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SELAGINELLA BRYOPTERIS (L.): A WONDER HERB

Nishant Vashistha and Ashish Tejasvi
Department of Botany, Agra College, Agra (U.P.), India
*E-Mail: tejasvi.botany@gmail.com

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ABSTRACT

Plants have been the foundation of several traditional medicinal systems all over the world to provide mankind with new remedies for thousands of years and still continue. In the ancient times human understanding about medicine was always near to some plant. It was the time when medicinal system was entirely based on plants. Among different medicinally useful plants one such plant is called *Selaginella bryopteris* L. in the botanical world and also known as Sanjeevani due to its magical medicinal properties. It is an herb which is traditionally used in many health-related problems like bacterial, viral, fungal infections, allergy, curing wounds, irregular menstruations and uterine disorders. According to some reports it is also used for fitness and better life span by the tribal communities of India. Different researchers across the country investigated and came up with its unique different properties and new possibilities every time. Apart from these Hindu mythological evidences are there which tells about its extraordinary potential of infuses life to dead. So, it is certainly a matter of more and more research to find out its ever-new hidden capabilities.

Keywords: : Ancient, bacterial, fungal, medicinal, sanjeevani, viral.

INTRODUCTION

There is no plant in the world which is non-medicinal or which cannot be used as medicine. Human civilization is using plant kingdom for different purposes since it was not even called civilized. According to Jaiswal, 2018 the Indian systems of medicine, particularly Ayurveda, Siddha, Unani and Homoeopathy medicine largely use plant base ancient texts had documented medicinal uses of large number of plants. These plants are being used for preparation of medicines for centuries. Plants are valuable gift of nature. People are always exploring entire plant kingdom in the search of ever new drugs. In the possibility of so many uses of plants they are being used potentially as medicine since date back. Almost from the very starting of this story of life on earth, plants were the only known medicines for any ailment. India has a rich traditional knowledge and heritage of herbal medicine in the form of Ayurveda. India is the largest producer of medicinal herbs and is called as botanical garden of the world (Jaiswal *et al*., 2016). We can say that with the help of existing historical evidences from the primitive times various plant extracts are being used for curing different health related problems. Human beings have always utilized plant parts, products or sometimes whole plant in different capacity as per the traditional knowledge. In that period, doctors almost all over the world used herbs to relieve pain and to cure various diseases. So many plants which are initially used as medicines are still in use today. Pteridophytes are the second largest group of plants occupying next place to angiosperms in number. According to Kumar, 2018 pteridophytes are the seedless vascular cryptogams which occupy a position between the lower non-seed bearing and higher seed-bearing plants from generally much neglected group of plants. About 250 million years ago, they constituted the dominant vegetation on earth surface. However, they are now replaced by seed bearing plants in the modern-day flora. Pteridophytes grow luxuriantly in moist tropical and temperate forest and their occurrence in different eco-geographically threatened regions from sea level to the highest mountain are of much interest. The ferns had an important role in folklore medicine. These plants have been successfully used in the different systems of medicines like Ayurvedic, Unani, Homeopathic and other systems of medicines. Pteridophytes possess medicinal properties like angiosperms and gymnosperms and many of them are being used medicinally since ancient times. In this order among other important various medicinal plants, *Selaginella bryopteris* (L.) is frequently being discussed and used by human beings all the time. From the long back time in India it is known for its remarkable medicinal properties so it holds the higher position as wonder herb traditionally.

Taxonomical status

Selaginella bryopteris (L.) is a pteridophytic resurrection plant native to India and a widely known member species of cosmopolitan family selaginellaceae among almost 750 estimated living species. Further it belongs to Genus: Selaginella, Order: Selaginellales, Class: Isoetopsida, Division: Lycopodiophyta and Kingdom: Plantae (Antony and Thomus, 2011).

Habitat

Selaginella shows considerable variation in size, symmetry and morphology. Mostly they are herbaceous perennials, however, a few are annuals. According to Antony and Thomas, 2011 Sanjeevani grows on the hills of tropical areas, particularly the Arawali Mountain terrains from east to west in India. *S. bryopteris* is known to be a poikilohydric lithophyte occurring along the mountains and in fact, this herb is sold for this peculiar feature in several markets in India mostly in places of piligrimage such as Rishikesh, Haridwar and Varanasi. The plant grows luxuriantly during rains exhibiting a lush green velvety landscape. Higher plants are unable to survive desiccation to an air-dried state. However, a small group of vascular plants termed "Resurrection plants" have evolved desiccation tolerance and they can revive from an air-dried state. Resurrection plants are able to withstand severe water loss and some are even able to equilibrate the leaves with air to 0% (v/v) relative humidity. This is the severest form of water stress since most protoplasmic water is lost from the cell under these conditions. Resurrection plants are mostly poikilohydrous which means that their water content adjusts with the relative humidity in the environment. They are able to stay in the desiccated state until water becomes available and allows them to rehydrate and to resume full physiological activities (Pandey *et al*., 2010).

Pandey *et al*., 2017 concluded that the capability of drought resistance makes this plant a wonder herb. *Selaginella bryopteris* (L.) has remarkable resurrection capabilities, being able to survive even without water. The herb does not die under water stress condition and just curls up and loses color, turning to brown in the absence of moisture and regain its original color within hours of coming in contact with water. The resurrection plants generally survive under water stress conditions showing various adaptations such as increase in sugar contents sucrose, galactinol and raffinose that prevent death of the tissues from dehydration and osmotic stress. These plants also contain several types of sugar acids and sugar alcohols protecting them from detrimental effects of cell destruction. The herb shows remarkable variation in chemical compositions. They have capacity to tolerate desiccation of vegetative tissues and survive even loss of most of its cellular water (>95%), regain structure after rehydration depending on the regulated expression of various genes. Resurrection plant shows a unique morphological, biochemical, physiological and genetic protective mechanisms to resist under extreme desiccation. The plant shows physiological and biochemical changes during desiccation and rehydration. Most of the proteins that are synthesized during dehydration are present in chloroplasts and plays significant role in the protection of photosynthetic structures and recovery in resurrection species. During this phase the net photosynthesis inhibits, PSII shows more photochemical efficiency, dark respiration proceeds even at 10% relative water content but burst after rehydration thus requiring protection mechanisms. Proteome studies of detached fronds reveals differentially expressed with highest quantity of transport, targeting and degradation proteins during desiccation phase and a very little change in electrolyte leakage, dehydrated and rehydrated fronds. The plant performs only respiration and there was decline in Fv/Fm values and fluorescence and photosynthesis activates after rehydration which seems as a physiological advantage of this resurrection plant (Pandey *et al*., 2017).

Unique ecological characters

Ecologically it is a lithophyte having multiple medicinal properties due to the presence of different secondary metabolites like alkaloids, phenol and terpenoid. According to Singh and Singh, 2015 *Selaginella bryopteris* (L.) plays a significant role in the soil conservation, humus and soil formation. It naturally produces dense underground network of stoloniferous long creeping rhizome which holds the soil and water to form dense velvety green carpet like structure. It protects the soil from direct rain showers and also checks the flowing rainwater.

They also trap the smaller fallen leaves, grass and other biodegradable materials useful for humus formation. This herb can grow well in xeric condition, as an indicator of atmospheric humidity. Leaves curled up in dry weather but retain original color and shape if dipped upside down in water.

Mythological evidences

It is considered that in Hindu mythological epic Ramayana written by poet Tulsidas, Selaginella is mentioned under the name of Sanjeevani Booti. Sanjeevani is also known as a magical herb due to its alleged potentiality for resurrecting life. Literally Sanjeevani means something that offers life. Out of preliminary listing of seventeen plant species which could be sanjeevani only three final species were shortlisted out of which currently *Selaginella bryopteris* (L.) is considered as Sanjeevani. It existed before 300 million years and come under a group of plants which were the first vascular plants on earth (Kumar *et al*., 2018).

According to Tejaswi and Ranjan, 2018 in Hindu mythology Sanjeevani was a magical herb which had the power to cure any disease. In the Ramayana poet Tulsidas, mentioned the description of wonder herb Sanjeevani when, Lakshmana fell unconscious, near death, hit by an arrow from Meghnath, Sushena (Lankan Royal Physician) asked Hanuman to bring four plants: Mrutha Sanjeevani (restorer of life), Vishalyakarani (remover of arrows), Sandhanakarani (restorer of the skin) and Savarnyakarani (restorer of skin color) from Dronagiri Hills. Hanuman, not able to identify them from the multitude and brought back with entire hill and Lakshmana was revived from near death back to life. Thus, it was likely that Sanjeevani had properties capable of awakening or rejuvenating (and in that sense resurrecting) him. Accordingly, if Sanjeevani

does exist, it should have the ability bringing coma patients back to normal living state. In Ramayana it had been clearly mentioned that Sanjeevani Booti glows in the dark when made slightly wet and kept in dark it glows; emits light.

General characteristics

The general characteristics of Selaginellaceae family of which *Selaginella bryopteris* (L.) is also known as Spike Moss family includes plants that grow in rocks crevices and feed off moss, nutrients in rain water, litter and even their own dead tissue. These usually have dichotomously branched stems, microphylls (small leaves), alternate, opposite or whorled, simple, one veined, sometimes dimorphic (two sizes) with scale-like ligule (early deciduous). Plants of *Selaginella* are creeping or ascendant plants with simple, scale-like leaves on branching stems from which roots also arise. The plants are heterosporous (megaspores and microspores) and have structures called ligules,scale-like outgrowths near the base of the upper surface of each microphyll and sporophyll. Unusually for the lycopods each microphyll contains a branching vascular trace. Roots are borne on wiry rhizophores arising from forks in stem.Sporangia are borne in axils of fertile leaves (sporophylls).Plants are heterosporous. Life cycle of *Selaginella* includes various stages having microsporangia, megasporangia etc. Microspores are small, numerous, megaspores, large, four per megasporangium. The gametophyte develops inside the megaspore. Chromosome count of *Selaginella bryopteris* (L.) is n=10 (Antony and Thomas, 2011).
According to Soni *et al*., 2012*Selaginella bryopteris* (L.) fronds have stomata smaller in size but greater in frequency as compared to other fern species. Diurnal studies under natural conditions show that *Selaginella bryopteris* (L.) have a very high stomatal conductance and transpiration and a low WUE (water use efficiency). This study demonstrates that this plant has a very poor mechanism for its stomatal regulation in response to light, high temperature, high VPD (vapor pressure deficit), high CO2 and ABA and thus show a lack of capacity to optimize WUE (water use efficiency). *Selaginella bryopteris* (L.) is at a disadvantage as they grow in the open under high light, temperature and VPD (vapour pressure defecit) conditions. Although it shows high net photosynthesis rates but this is also offset by high transpiration. Several other findings would also represent a useful tool for further understanding of the development of stomatal regulation in lycophytes and higher vascular plants.

Ethnomedicinal importance of *Selaginella*

In India, it is used as a major ingredient in local pills for the treatment of patients with spermatorrhoea, venereal diseases, constipation, colitis, indigestion and urinary problems (diuretic). It is also used to treat patients who are unconscious and to lower the body temperature in patient with fever. In Madhya Pradesh, the herb is traditionally used as a strength tonic by members of the Gond tribes. The women in the tribes of the Bastar region of Chattishgarh use dried powders of this herb to treat gynecological problems like menstrual irregularities and leucorrhoea and to minimize labor pain. Herb paste is used orally by the local indigenous people of Songhati, Sonbhadra U.P. to cure patients with beri-beri and dysentery and for rejuvenation when given with cow's milk (Paswan *et al*., 2017).

According to Rupa and Bhawani, 2014 pteridophytes are found to have ethno-medicinal importance and are used by the local and tribal people. *Sellaginella sp.* are traditionally used to cure several diseases like wounds, fever, cancer, pneumonia, tonsils, kidney stones, headache, hepatitis, fever, paralysis, skin diseases, bone fractures, jaundice, toothache, blood coagulation, diarrhoea, gastric ulcers, asthma, backache, blood purification, fatigue and to neutralize the poison of snake and scorpion bite. *Selaginella bryopteris* (L.) has been used in Indian herbal medicine from olden days. Extraction obtained from the stem of plant showed the anti-bacterial activity against *Niesseria gonorrhea* and the paste of leaves is used in Spermatorrhea, leucorrhoea for stomachache and urinary tract inflammation in children. Ethanolic extract of *Selaginella bryopteris* (L.) can cure stomachache. Water extract of *Selaginella bryopteris* (L.) reduces cell death caused by UV irradiation. The extract of this plant increased cell growth and protected against dead cells induced by oxidative stress. Plant is treated as anti-inflammatory and cures venal diseases. Amentoflavone and hinkoflavone from *Selaginella bryopteris* (L.) have anti-protozoan activity against *Plasmodium falciparum*, *Leismania donovani* and *Trypano soma sp.* etc.

According to Mishra *et al*., 2011 the herb is popular among tribal people of India as a dietary supplement in treatment, signifying its role as a 'panacea' against varied maladies. Several studies have explored the bioactive components contributing to the medicinal properties of varied species of *Selaginella*. In particular the flavonoid-rich contents of this herb have demonstrated numerous and varied biological activities. *S. bryopteris* aqueous extract showed strong anti-cancer and chemopreventive activities through a medium-term anti-carcinogenesis bioassay, at initiation as well as post-initiation phases of DMBA-induced mouse skin tumorigenesis. Their study provides evidence of anti-carcinogenic and chemopreventive activity of *S. bryopteris* hitherto unreported. The observed effects may be attributed to a mixture of bioactive flavonoids present in the benzene fraction. It has been fairly well established that flavonoids offer high level of protection against a number of potential diseases including cancer. Often, described as biological response modifiers, flavonoids possess anti-oxidant activity helping the body to build immunity and fight off unhealthy free radical scavengers. In addition, they also possess anti-inflammatory properties and have a number of nutritional functions as many of the medicinal actions of fruits, vegetables and herbs are directly related to their flavonoid content. Since it may not always be

possible to obtain all the required amounts of flavonoids from these dietary sources, a nutritional supplement such as a flavonoid-enriched fraction from *S. bryopteris* reported in this study might offer a decent alternative and the desired levels of cancer protection. Further studies to understand the subtle targets of intracellular signaling pathways, characterization of individual flavonoids, pharmacological profile and toxicological safety of this bioactive fraction are essential to pave the way for successful translation of our findings to the clinic. Study endorses and favors the inverse association between dietary flavonoid intake and cancer risk.

Molecular bioactivities

According to different researchers *Selaginella bryopteris* (L.) contains a number of secondary metabolites and bioactive compounds. Setyawan, 2011 concluded that Selaginella is a potent medicinal matter, which mostly contains phenolic (flavonoid), alkaloid and terpenoid. This matter is traditionally used to cure several diseases especially for wound after childbirth and menstrual disorder. Biflavonoid, a dimeric form of flavonoids, is one of the most valuable natural products of Selaginella which constituted at least 13 compounds namely amentoflavone, 2',8''-biapigenin, delicaflavone, ginkgetin, heveaflavone, hinokiflavone, isocryptomerin, kayaflavone, ochnaflavone, podocarpusflavone, robustaflavone, sumaflavone and taiwaniaflavone. Human medically use biflavonoid especially for anti-oxidant, anti-inflammatory and anti-cancer. Selaginella also contains several natural products such as trehalosevaluable for bioindustry. Selaginella research exhaustively needs to be conducted to explore all natural products constituents and their bioactivities. According to Kunert, *et al*., (2015) the genus is especially well-known to be a rich source of biflavonoids, some of which have reported pharmacological activities. Selaginella species have attracted attention of researchers worldwide due to the presence of high value bioactive molecules such as flavonoid, biflavonoids, tannin, saponin, triterpene, steroid and many other secondary metabolites. The pharmacological properties of biflavonoids were well reported that includes anti-microbial, anti-viral, anti-cancer, anti-inflammatory activities. *Selaginella bryopteris* (L.) is one of the plants enriched with flavonoids and biflavonoids found mainly in hilly terrain of Indian states like Bihar, Jharkhand and Uttar Pradesh and southern India states also reported in Indian folklore as herbal drug. Natural habitat is the only source of plant material for use as local herbal drug as well as research purposes that led to its overexploitation. These valuable plant needs attention for its conservation in its niche. An anti-microbial is a substance that kills or inhibits the growth of microorganisms like bacteria, fungi or protozoan and anti-microbial drugs either kill microbes or prevent the growth of microbes. Earlier, *Selaginella bryopteris* (L.) was investigated for its anti-bacterial effect on urinary tract infection (Singh *et al*., 2018).

Infectious protozoal diseases such as malaria, leishmaniasis, human African trypanosomiasis and Chagas disease are major causes of morbidity and mortality in developing countries and the need for the discovery of anti-protozoal drugs is high. Acquired resistance leads to a loss of treatment capacity for currently available drugs. A series of eleven biflavonoids containing amentoflavone and hinokiflavone derivatives from the Indian medicinal herb *Selaginella bryopteris* (L.) has been investigated for their anti-protozoal activity using in vitro assays against the KI strain of *Plasmodium falciparum*, *Leishmani adonovani*, *Trypanosoma bruceirhodesiense* and *Trypanosoma cruzi*. Out of more than 60 species of Selaginella occurring in India a few species are used medicinally for example *Selaginella bryopteris* (L.) as a tonic and for the regeneration of vitality.In a survey of Indian Selaginella species, extracts of *Selaginella bryopteris* were screened against *Trypanosoma bruceirhodesiense, Trypanosoma cruzi, Leishmania donovani* and *Plasmodium falciparum* and IC50 values of eleven biflavone derivatives were determined. The highest anti-protozoal activity was found for 7,4,7-tri-o-methylamentoflavone, a minor compound in *Selaginella bryopteris* (L.) (Kunert *et al.,* 2008). Chemical investigation of *Selaginella chrysocaulos* from Northeast India yielded three new and two known biflavonoids. From *Selaginella bryopteris* collected in the southern part of India one new and eleven known biflavonoids of the amentoflavone and hinokiflavone type were isolated and identified. The structures of the compounds were elucidated by 1D- and 2D-NMR spectroscopy and by mass spectrometry. The absolute configurations of chiral biflavonoids with flavanone subunits (from *S. bryopteris*) were determined with the aid of circular-dichroism (CD) spectroscopy. Several very rare or even unprecedented substructures in biflavonoids were found (Swamy *et al*., 2006).

Most of the medicinal properties of the different species of *Selaginella* have been examined under non-native conditions that include extraction of the plant content using organic solvents. Native methods of use of these plants include soaking them in water over night preferably in an earthen pot. The plants are discarded and water containing aqueous leaching is filtered and taken orally to cure the different health complications. The primary objective of this endeavor is to produce an experimental evidence of medicinal efficacy of this herb in its native method as employed by the people. Because of the remarkable medicinal properties *Selaginella bryopteris* (L.) has also been known as Sanjeevani. It is therefore hypothesized that this herb possesses a growth-promoting activity as well as protective action against stress-induced cell death that play vital roles in organismal growth and development, tissue homeostasis and maintenance of genomic integrity. Inappropriate apoptosis has been conclusively shown to result in several human diseases including cancer, neurodegenerative diseases such as atherosclerosis, alzheimers, parkinsons disease etc. Researchers therefore wanted to use an experimental cell

system containing Sf9 insect cell and certain mammalian cells in culture to examine medicinal properties of the herb in its native form of use. Results demonstrate for the first time that aqueous extract of the herb possesses significant growth promoting and protective activities against several stress-induced apoptosis in experimental cell system (Sah *et al*., 2005).Systematic chemical investigation of the whole plant of *Selaginella bryopteris*(L.) was done, which lead to the isolation and characterization of a sterol, a lignan, two biflavonoids, a phenolic compound and a glucoside from the acetone extract of this plant. The crude extracts and isolated compounds were screened for their anti-fungal and anti-bacterial activity of this plant. The crude extracts and isolated compounds were screened for their anti-fungal and anti-bacterial activity. Six compounds were isolated from the acetone extract of *S. bryopteris*. These were identified as sitosterol, heve a flavone, syringaresinol, amentoflavone, vanillic acid and sitosterol D-glucoside (Verma *et al*., 2015).

The silver nanoparticles have been produced by *Selaginella byopteris* (L.) which is an economical efficient and eco-friendly process. *Selaginella byopteris* (L.) as the material was successfully utilized for the consistent and quick synthesis of silver nanoparticles. The synthesized silver nanoparticles were characterized using FT-IR, PXRD, FESEM, EDAX, TEM and UV–Vis techniques. The obtained nanoparticles appeared to be uniform, spherical and monodispersed with an average particle size of 5–10 nm. Synthesized silver nanoparticles revealed strong anti-microbial activity as it inhibited the growth of a pathogenic microorganism that was compared with the standard anti-biotic. In addition; it also exhibits anti-fungal, anti-coagulant and anti-platelet activities while it was devoid of RBC lysis property. Over all, it can be concluded that SPE@Ag-NPs may be of immensely used as therapeutic agent in the biomedical field (Dakshayani *et al*., 2019). The study by Saxena *et al*., 2015 of several extracts show positive results for the test of flavonoids and it has been already established that *Selaginalla sp.* have flavones and biflavonoids, it surely can be tested for the pharmacological properties including anti-microbial, anti-cancer, anti-viral, anti-inflammatory and anti- fibrillogenesis activities. According to their study the positive result for carbohydrate test indicates that disaccharides like trehalose, sucrose, glucose might be present in this species which are known to be responsible for resurrection properties. Thus, compounds from *Selaginella* can act both as a potential anti-microbial drug as well as a source of natural compounds.

India is a mega-biodiversity country which is not only rich in medicinal plant resource but also rich in traditional knowledge about such medicinal plants. Different foreign researchers have explained the medicinal potential of *Selaginella sp.* But Indian species of *Selaginella* have not yet been subjected to such phytochemical screening to understand the medicinal values. It is evident from the fact that in 'Ayurvedic Pharmacopoeia of India' out of hundred drugs, only one is of the fern (*Adiantum lunulatum*) (Irudayaraj *et al*., 2010).According to Setyawan, 2009Selaginella has been used traditionally to treat wounds and bleeding such as menstruation, uterine disorders and other internal injuries. It is also used as a tonic to improve fitness and to expand life span. Several species of *Selaginella* are also used as food (raw vegetables), ornamental plants, handicrafts materials as well as socio-cultural and packaging materials. The world health organization estimates that about 80% of the population of most developing countries relies on herbal medicine for their primary healthcare needs (Shukla *et al*., 2010). The utilization of *Selaginella* is very limited compared to the number of species and the potential benefits of the medicine so it requires further ethno-botanical and phytochemical researches.

CONCLUSION

On the basis of earlier researches mythological evidences and the available traditional knowledge we can conclude that this plant still has many more hidden possibilities which are yet to be explored. Therefore, there is a timely need to screen the ever-new possible medicinal qualities of this plant and develop novel drugs which can be used to combat various fatal diseases.

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