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Divya aushadhi decoded: A comprehensive review of safed musli's phytochemistry, therapeutics, and future in modern medicine

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Abstract
Safed Musli (*Chlorophytum borivilianum* Santapau & Fernandes) is an important medicinal herb of the Indian subcontinent and is traditionally regarded as a rejuvenating, nutritive and aphrodisiac plant. Its tuberous roots have been incorporated into Ayurvedic and other traditional systems of medicine for conditions associated with weakness, impaired sexual function, convalescence and general vitality. Modern phytochemical investigations have demonstrated that the roots contain steroidal and furostanol saponins, fructans, polysaccharides, phytosterols, fatty acids, carbohydrates and other secondary metabolites. Among these constituents, saponins and fructo-oligosaccharide fractions have received particular scientific attention because of their possible contribution to reproductive, antioxidant, metabolic and immunomodulatory effects. Experimental investigations have reported aphrodisiac and spermatogenic activity, hypoglycaemic and analgesic effects, lipid-modulating properties, antioxidant activity and immunomodulatory potential. At the same time, concerns remain regarding extract standardization, species authentication, dose-response relationships, long-term toxicity, adulteration, clinical reproducibility and conservation of the plant. This review critically examines the phytochemistry, pharmacological evidence, therapeutic prospects, safety considerations and future research directions of *C. borivilianum*. Safed Musli represents a promising botanical candidate for evidence-based phytopharmaceutical development, but translation from traditional medicine and preclinical observations to modern therapeutics requires standardized preparations, mechanistic investigations and well-designed multicentre clinical trials.

Keywords: Safed musli, phytochemistry, medicine, health

Introduction

Due to growing knowledge of maintaining one's own health with natural materials, herbal medicines have become considerably more popular for treating minor illnesses. In fact, there is a significant risk of many medicinal plants going extinct due to the market and public demand, as well as a clear loss of genetic diversity. Plants have been used for more than 5000 years to treat a variety of illnesses. The "Vedas" are an excellent repository of ancient knowledge, with the "Yajur Veda" being the primary source. Numerous plants' medicinal use has been referenced in these Vedas. Medicinal plants continue to provide an important bridge between traditional healthcare systems and modern pharmacological research. Among the medicinal plants associated with Indian traditional medicine, Safed Musli, scientifically identified as *Chlorophytum borivilianum*, has attracted considerable interest because of its long history of use and its diverse biological activities. The plant is commonly associated with the Ayurvedic concept of *Rasayana* and *Vajikarana*, reflecting its traditional applications as a rejuvenating, nutritive and reproductive-health-promoting herb. Its fleshy tuberous roots constitute the principal medicinal material and are commercially valued in several herbal preparations. The renewed scientific interest in Safed Musli is closely related to the discovery of chemically diverse constituents and the increasing number of experimental investigations examining its pharmacological properties. Thakur *et al*. described *C. borivilianum* as a traditional medicinal herb with considerable potential for biopharmaceutical and nutraceutical applications, emphasizing steroidal and triterpenoidal saponins, sapogenins, fructans, carbohydrates, proteins and other constituents as important components of its chemical profile (Thakur *et al*., 2009) [11].

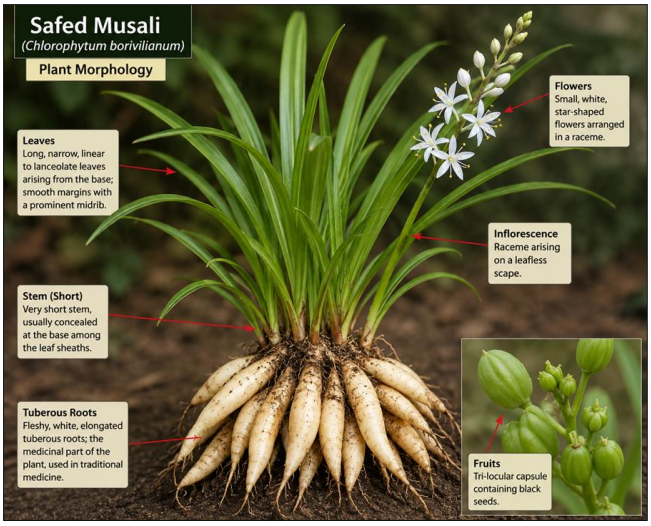
The traditional reputation of Safed Musli is particularly strong in the context of male sexual health. Experimental studies have provided preliminary evidence for increased sexual behaviour and sperm production, while clinical research has attempted to investigate effects on semen characteristics and testosterone (Kenjale *et al*., 2008; Sharma and Kumar, 2012) [4, 10]. Nevertheless, the scientific literature should be interpreted cautiously because many pharmacological observations originate from animal models, crude extracts or relatively small experimental studies. The purpose of the present review is therefore not merely to catalogue traditional uses but to examine Safed Musli from a modern pharmacological perspective, emphasizing its phytochemical basis, experimentally demonstrated biological activities, emerging clinical evidence, safety and quality challenges, conservation issues and future possibilities in modern medicine.

Botanical and Ethnomedicinal Background

Chlorophytum borivilianum belongs to the family Liliaceae and is a small herb characterized by elongated leaves and clusters of fleshy tuberous roots. The roots are the principal commercially utilized part because they contain concentrated levels of several pharmacologically relevant constituents. Traditional preparations generally employ dried root material or aqueous preparations, although modern herbal products may use hydroalcoholic, ethanolic or standardized extracts. The ethnomedicinal importance of Safed Musli has been associated particularly with physical weakness, sexual dysfunction, reproductive problems and general vitality. Thakur *et al*. documented its extensive traditional applications and described its historical use as an aphrodisiac, revitalizing agent and general tonic (Rizwi *et al*., 2010). A later comprehensive review also emphasized its traditional identity as a "Vajikaran Rasayana" and highlighted aphrodisiac, immunomodulatory and other pharmacological investigations while noting significant limitations in the existing evidence base (Dhakad *et al*., 2024) [3]. The distinction between ethnomedical reputation and clinically established efficacy is important. Traditional use provides a valuable starting point for pharmacological discovery but cannot by itself establish therapeutic effectiveness. Consequently, Safed Musli should be evaluated using modern principles of botanical authentication, phytochemical standardization, pharmacokinetics, toxicology and controlled clinical research.

Phytochemical Profile

The pharmacological interest in Safed Musli is closely associated with its complex chemical composition. Its roots contain steroidal saponins, sapogenins, fructans, polysaccharides, mucilage, carbohydrates, phytosterols, fatty acids and other secondary metabolites (Dhakad *et al*., 2024) [3]. Among these, steroidal saponins have received particular attention because structurally related compounds in medicinal plants can exert membrane-associated, anti-inflammatory, immunomodulatory and reproductive effects. Detailed phytochemical isolation has demonstrated that the root contains identifiable individual compounds rather than only broad classes of constituents. Deore and Khadabadi isolated fatty acids, stigmasterol and a furostanol saponin designated ChlorophytosideI from the roots of *C. borivilianum* (Rizwi *et al*., 2010). Structural characterization involved chromatographic and spectroscopic techniques, demonstrating the presence of a chemically defined steroidal saponin system (Panda *et al*., 2007). Fructans are another potentially important group. Narasimhan *et al*. investigated a (2→1)-fructo-oligosaccharide fraction of *C. borivilianum* in a streptozotocin-induced oxidative-stress model and reported protective effects against oxidative damage (Narasimhan *et al*., 2006) [6]. This observation is important because it indicates that the biological activity of Safed Musli cannot necessarily be attributed exclusively to saponins. The chemical complexity of the plant creates both opportunities and challenges. Multiple constituents may act synergistically, but variability in soil, climate, genotype, maturity, harvesting, drying and extraction conditions can change the chemical composition of the final product. Consequently, future pharmaceutical development should move from non-standardized powdered roots toward chemically characterized extracts with defined marker compounds.



Antioxidant and Anti-Inflammatory Potential

Oxidative stress represents a common mechanistic pathway involved in metabolic dysfunction, reproductive impairment, inflammation and cellular aging. Several experimental studies have therefore investigated Safed Musli for antioxidant activity. Deore and Khadabadi (2008) reported antioxidant and anti-inflammatory activity from different root extracts of *C. borivilianum*. Methanolic and aqueous extracts demonstrated notable activity in experimental models, while methanolic extract showed particularly strong free-radical-scavenging effects in the assays employed. The antioxidant potential has also been investigated in metabolic and reproductive models. Visavadiya and Narasimhacharya observed increased antioxidant status in hyperlipidaemic rats receiving *C. borivilianum* root powder, including increases in superoxide dismutase and ascorbic acid levels (Visavadiya and Narasimhacharya, 2007) [13]. Similarly, Narasimhan *et al*. demonstrated protective effects of a fructo-oligosaccharide fraction against streptozotocin-induced oxidative stress. These findings suggest that Safed Musli may influence oxidative balance through multiple chemical fractions. However, *in-vitro* radical-scavenging activity should not automatically be interpreted as clinical antioxidant efficacy. Future studies should establish pharmacokinetically relevant concentrations, identify active metabolites and determine whether antioxidant effects are responsible for clinically meaningful outcomes.

Reproductive and Aphrodisiac Potential

The reproductive-health application of Safed Musli is the most extensively discussed aspect of its pharmacological profile. Traditional use has long associated the plant with sexual vitality and male reproductive health. Experimental evidence provides some support for these traditional observations. Kenjale *et al*. evaluated an aqueous root extract in male Wistar rats and reported increased libido, sexual vigour, sexual arousal and sperm count. The study included sildenafil as a positive control and found that treatment with 125 and 250 mg/kg of the extract increased sexual behavioural parameters, with increased sperm count following longer treatment (Kenjale *et al*., 2008) [4]. The reproductive effects may extend beyond behavioural

changes. Thakur *et al*. investigated *C. borivilianum* in hyperglycaemic male rats and reported beneficial effects against diabetes-associated sexual dysfunction. Such findings are relevant because metabolic disorders and oxidative stress can negatively influence spermatogenesis and sexual function (Thakur *et al*., 2009) [11]. Sharma and Kumar further investigated the protective potential of *C. borivilianum* against arsenic-induced testicular impairment. In their mouse model, root extract administration reduced oxidative and reproductive damage associated with arsenic exposure and improved parameters including sperm count, sperm motility, glutathione and serum testosterone (Kumar *et al*., 2010) [5]. Importantly, Das *et al*. evaluated a standardized root extract in male Wistar rats. Administration for 54 days at 125 and 250 mg/kg enhanced sexual vigour and libido and increased sperm count and motility. The study also assessed reproductive safety and reported that sperm abnormalities remained below 10% despite an increase in the abnormality percentage (Rath and Panja, 2013) [8]. These studies collectively suggest that the reproductive effects of Safed Musli may involve several interacting mechanisms, including antioxidant protection, modulation of reproductive physiology, improvement of sperm production and possible effects on sexual behaviour. Nevertheless, the available evidence remains insufficient to regard Safed Musli as a replacement for established medical treatment of infertility or erectile dysfunction.

Evidence from Human Clinical Research

Although preclinical evidence is relatively extensive, clinical evidence remains limited. One particularly relevant investigation was conducted by Rath and Panja in healthy adult males. Their randomized, double-blind, placebo-controlled study examined a water-soluble extract of *C. borivilianum* root tubers administered over 12 weeks. The investigators assessed semen volume, liquefaction time, sperm count, sperm motility and serum testosterone (Sharma and Kumar, 2012) [10]. The study reported significant improvements in the assessed reproductive parameters compared with placebo. These findings provide an important bridge between traditional claims and clinical research. However, the study was relatively small, and its results require confirmation through larger, independently conducted randomized trials. Clinical research should also examine outcomes that matter directly to patients, including validated measures of sexual function, infertility outcomes, pregnancy rates, hormonal profiles and quality of life. Trials should use chemically standardized extracts, clearly defined doses and reproducible manufacturing methods. Without such controls, differences between commercial Safed Musli products may make clinical findings difficult to compare.

Metabolic and Antidiabetic Potential

Safed Musli has also attracted attention for possible metabolic effects. Panda *et al*. (2007) investigated methanolic root extract in normoglycaemic and alloxan-induced hyperglycaemic animals and reported significant reductions in blood glucose, together with analgesic effects. The fructo-oligosaccharide fraction investigated by Narasimhan *et al*. further supports the possibility that non-saponin carbohydrates contribute to metabolic protection. Meanwhile, Visavadiya and Narasimhacharya demonstrated beneficial changes in lipid metabolism in hyperlipidaemic rats treated with root powder, including increased HDL cholesterol and reductions in plasma and hepatic lipid profiles (Visavadiya and Narasimhacharya, 2007) [13]. These findings indicate potential metabolic activity, but they should not be interpreted as evidence that Safed Musli can independently treat diabetes or dyslipidaemia in humans. Human metabolic studies with standardized preparations are required before therapeutic recommendations can be made.

Immunomodulatory Activity

Immunomodulation represents another important area of investigation. Thakur *et al*. evaluated ethanolic root extract and sapogenin fractions in experimental models of immunosuppression. The extract improved several immune-related parameters, including delayed-type hypersensitivity, neutrophil adhesion and phagocytic activity, and enhanced survival following experimental. This evidence provides a mechanistic rationale for the traditional classification of Safed Musli as a rejuvenating or adaptogenic herb. However, immunostimulation is not inherently beneficial in every clinical setting. Excessive immune activation could potentially be undesirable in autoimmune or inflammatory conditions. Modern research should therefore focus on defining whether Safed Musli produces generalized immune stimulation or more selective modulation of particular immune pathways.

Lipid-Modulating and Cardiometabolic Effects

The lipid-modulating activity reported by Visavadiya and Narasimhacharya is of particular interest because it connects traditional nutritional use with contemporary cardiometabolic research. Four weeks of root powder administration in hypercholesterolaemic rats increased HDL cholesterol and reduced plasma and hepatic lipid concentrations. Increased faecal cholesterol and bile-acid excretion were also observed, suggesting enhanced cholesterol turnover. Such findings raise the possibility that Safed Musli could have supportive nutraceutical applications. However, the evidence remains experimental. Future studies should determine whether the effect is attributable to saponins, soluble fibres, fructans or combinations of these components and whether similar responses occur in humans.

Cultivation, Conservation and Genetic Resources

The growing medicinal demand for Safed Musli creates a major sustainability challenge. Increased commercial harvesting can place pressure on wild populations, particularly because the medicinally valuable portion is the root. A comprehensive review highlighted concerns related to commercial exploitation, adulteration and inadequate standardization of raw materials (Dhakad *et al*., 2024) [3]. Genetic conservation is particularly important. Tripathi *et al*. used amplified fragment length polymorphism markers to evaluate 34 accessions and found limited genetic variation among sampled populations in central India. Low genetic diversity can reduce adaptive capacity and complicate long-term conservation. Micropropagation, elite-line selection, authenticated germplasm banks and controlled cultivation could therefore contribute simultaneously to conservation and pharmaceutical quality.

Quality Control and Standardization

One of the greatest barriers to the integration of Safed Musli into modern medicine is the absence of universally accepted

standards for commercial preparations. The term "Safed Musli" may be used commercially for different Chlorophytum species or mixtures, creating a risk of substitution and adulteration. A scientifically acceptable medicinal product should therefore begin with botanical authentication supported by morphological, microscopic and molecular methods. Chemical standardization should include quantitative determination of selected steroidal saponins or other validated marker compounds. Deore and Khadabadi's identification of Chlorophytoside-I demonstrates the feasibility of using defined phytochemical constituents for authentication. Modern quality control should combine DNA-based authentication, chromatographic fingerprinting, quantitative marker analysis, microbial testing, pesticide-residue testing, heavy-metal analysis and stability studies. Standardization is particularly important for clinical trials because differences in extraction procedure can produce apparently contradictory pharmacological results.

Safety and Toxicological Considerations

The therapeutic reputation of Safed Musli has sometimes encouraged the perception that it is inherently safe. Such an assumption is scientifically inappropriate. Herbal products can vary in chemical composition, contamination and dose, and therefore safety must be evaluated for the specific preparation. The available animal evidence is encouraging but incomplete. Das *et al*. reported a generally acceptable reproductive safety profile in rats receiving standardized extract for 54 days, although some changes in sperm abnormality were observed. The 2013 comprehensive review also emphasized that toxicity, safety and quality data were insufficient for confident commercial pharmaceutical utilization. Future safety programs should include acute, subacute and chronic toxicity, reproductive and developmental toxicity, genotoxicity, hepatotoxicity, nephrotoxicity, drug-herb interactions and pharmacokinetic investigations. Particular attention should be paid to individuals taking antidiabetic, antihypertensive, anticoagulant or reproductive medicines.

Future Prospects in Modern Medicine

The future of Safed Musli should move beyond its popular characterization as an "herbal Viagra." Such terminology oversimplifies a chemically and pharmacologically complex plant. Current evidence suggests several research directions. First, metabolomics and high-resolution mass spectrometry could identify additional bioactive constituents and establish chemical fingerprints of high-quality extracts. Second, structure-activity studies should determine which steroidal saponins, fructans or other compounds contribute most strongly to reproductive and antioxidant effects. Third, pharmacokinetic studies are necessary to establish absorption, metabolism and bioavailability. Fourth, well-designed randomized controlled clinical trials should evaluate standardized preparations for male reproductive dysfunction, particularly in patients with defined clinical conditions. Fifth, combination approaches could investigate whether Safed Musli constituents act synergistically with nutritional or pharmacological interventions. Recent reviews continue to identify Safed Musli as a promising medicinal plant while emphasizing the need to connect phytochemical composition with pharmacological outcomes and clinically relevant evidence (Das *et al*., 2016) [1]. The plant may ultimately find applications not only as a traditional medicine but also as a standardized botanical ingredient, nutraceutical, reproductive-health formulation or source of lead molecules for pharmaceutical development.

Conclusion

Safed Musli (*Chlorophytum borivilianum*) represents a scientifically intriguing medicinal plant at the interface of traditional knowledge and modern pharmacology. Its roots contain steroidal saponins, furostanol saponins, fructans, polysaccharides, phytosterols, fatty acids and other constituents that may collectively explain several of its reported biological activities. Experimental research has demonstrated antioxidant, anti-inflammatory, immunomodulatory, hypoglycaemic, lipid-modulating and reproductive effects. Among these, the evidence supporting reproductive and spermatogenic activity is particularly notable, with both animal studies and a preliminary human clinical trial providing encouraging observations. Conservation must proceed alongside pharmaceutical development because excessive harvesting and limited genetic diversity may threaten the long-term availability of the plant. Micropropagation, controlled cultivation and germplasm conservation provide promising strategies for sustainable production. Thus, the scientific future of Safed Musli lies not in replacing conventional medicine on the basis of traditional reputation alone, but in transforming a historically valued medicinal herb into a standardized, reproducible and clinically validated botanical resource.

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