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Original Article

The Role of Indian Magical Herb *Selaginella bryopteris* L. (Selaginaceae) in Pharmacotherapeutic Perspective: An Overview

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ABSTRACT

This review involves the medicinal as well as therapeutic applications of Sanjeevni (*Selaginella bryopteris* L.) in curtailing different types of acute and chronic maladies. The magical herb (*Selaginella bryopteris*) is utilized for its resurrecting and medicinal properties in various regions of the world. *S. bryopteris* based formulations have been widely used in folk medicine to treat spermatorrhoea, colitis, epilepsy, leucorrhoea, urinary tract infections, fever, venereal illnesses, constipation, beri-beri, cancer, and many other ailments. The medicinal and pharmacological effects of *S. bryopteris* have been extensively studied in recent years, employing a variety of *in vivo* and *in vitro* models and clinical studies. Many biochemical and pharmacological studies on *Selaginella bryopteris* have been conducted, and many of its traditional applications have been validated scientifically. Different biological activities are concerned with it, like anti-bacterial, growth-promoting, anti-protozoan, relief from heat stroke and the burning sensation during urination, anti-stress cell death, memory improvement, relief from stomach-aches, anti-hyperglycemic activity, and anti-depressant activity. *S. bryopteris* is undeniably one of the most significant plants owing to its enormous pharmacological and therapeutic potential. On the other hand, several information gaps found in this article might spur fresh academic and R&D efforts to produce *S. bryopteris*-based herbal medications and nutraceuticals.

Key words: *S. bryopteris* L., Sanjeevni, Selaginaceae, Biflavonoid.

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INTRODUCTION

Herbal preparations have been used for a long time as medicinal, prophylactic, and health-promoting agents all over the world. Sanjeevni (*Selaginella bryopteris* L.) *selaeagnaceae*, a one-of-a-kind and extremely valuable plant, has attracted international attention due to its therapeutic and miraculous restoration potential. *S. bryopteris* is an anitrogen-fixing thorny deciduous plant endemic to Europe and Asia that grows in colder climates.[1] It has been introduced in a number of countries. It is employed as a key source ingredient in local tablets to treat spermatorrhoea, venereal disorders, constipation, indigestion, colitis, and urinary ailments in patients in India (diuretic). It's also used to treat comatose individuals and reduce the body temperature of those who have a fever.[2] It has robust vegetative reproduction and a strong, complex root structure with nitrogen-fixing ability. It is a hardy herb that is both drought and cold-resilient, making it excellent for land restoration and farmstead protection.[3] This herb has been often used in oriental traditional medicine to cure unconscious patients as well as lower body temperature in patients with fever. Recent studies are now underway to further understand and support *S. bryopteris* traditional usage. So far, *S. bryopteris* has been associated with a wide range of pharmacological actions, like anti-stress cell death, relief from heatstroke and the burning sensation during urination, memory enhancement, anti-hyperglycemic activity, relief from stomach aches, and anti-depressant activity.[2,4] The current study describes the current and ancient medical uses of *S. bryopteris*, as well as relevant scientific investigations into its medicinal and pharmacological properties.

HISTORICAL BACKGROUND AND BOTANICAL DESCRIPTION

Sanjeevani, in botanical language, is also known as *S. bryopteris* (Figure 1). It is known for its remarkable renaissance capabilities. According to the Ramayana, Ravana flung a formidable weapon at Lakshmana (Lord Rama's brother), who had murdered his eldest son Indrajit, according to the Ramayana. Hanuman sought guidance from Sushena, the Lankan Imperial Physician. Sushena requested that Hanuman run to the Dronagiri Hills and collect four plants: Sanjeevani was one of those four plants.[5] The great traditional knowledge of *S. bryopteris* herb to cure many ailments has been properly described in the Charaka Samhita and Sushruta. *Selaginella* contains sweet, spicy, bitter, and frigid qualities and is related to the liver, stomach, and lung meridians in traditional Chinese medicine.[6] *S. bryopteris* is a poikilohydric lithophyte that may be found all over the mountains. This plant is sold in various regions of India for its peculiar characteristics, mostly in pilgrimage destinations such as Rishikesh, Haridwar, and Varanasi.[7] It's called "punjemariam" or "hathazori" in Unani. These possess dichotomously branching stems, little leaves that are alternating, opposite, simple, one-veined, and occasionally two sizes, and ligule-like scales (early deciduous). Selaginella is a creeping plant with small scale-like leaves on branched stems that also produce roots. The plants have two types of spores: megaspores and microspores,[8] and all microphyll and sporophyll have ligules, which are scale-like outgrowths towards the base of the upper surface. Each microphyll has a branching vascular trace, which is unusual for lycopods. Roots grow on wiry rhizophores that emerge from stem forks. Sporangia

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are borne in fertile leaf axils (sporophylls). Selaginella's life cycle comprises microsporangia, megasporangia, and other forms (Figure 2). Microspores are microscopic and abundant, whereas megaspores are large and come in groups of four per megasporangium. The megaspore is where the gametophyte grows. *S. bryopteris* has n=10 chromosomes.[9] The months of July to September are the most fertile for *S. bryopteris*.

PHYSIOLOGICAL AND BIOCHEMICAL PROCESSES OF *S. BRYOPTERIS*

The resurrection plant has biochemical, morphological, physiological, and genetic mechanisms that allow it to sustain harsh desiccation.[10] During dehydration and rehydration, the plants undergo metabolic alterations. The majorities of proteins produced during dehydration are found in chloroplasts and perform vital roles in photosynthetic structure preservation and recovery in resurrection species.[11] During this period, net photosynthesis is limited, PSII has higher photochemical efficiency, and dark respiration continues even at 10% relative water content, but bursts following rehydration, necessitating protective measures.[12] Proteome analysis of detached fronds indicates that transport, targeting, and degradation proteins are variably expressed during the desiccation phase, with minimal difference in electrolyte leakage among dehydrated and rehydrated fronds. The plant solely performs respiration, with a decrease in Fv/Fm ratios and fluorescence after rehydration, which appears to be a physiological

Table 1: Scientific classification.

Kingdom	Plantae
subkingdom	Viridiplantae
superdivision	embryophyta
division	Lycopodiophyta
Class	Isoetopsida
Order	Selaginellaies
Family	Selaginellaceae
Genus	*Selaginella*
Species	*Bryopteris*

Figure 1: *S. bryopteris* (Sanjeevni) collected herb.

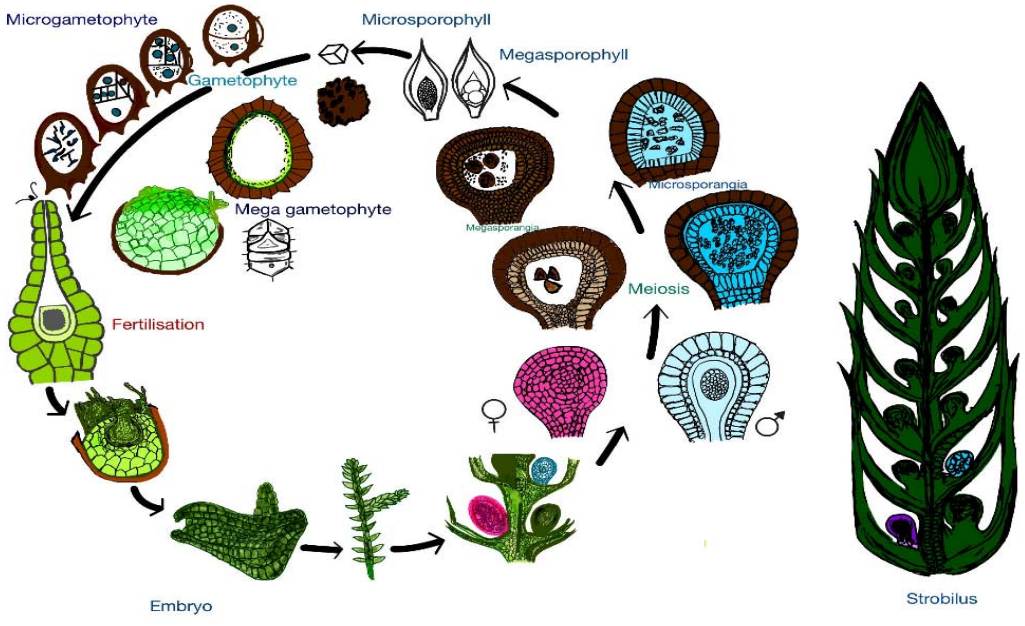

Figure 2: Life cycle of *S. bryopteris*.

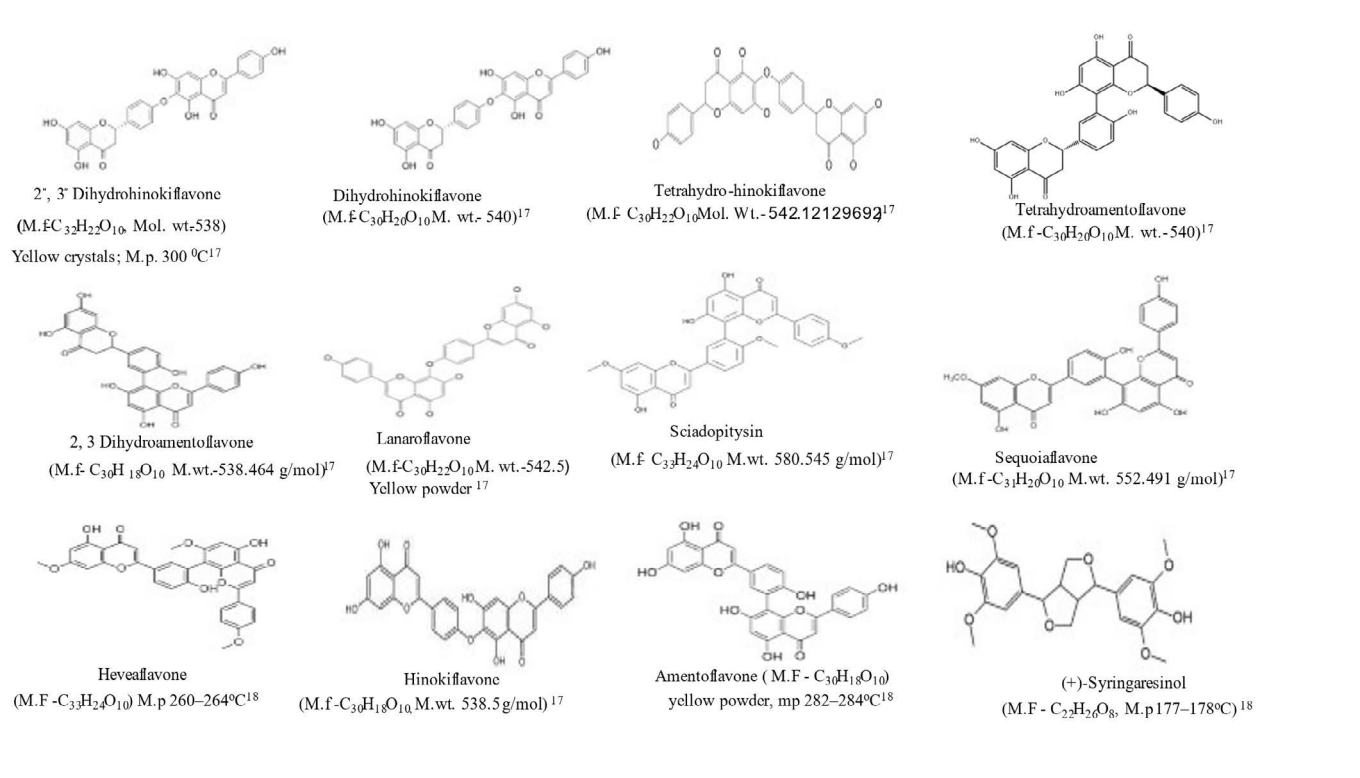

Figure 3: Physical properties of various compounds of *S. bryopteris.*

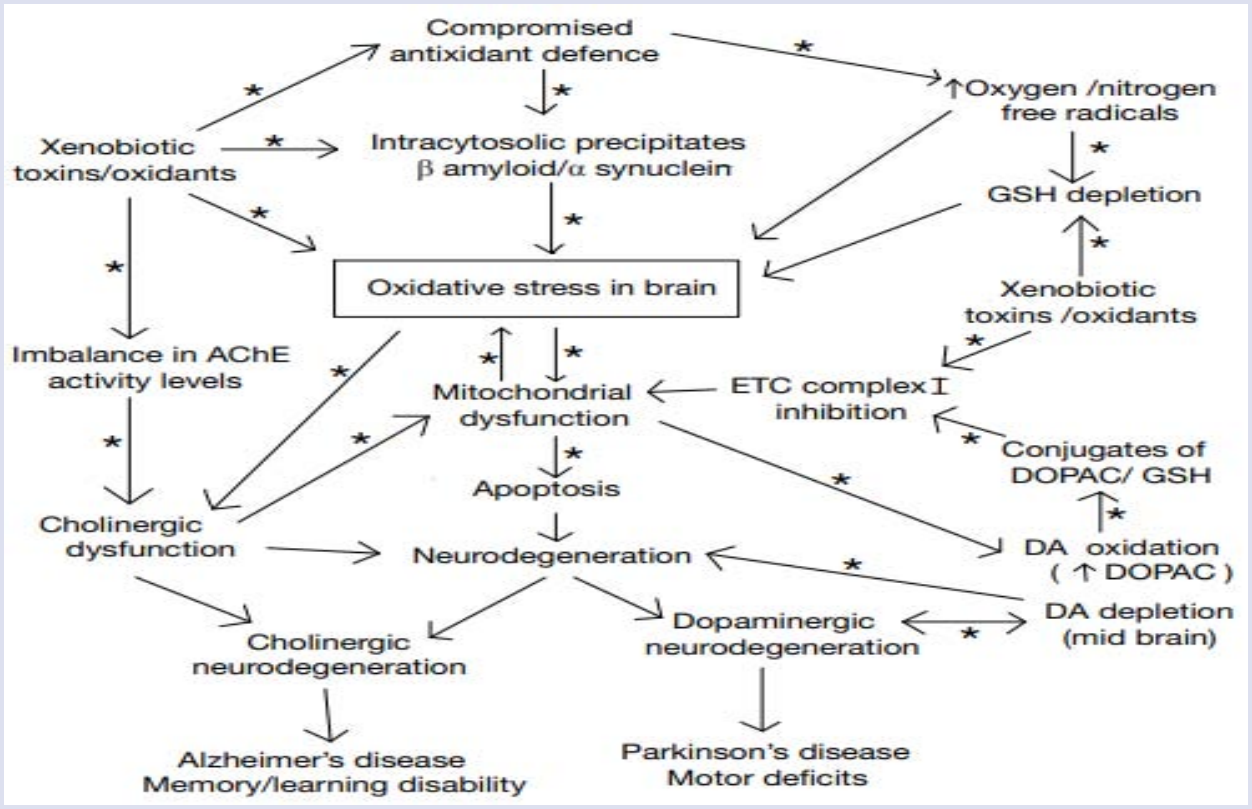

Figure 4: The role of oxidative stress and mitochondrial dysfunction in the evolution of neurodegenerative illnesses (*-Therapeutic targets for phytochemical action) is depicted in this diagram.

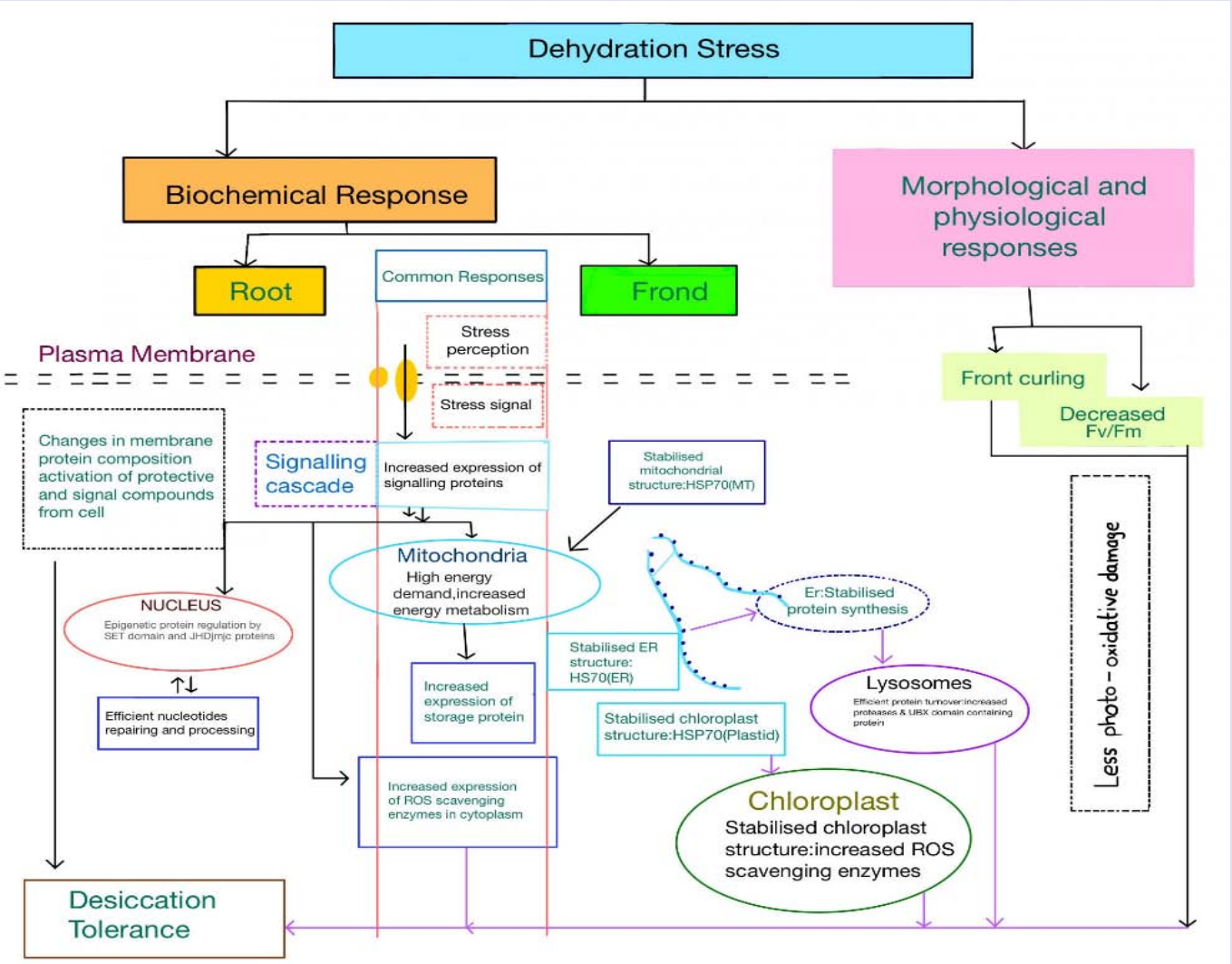

Figure 5: Simplified model of *S. bryopteris* dehydration/rehydration response based on physiological and proteomic data, illustrating the combined actions of many processes that contribute towards the development of desiccation tolerance.

Table 2: Some chemical properties and their pharmacological activity.

Compound Name	Molecular formula	Biological activity
Lanaroflavone	$C_{30}H_{18}O_{10}$	Antimicrobial activity against axenically grown Leishmania donovani amastigotes and plasmodium falciparum[17]
2, 3 Dihydrohinokiflavone	$C_{30}H_{22}O_{10}$	Antimicrobial Neuroprotective activity against 0.1 uM amyloid beta 42-induced toxicity in rat PC12 cells evaluated as cell viability after 24 hrs by MTT method.[19,20]
Heveaflavone	$C_{33}H_{24}O_{10}$	cytotoxic activity against L 929 murine cells[21]
(+)-Syringaresinol	$C_{22}H_{26}O_8$	inhibitory effects on the P-MCF-resistant human breast cancer cells, glycoprotein 7/ ADR, adriamycin[22]
2″,3‴Dihydroamentoflavone	$C_{30}H_{20}O_{10}$	beta-Secretase (BACE-1) inhibitory effect and cytotoxic effect against P-388 and/or HT-29 cell lines in *in-vitro*high inhibitory potency against α-glucosidase[23]
2,3-Dihydrohinokiflavone	$C_{32}H_{22}O_{10}$	cytotoxicactivity against Mouse lung cancer LLC cell and B16 melanoma cell lines[24]
β-sitosterol β-D-gl1ucoside	$C_{35}H_{60}O_6$	NO release inhibition in RAW 264.7 cells (an LPS-activated macrophage cell line)[25]
Aniline	$C_8H_8O_4$	anti-diabetic,[26] antimicrobial,[27] antifungal antispasmodic,[28] anti-tumor[29]

benefit of this resurrection plant.[13] Residual oxygen species, proline lipid peroxidation, deposition, and antioxidative enzymes, such as ascorbate peroxidase, catalase, and superoxide dismutase, as well as soluble acid invertase, were enhanced, despite a slight decrease in chlorophyll content and a reduction in sucrose and starch content. The plant exhibits 100% recovery following rehydration, even in the presence of photo inhibitory or thermal damage to PSII, indicating its drought resistance. The hydrated condition boosts intermediate of processes such as glycolysis, gluconeogenesis, and the tricarboxylic acid cycle, as well as antioxidant vanillate, sugar alcohols, sugar acids, and polyunsaturated fatty acids. Nitrogen-rich and nucleotide catabolism materials (e.g., allantoin), UV-protective molecules such as 3-(3-hydroxyphenyl) propionate, apigenin, naringenin, and γ -glutamyl amino acids such as citrulline, and lipids such as choline phosphate are

formed much more during dry state conditions, and play a key role in cell membrane hydration and maintenance.[14] Researchers reported 500 protein spots in dried *Selaginella bryopteris* plants using two-dimensional gel electrophoresis, nine of which showed substantial changes in abundance, eight of which were up-regulated, and one of which was downregulated, presumably by conserving photosynthetic function.[15]

Phytochemistry

Some significant secondary plant metabolites such as alkaloids, phenol, flavonoids, tannins, saponins, and terpenoids were identified in the chemical analysis of *S. bryopteris* (triterpene, steroid). Biflavonoid is the most important secondary metabolite. *S. bryopteris* (L.), a desiccation tolerant Indian resurrection and medicinal herb, is abundant in flavonoids.[12,16]

Scope of secondary metabolites in biogenesis

Sanjeevani Booti (*S. bryopteris*) has the highest degree of drought resilience, as one of its special features. The strength of this fern is unaffected by years of drought. Its drought-resistant gene is the source of this remarkable ability. This fern's one-of-a-kind feature is truly extraordinary. Scientists at CSIR- National Botanical Research Institute in Lucknow, India, are seeking to identify its unique drought-resistant gene, and they also want to use biotechnology to create transgenic agricultural crops by inserting its gene into the genomes of cereals like wheat, rice, and legumes. So that, even if the monsoon fails, the cereal grains will not be affected and will be able to endure the tough circumstances courtesy of Sanjeevani's gene.[30]

Role of biflavonoid as neuromodulators

It is widely accepted at this point that medicinal defensive mechanisms cause molecular changes in the system not only through their "antioxidant properties," but also through interactions with membrane receptors and gene regulation. In a review of 23 industrialised nations, Beking and Vieira reported a negative relationship between flavonoids in the diet and Alzheimer's disease-related dementia. According to recent epidemiological research, consuming a variety of flavonoids in one's diet decreases the chance of developing Parkinson's disease in males. A recent analysis found epidemiological evidence that flavonoids in cuisine can help to reduce the incidence of cancer and cardiovascular disease.[31,32]

Water stress tolerance capacity

Resurrection plants can tolerate vegetative growth desiccation and can survive even when the majority of their cellular water (> 95 percent) is lost and they restore their structure after rehydration by controlling the expression of several genes.[15] In pteridophytes, resurrection plants are uncommon, indicating a herbaceous life-form found in deserts or temperate climates. Several investigations have been conducted to determine how this plant adjusts to the dry phase and lives. Due to the presence of a unique disaccharide called trehalose, most *Selaginella* species can tolerate extreme drought circumstances.[31] Cellular mechanisms research revealed the activation of stress-associated genes and elevated levels of defensive metabolites in the absence of stress, as well astranscriptome and metabolome reconfigurations that occur rapidly throughout drought stress periods, allowing them to endure significant drought stress.[15] A broad spectrum of metabolites, including aromatic amino acids, osmoprotectant betaine, and flavonoids, are used by several different species to resist desiccation. Higher quantities of c-glutamyl amino acid in these species have been connected to glutathione metabolism, which is utilised in the detoxification of reactive oxygen species, followed by nitrogen remobilization and rehydration.[33]

OTHER MEDICINAL APPLICATIONS

It's also been used to treat liver and epilepsy-related issues.[34] In Madhya Pradesh, the plant is primarily used as a strengthening tonic by the Gond tribes. The dried powder of this herb is used by women in Chattishgarh's Bastar district to treat gynaecological issues such as monthly irregularities, leucorrhoea, and childbirth discomfort.[35] Its herb paste is eaten orally by the native population of Songhati and Sonbhadra in UP to treat beri-beri, dysentery, and rejuvenation when taken with cow's milk. *S. bryopteris* (L.) Bak. is also important for soil conservation, humus production, and soil formation. They also collect tiny fallen leaves, grass, and other biodegradable components that are beneficial to the creation of humus. As an indication of atmospheric humidity, this plant may flourish effectively in xeric conditions. *S. bryopteris* can also be used to treat abnormalities in the oestrous cycle or menstrual cycle. *S. bryopteris* is widely used to treat heat strokes, which is one of the most annoying things for humans who work outside in extremely hot temperatures, particularly in the months of May and June in the tropical part of the country.[7]

AYURVEDIC FORMULATION

<table>
<tr><td colspan="3">SANJEEVNI
Beauty Elixir
Ayurvedic name: Sanjeevani</td></tr>
<tr><td>Authentic Ayurveda Formulation
The elixir has reciving and rejuvening properties. A uniqe formulation which resembles the natural sebum on the skin</td><td colspan="2" rowspan="2">Store only in cold, dry location and usage externally
CAUTION: Certain people may be allergic to natural items. Place the patch on the inside of your elbow and wait thirty minutes. If irritation occurs, stop using it.</td></tr>
<tr><td>Directions: After washing and tonning, use a tiny quantity and gently massage upwards in strokes on the face and neck using your fingertips.
used on a regular basis.</td></tr>
<tr><td rowspan="2">key ingredients: Aqua, prunsamygdalusduicis (sweet almond) kernel oil, S. bryopteris (Sanjeevni) infusion, Buchananialanzan (chirongi) seed extract, glycerin, simmondsia chinensis (jojoba) seed oil, hemideddmus indicus (anantmool) root extract, terminalia chebula (haritaki) fruit extract, mesua ferrea (nagkesar) extract, curcuma longa (turmeric) rhizome extract, tocophenyl acetate (vitamin E), eiettaria cardamomum (cardamom) extract
*cold pressed</td><td>Code 7541 R
B. No
Mfd, M/Y
Best before
MRP (incl. of all taxes)</td><td rowspan="2">  </td></tr>
<tr><td>Manufactured & marketed by:
Mountain velley springs (1) pvt. Ltd.
E46l, A, bahadravad, Haridwar, uttarakhand-249402
M.L. No UA/ AYU164/2009
C, Care No. + 91.120.4696969
care@forestessentla/ sindha.com
MADE IN INDIA</td></tr>
</table>

CONCLUSION

Ethnobotany is now a prominent area of study for India's major funding bodies. The subject has helped humanity to grasp the scientific foundations of our cultural history and has served as a link between a variety of social and physical disciplines, as well as classical botany and medical sciences. Many ethnomedicines are used by many R & D organisations as a repository for plant-based pharmaceutical industries and herbal medication development. This plant, no doubt, exhibits various vital medical benefits and has been revered as a mystical herb by

the locals due to its medicinal capabilities. However, the presence of a drought resistance gene within the cells of this fern is a more significant feature, and it is likely that it will soon become a real Sanjeevani (life-giving herb) for global agricultural crops, even in the lack of water. Selaginella species are also utilised as food (raw vegetables), ornamental plants, handicraft materials, and socio-cultural and packing items. *S. bryopteris* (L.) Bak. has a limited use compared to other species, but it has many medicinal properties and has been used by local people in the past to treat heat stroke and burning sensations during urination, to control irregular periods, to ease childbirth and reduce labour pain, and to treat jaundice. Nature enthusiasts, botanical experts, and forest officials may find this document useful in the protection and sustainable usage of this rare and endangered species. As a result, it is critical to understand more about this miracle plant and to work toward its preservation.

CONFLICTS OF INTERESTSTATEMENT

I declare that I have no conflicts of interest.

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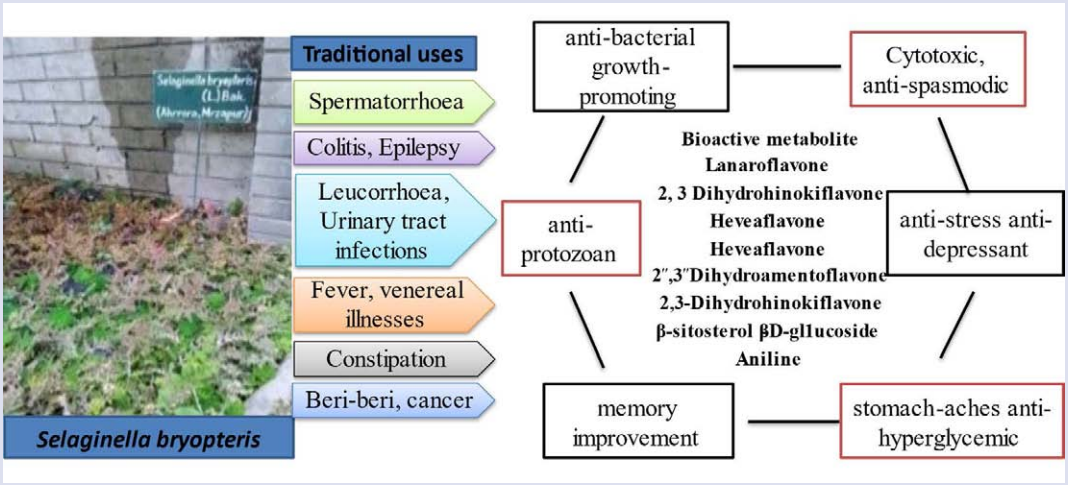
GRAPHICAL ABSTRACT



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Dr. Lal Chand Pal has done Ph.D. from pharmacology Division of CSIR-National Botanical Research Institute Lucknow (India), his research focus on the mechanism of hepatoprotective activity from traditional medicinal plants, with special interest in various In-vitro and In-vivo activity. His interest also spans the preclinical toxicity studies, Anti-cancer and antioxidant activity.

Dr. Ch. V. Rao currently working as a Senior Principal Scientist and Head, Department of Pharmacology, CSIR National Botanical Research Institute, Lucknow (India). He is in instrumental in setting up of pharmacology laboratory in NBRI, devoted to botanical herbal drug development, safety and efficacy studies. Dr. Rao published 130 research papers in peer reviewed national and international journals. To his credit he is holding 35 patents and numbers of products were commercialized.

Dr. Vikas Kumar currently working as a Assistant Professor (pharmacognosy), Department of Pharmaceutical Sciences Sam Higginbottom University of Agriculture Technology and Science Prayagraj (India). Has been working on traditional medicine encouraged drug discovery leading to development of therapeutic lead from natural resources. His research work on diabetes, cardiovascular disease and cancer. His credit above 90 (impact factor=260.67), 80 book chapters. He has received national and international award.

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