2017; Spyros *et al.*, 2023). In India alone; different agro based field experiments have been conducted across the states so as to study the response shown by *C. borivilianum* such as increase in overall root yield, its effective conservation and management in natural habitats. (Table 2).

C. borivilianum has been categorized into critically endangered status according to the IUCN red data list. (Ved *et al.*, 2015). Due to the consistent rise in the popularity and consumption of *C. borivilianum*; and also, huge economic returns; national and international phytopharma market is expanding at rapid rate. Review of relevant literature revealed that the consistent research and developmental activities are needed especially at educational, pharmaceutical institutions and medicinal plant repositories so as to explore genetic diversity, phytopharmaceuticals/ nutraceuticals from *C. borivilianum*. (Tandon *et al.*, 2012). Moreover, countries like India; are providing subsidies for the promotion of cultivation, processing and marketing of *C. borivilianum*. (Gunjan *et al.*, 2015; Verma and Bisen *et al.*, 2020).

DISCUSSION

In India as well as across the world; from the pharmacological point of view; *C. borivilianum* serves as valuable medicinal herb with a great potential to cure many diseases. Plants like *C. borivilianum* possess great medicinal importance. Apart from their medicinal role *Chlorophytum* species have also been recognized as food source across different regions of the world. *C. borivilianum* is having great potential in treating sexual disorders like impotency and many other such ailments which could be treated in coming future. Apart from the aphrodisiac properties mostly confined to the roots; the efficacy of this important medicinal herb needs to be investigated for other attributes especially on human model.

Currently, *C. borivilianum* is categorized as critically endangered plant species by IUCN red data list. Also; due to overexploitation and lack of ecological as well as conservation perspective; the species number of *Chlorophytum borivilianum* is found to be decreasing consistently. This necessitates its study in detail; emphasizing its ecological conservation. Moreover; studies so as to understand novel gene, reproductive biology etc. are needed. Thus, more elaborative, innovative conservation approaches should be adopted to protect this plant from becoming endangered.

Table 1. Pharmacological and physiological response different organisms observed during various experiments.

Organism involved	Formulations/ Plant part used	Pharmacological/ Physiological response	Reference
Human	Root	Loss of vigour and sexual fatigue, for improving strength, Promoting the semen and sexual vigor.	Kumar <i>et al.</i> , 2004, Bansal, 2018; Khairnar and Gadekar, 2019.
	Root extract	Aphrodisiac and erectile dysfunction	Kumar and Gadhwal, 2020.
	Methanolic callus extract	pathogenic microbes and cytotoxicity against colon cancer cells.	Huang <i>et al.</i> , 2019.
Rat	Methanolic Seed extract	antioxidant and antimutagenic activity.	Rai <i>et al.</i> , 2022.
	Root extract	Maintaining normal blood glucose, insulin and lipid levels.	Giribabu <i>et al.</i> , 2014.
Cows	root powder	Stimulate lactation.	Deshwal <i>et al.</i> , 2011.
Crossbred Cows	Root extract	Antioxidant, improvement in immune response.	Devi <i>et al.</i> , 2021.
Earthworm (<i>Pheritima posthuma</i>)	Crude Spaoinin extract	Anthelmintic property against selected worms.	Sharma and Chandrul, 2017.
Fish (<i>Labeo rohita</i>)	Polysaccharide fraction	Improvement in immune response and disease resistance.	Giri <i>et al.</i> , 2015.
Yeast (<i>Saccharomyces cerevisiae</i>)	Polysaccharide fraction	Increase in the lifespan/longevity. Results to be used for studying the aging process.	Pannakal <i>et al.</i> , 2017.

Table 2. Effects of different parameters on growth and yield of *C. borivilianum*.

Region of Study	Parameters studied	Outcome of study	Reference
Karnataka, India.	Effect of bio formulations, organic and inorganic source of nutrients.	Growth in leaf area, Physiological Characters, Dry root yield.	Hiremath <i>et al.</i> , 2020.
Faizabad, Uttar Pradesh	The effect of organic manures	overall growth and root yield.	Ram <i>et al.</i> , 2014.
Bhopal, India	plant ecology, biology, collection and Use/trade parameters.	Ex situ conservation and management of plant in the natural forests.	Mishra, 2011.
Akola, Maharashtra.	Effect of inter cropping with pigeon pea (3:1).	Increase in the overall yield and economic return	Tapre <i>et al.</i> , 2021.

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AUTHOR CONTRIBUTIONS

Conceptualization, Shinde, H.P., referencing and draft preparation, Pawar, R. P. formal analysis, Nikam, P. D. technical assistance, Waghmode, A.V.

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