

## Review Article

A brief study on *Strebulus asper* L. -A Review

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**Abstract**

*Strebulus asper* L. is a small tree found in tropical countries, such as India, Sri Lanka, Malaysia, the Philippines and Thailand belonging to family moraceae. Various parts of this plant are used in Ayurveda and other folk medicines for the treatment of different ailments such as filariasis, leprosy, toothache, diarrhea, dysentery and cancer. Research carried out using different *in vitro* and *in vivo* techniques of biological evaluation support most of these claims. This review presents the botany, chemistry, traditional uses and pharmacology of this medicinal plant.

**1. Introduction**

Herbal medicines are the oldest remedies known to mankind. Herbs had been used by all cultures throughout history but India has one of the oldest, richest and most diverse cultural living traditions associated with the use of medicinal plants [1]. In the present scenario, the demand for herbal products is growing exponentially throughout the world and major pharmaceutical companies are currently conducting extensive research on plant materials for their potential medicinal value. In many journals, national and international, we find an increasing number of research publications based on herbal drugs. Herbal medicines form a major part of remedies in traditional medical systems such as Ayurveda, Rasa, Siddha, Unani, and Naturopathy. Hence all animal and clinical studies on herbal medicines were reviewed. The data for the years 1981-1983 were taken as baseline for the comparison of recent herbal drug research trends. The present study showed that interest has increased in herbal drug research in India, which supported the findings of Adithan (1996), with maximum utilization of the phytotherapeutic approach where in crude plant preparations were used. The maximum work was observed with polyherbal preparations. Recently there has been a shift in global trend from synthetic to natural medicine, which we can say 'Back to nature'. Medicinal herbs have been known for millennia and are highly esteemed all over the world as a rich source of therapeutic agent for prevention of disease and ailment. India is perhaps the largest producer of medicine or herbs and is rightly called the "Botanical garden of the world". India in this regard has a very unique position in the world, where a number of recognized indigenous systems of medicine viz., Ayurveda, Siddha, Unani, Homeopathic, Yoga and Naturopathy are practiced and utilized for the health care of the people [2].

India has an ancient heritage of traditional medicine. Materia medica of India provides lots of information on the folklore practices and traditional aspects of therapeutically important natural products. Indian traditional medicine is based on various systems including Ayurveda, Siddha and Unani. The evaluation of these drugs is mostly based on phytochemical, pharmacological and allied approaches including various instrumental techniques like chromatography, microscopy and others. These traditional systems of Indian medicine have their uniqueness no doubt but there is a common thread running through these systems in their fundamental principles and practices. With the emerging interest in the world to

adopt and study the traditional system and to exploit their potentials based on different healthcare systems, the evaluation of the rich heritage of the traditional medicine is essential. The government and private sectors are trying their best to explore all possibilities for the evaluation of these systems to bring out therapeutic approaches available in original systems of medicine as well as to help in generating data to put these products on national health care program [3].

The World Health Organization (WHO) estimates that about 80% of the populations living in the developing countries rely almost exclusively on traditional medicine for their primary health care needs. In almost all the traditional medicine, the medicinal plants play a major role and constitute the backbone of traditional medicine. Indian material medica includes about 2000 drugs of natural origin all of which derived from different traditional systems and folklore practices. Out of these drugs derived from traditional system, 400 are of mineral origin while the rest are of vegetable origin. India has a rich heritage of traditional medicine and the traditional health care system namely Ayurveda, Siddha and Unani. Lot of efforts has been taken by the government and private sectors for the development of the traditional system based on these three methods [3].

The use of medicinal plants was compiled in Ayurveda, which listed more than 8000 herbal remedies. India is one of the world's twelve leading biodiversity centers with the presence of over 45,000 different plant species. Of these, about 15,000-20,000 plants have good medicinal properties, of which only 7000-7500 are being used by traditional practitioners. The Siddha system of medicine uses around 600, Ayurveda 700, Amchi 600, Unani 700 and modern medicine about 30 plant species. Projection is being made that next to information technology, herbal technology will be India's biggest revenue earner [4].

In the global perspective, there is a shift towards the use of medicine of herbal origin, as the dangers and shortcomings of modern medicine have started getting more apparent, majority of Ayurvedic formulations are prepared from herbs [5]. It is the cardinal responsibility of the regulatory authorities to ensure that the consumers get the medication, which guarantee purity, safety, potency and efficacy. This duty is discharged by the regulatory authorities by rigidity following various standards of quality prescribed for raw materials and finished products in pharmacopoeias controlling manufacturing formulated through the

use of formularies and manufacturing operation through statutory imposed "Good manufacturing practices".

## 2. Current Regulations for Standardization of Crude Drugs

In India a great deal of bulk knowledge exists among ordinary people about the traditional use of herbal medicine. It is difficult to quantify the market size of the traditional Indian system. Since most practitioners formulate and dispense their own recipes. The present annual turnover of product manufactured by large companies is estimated at approximately US \$ 300 million compared to a turnover of approximately US \$ 2.5 billion for modern drugs. According to the study on the attitude of modern medicine practitioners are relatively unfamiliar with Ayurvedic product even though some are practiced. They are willing to try an Ayurvedic product if its efficiency is scientifically proven and would try ailment such as cough, cold, diarrhea, stomach problem, reproductive disease, liver and skin disease [6]. Patent proprietary Ayurvedic medicines are sold over the counter in pharmacies. These products appear to represent a major share of branded traditional medicine in India. Nevertheless systems like Ayurveda still need to gain an empirical support of modern medical sciences to make them credible and acceptable for all. An innovative research effort to define the advantage of traditional system of medicine with respect to their safety and efficacy could result in a better utilization of these complementary systems of medicine. Internationally several pharmacopoeias have provided monographs stating parameter and standard of many herbs and some product made out of these herbs. Several pharmacopoeias like Pharmacopoeia Committee

- Chinese Herbal Pharmacopoeia
- United States Herbal Pharmacopoeia
- British Herbal Pharmacopoeia (BHP)
- British Herbal Compendium (BHC)

Japanese Standards for Herbal Medicine and The Ayurvedic Pharmacopoeia of India (API) lay down monograph for herbs and herbal products to maintain their quality in their respective nations. Government of India too has brought out Ayurvedic Pharmacopoeia of India, which recommends basic quality parameters for eighty common Ayurvedic herbal drugs. Accounting to WHO it is the process involving the physicochemical evaluation of crude drug covering the aspects, as selection and handling of crude material, safety, efficacy and stability assessment of finished product, documentation of safety and risk based on experience, provision of product information to consumer and product promotion.

**Macro and Microscopic Examination:** For Identification of right variety and search of adulterants.

**Foreign Organic Matter:** Remove of matter other than source plant to get the drug in pure form.

**Ash Values:** It is criteria to judge the identity and purity of crude drug - Total ash, sulfated ash, water soluble ash and acid insoluble ash etc.

**Moisture Content:** To check moisture content helps prevent degradation of product.

**Extractive Values:** These are indicating the approximate measure of chemical constituents of crude drug.

**Crude Fiber:** To determine excessive woody material Criteria for judging purity.

**Qualitative Chemical Evaluation:** It covers identification and characterization of crude drug with respect to phytochemical Constituent.

**Chromatographic Examination:** Include identification of crude drug based on use of major chemical constituent as marker.

**Qualitative Chemical Evaluation:** Criteria to estimate amount the major class of constituents.

**Toxicological Studies:** Pesticide residue, potentially toxic elements, and Microbial count approach to minimize their effect in final product.

### (a) Physical evaluation:

The physical characteristics of each plant that can be used to insure both identity and purity. Each description is accompanied by detailed illustrations and photographic images which provide visual documentation of accurately identified material. Each monograph contains detailed botanical, macroscopic and microscopic descriptions.

### (b) Microscopic evaluation

Full and accurate characterization of plant material requires a combination of physical and chemical tests. Microscopic analyses of plants are invaluable for assuring the identity of the material and as an initial screening test for impurities. Most manufacturers of herbal products lack the quality control personnel to accurately assess plant identity and purity microscopically. The Ayurvedic Herbal Pharmacopoeia (AHP) fully characterizes herbal products against the literature and AHP. Verified trade mark authenticated materials to assure identity of test materials. Ideally, submitted materials should be in their whole or semi-whole (cut) form for microscopic assessment. However, much information can be discerned from microscopic evaluation of powders as well.

### (c) Chemical evaluation

A chemical method for evaluation covers the isolation, identification and purification. Chemical analysis of the drug is done to assess the potency of vegetable and animal source material in terms of their active principles. The chemical tests include color reaction test, these tests help to determine the identity of the drug substance and possible adulteration.

### (d) Biological evaluation

Pharmacological activity of certain drugs has been applied to evaluate and standardize them. The assays on living animal and on their intact or isolated organs can indicate the strength of the drug or their preparations. All living organism are used, these assays are known as Biological assays or Bioassay.

### (e) Analytical Methods

Critical to compliance with any monograph standard is the need for appropriate analytical methods for determining identity, quality, and relative potency. There are a plethora of analytical methods available. However, it is often difficult to know which is the most appropriate to use. The primary goal of AHP is to provide multiple methods of identification and testing by which all aspects of the botanical can be appropriately assayed.

### (f) Chromatographic Characterization

Chromatography is the science in which we study the separation of molecules based on differences in their structure and/or composition. In general, chromatography involves moving a preparation of the materials to be separated the "test preparation" over a stationary support. The molecules in the test preparation will have different interactions with the stationary support leading to separation of similar molecules. Test molecules which display tighter interactions with the support will tend to move more slowly through the support than those molecules with weaker interactions. In this way, different types of molecules can be separated from each other as they move over the support material. Chromatographic separations can be carried out using a variety of supports, including immobilized silica on glass plates (thin layer chromatography), very sensitive High Performance Thin Layer Chromatography (HPTLC), volatile gases (gas chromatography), paper (paper chromatography), and liquids which may incorporate hydrophilic, insoluble molecules (liquid chromatography).

### (g) Purity Determination

Each monograph includes standards of purity and other qualitative assessments which include foreign matter, ash, acid-insoluble ash, moisture content, loss of moisture on drying, and extractives. High performance thin layer chromatography (HPTLC) is valuable quality assessment tool for the evaluation of botanical materials. It allows for the analysis of a broad number of compounds both efficiently and cost effectively. Additionally, numerous samples

can be run in a single analysis thereby dramatically reducing analytical time. With HPTLC, the same analysis can be viewed with different wavelengths of light thereby providing a more complete profile of the plant than is typically observed with more specific types of analyses.

#### (h) Quantitative Analysis

When applicable, the most appropriate quantitative analytical method with accompanying chromatograms shall be provided. The primary goal of the methods is to provide validated methods to be used for the quantization of the compounds most correlated with pharmacological activity or qualitative markers as determined by the primary pharmacological literature, constituent declaration in product labeling, and a survey of experts. The methods will be selected from the primary analytical literature by a Methods Selection Committee with priority given to compendial methods when available. In this context, validation consists minimally of a two-lab validation using the same procedures, samples, and reference standards.

### 3. Advantages of Herbal Medicine

1. Herbal medicine have long history of use and better patient tolerance as well as acceptance.
2. Medicinal plants have a renewable source, which is our only hope for sustainable supplies of cheaper medicines for the world growing population.
3. Availability of medicinal plants is not a problem especially in developing countries like India having rich agro-climatic, cultural and ethnic biodiversity.
4. The cultivation and processing of medicinal herbs and herbal products is environmental friendly.
5. Prolong and apparently uneventful use of herbal medicines may offer testimony of their safety and efficacy.
6. Throughout the world, herbal medicine has provided many of the most potent medicines to the vast arsenal of drugs available to modern medical science, both in crude form and as a pure chemical upon which modern medicines are structured.

### 4. Importance of Herbal Medicines in Health Care System

Contrary to the rapid developments in the entire health care system, the man is experiencing greater exposure to the threat to his health. The widespread scare of AIDS assuming an epidemic form is just one example to site. Worldwide efforts have been made to attack the virus by various mechanisms unsuccessfully. Toxicity is another factor which seems to be playing an important role in undermining the health of the people and making them prone to episodes of mild fever and aches. The man is exposed to innumerable toxic materials in his daily life which come from chemical, pesticides and various other pollutants. With huge amounts of money put into development of more potent antibiotics and chemo therapeutic agents all across the globe and especially in developed western countries, an overall improvements in the health of people is obviously expected. However the recent WHO reports states that though people live longer today, they are not healthier. People in general live in a state of morbidity and are more prone to illness then before. The solution to many of these problem may be found in the indigenous system of medicine practiced throughout the world, those practiced in India (Ayurveda, Unani, Siddha etc.) gain maximum importance. Presently both common consumers and health care professionals seek updated, authoritative information towards safety and efficacy of any recommended medicinal plant prior to its use. The present attempts is to review and compile updated information on various aspects of *Streblus asper* a plant used in Indian system of medicine for variety of purposes.

*Streblus asper* (family-Moraceae) is a small tree which is indigenous to tropical countries such as India, Srilanka, the Philippines and Thailand. In India it is distributed in the Himalayas from Himachal

Pradesh to West Bengal and in hills and plains of Assam and Tripura. It is also found in the drier parts of India, from Rohilkhand, eastward and southwards to Travancore [9].

**Table 1: Vernacular names [10-12]**

English	Sand paper mulberry
Sanskrit	Sakhotaka, Sakhota, Pitaphalaka, Bhtavasa, Kharacchada
Hindi:	Sahora, Sihoda, Sihar, Dahia, Karchanna, Rusa
Bengali	Sheoda, Sheora, Syaora
Marathi	Sahod, Karvatte, Karera, Kharaoli, Kharota, Paraya, Parayu
Gujarati	Sahoda
Tamil	Pirayanpirai, Kurripila, Kuttippirai, Parayan, Pasuna, Pira
Telugu	Baranki, Baranika, Barrenka, Brninka
Oriya	Sahod
Kan	Mittlamara

**Table2: Scientific Classification:**

Kingdom	Plantae
(Unmarked)	Angiosperms
(Unmarked)	Eudicots
(Unmarked)	Rosids
Order	Rosales
Family	Moraceae
Genus	<i>Streblus</i>
Species	<i>asper</i>

#### 4.1 Uses

Various parts of this plant are used in Ayurveda and other folk medicine for the treatment of different ailments such as Filariasis, Leprosy, Tooth ache, Diarrhea, Dysentery, and Cancer. Root is used as an application to the unhealthy ulcers and sinuses, and as antidote to snakebite, in epilepsy and obesity. Stem is used in toothache, Stem bark is given in fever, dysentery, diarrhea, stomach ache, urinary complaints, piles, edema and wounds. Decoction is effective against lymphadema, chylurea, and other effects of Filariasis. Leaves are used in eye complaints; milky juice is used as antiseptic, astringent, applied to chapped hand and sore feet, in pneumonia and swells of cheeks. Seeds are used in epistaxis and diarrhea. The other part which is not specified is used in cancer, cholera, colic, diarrhea, dysentery, epilepsy and inflammatory swellings. The branch of *Streblus asper* has been used as tooth brush for strengthening teeth and gums. *Streblus asper* extracts thus has the potential for being used as a natural product for controlling dental carries [9,10].

#### 4.2. Description of plant

*Streblus asper* is a rigid shrub or gnarled evergreen tree; bark light grey or greenish with faint ridges, rough when old; juice milky; twigs hairy, scabrid; leaves alternate, 2.5-10 cm long, rhomboid-elliptic, obovate or elliptic oblong, acute or shortly abruptly acuminate, more or less sinuate or crenate, scabrid on both surfaces but especially beneath; lateral nerves 4-6 pairs, prominent beneath, joined by intra marginal loops, petiole 1.3-3.8 mm. long, stipules rather longer than the petiole, obliquely lanceolate, acuminate; Flowers dioecious, axillary. Male flowers in globose pedunculate heads 7.5 mm, peduncles 1-4 together, 7.5-13 mm long, Perianth campanulate, sepals 4, pubescent outside, imbricate in bud. Stamen 4, inflexed in buds, anthers reniform, Female flowers solitary, inconspicuous, long peduncle; peduncles 1-4 together, 5-13 mm. long bracts 2-3 below peduncles; style 2, very long, filiform connate at the base. Fruit, one celled berry, loosely enclosed by the enlarged sepals, yellow when ripe, 5mm diameter [10-12].



Figure1: *Streblus asper* leaves

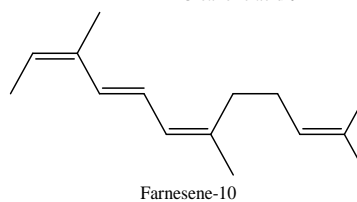
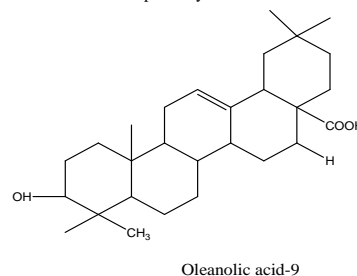
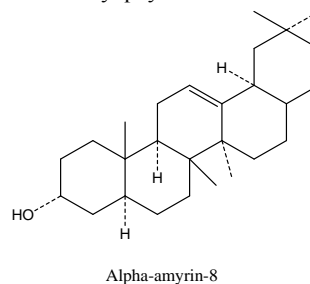
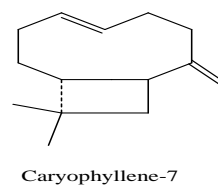
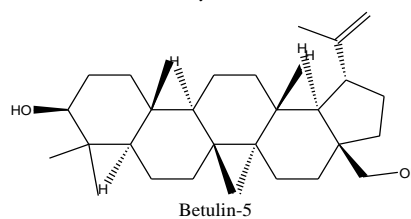
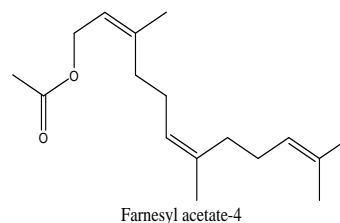
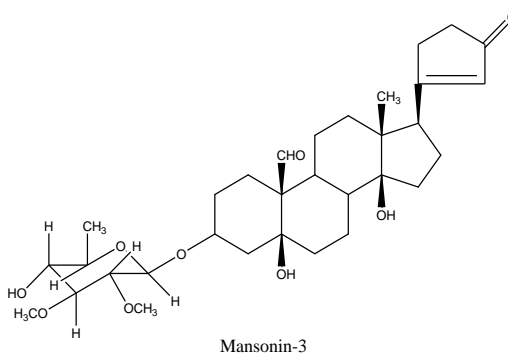
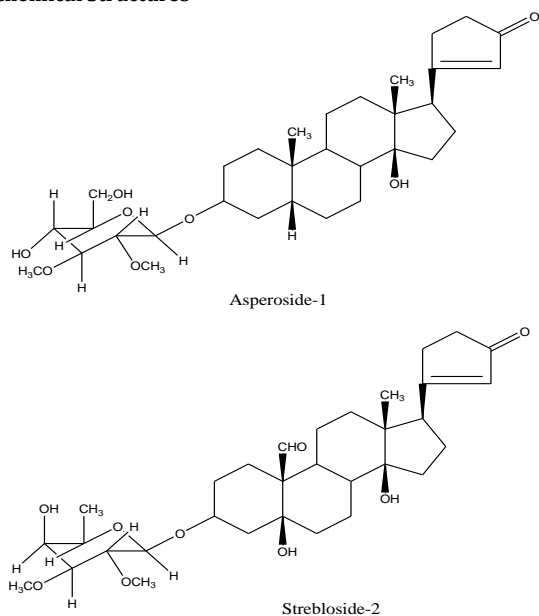


Figure1: *Streblus asper* bark

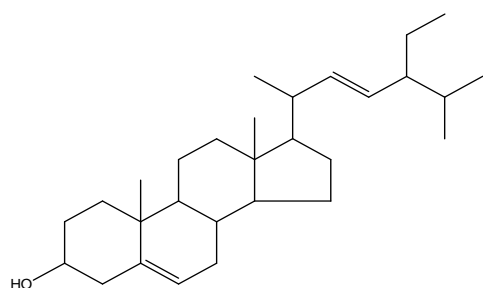
#### 4.3 Chemical Constituents

*Streblus asper* is a rich source of cardiac glycosides. More than 20 cardiac glycosides from the root bark of *Streblus asper* have been reported and were able to structurally characterize about 15 such compounds, mainly as a result of the application of degradative techniques, namely kamloside, asperoside, streblaside, cannodememside, strophalloside, strophanolloside, glucogitomethoside, glucogitodimethoside, glucokamloside, sarmethoside, and glucostreblaside, some of them are summarized in the following table. Asperoside [9], Indroside, Kamloside, Cannodememside, Strophalloside, Glucokamloside, Sarmethoside, Sarmethoside, Glucostreblaside, Vijalloside, Streblaside [9],  $\alpha$ -amyrin [7], Lupeol acetate [7],  $\beta$ -sitosterol [7], Lupeol and diol, Sioraside, n-Triacontane, Stigma sterol [7], Betulin, Oleanolic acid, Phytol, Caryophyllene, Farnesyl acetate, Farnesene,  $\alpha$ -farnesene, Farnesene,  $\alpha$ -copaene,  $\beta$ -elemene, Geranyl acetone, Germacrene,  $\alpha$ -copaene, Farnesene,  $\beta$ -elemene, Geranyl acetone, Germacrene [9,13].

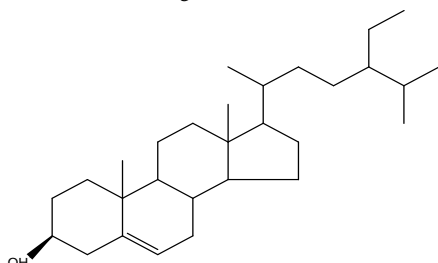
#### 4.4 Chemical Structures



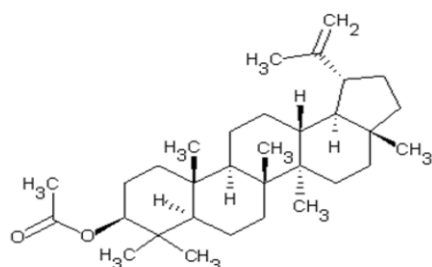




Stigma sterol-11



Beta-sitosterol-12



Lupeol acetate-13

## 5. Pharmacological Properties

Several workers have reported the different biological activities of *S. asper* in various *in vitro* and *in vivo* test models. Different parts of this plant have been found to exhibit cardiotoxic, antifilarial, anticancer, antimicrobial, anti-allergic and antimalarial activities. These have been described in greater detail in the following.

### 5.1 Cardiotoxic Activity

The total ethanolic extract of the root bark of *S. asper* was found to indicate interesting activity on blood pressure, isolated frog heart, isolated rabbit intestine and guinea pig uterus. An  $\alpha\beta$ -unsaturated lactone was isolated which when administered by i.v. route gave the LD<sub>50</sub> of 4.8 mg /kg in white mice. Studies on isolated frog heart showed that it induces a positive inotropic effect in 10<sup>-5</sup> dilution and a systolic response in 10<sup>-4</sup> dilution. Pronounced *in vitro* spasmolytic effect of the compound was seen on the smooth muscles of the rabbit intestine and guinea pig uterus in those high dilutions [14]. Pharmacological studies carried out have indicated that the drug has got definite action on myocardium [15].

### 5.2 Antifilarial Activity

The crude aqueous extract of the stem bark of *S. asper* revealed significant macrofilaricidal activity against *Litomosoides carinii* and *Brugia malayi* in rodents. The study revealed two cardiac glycosides, asperoside and streblaside, of the extract to be responsible for antifilarial activity. Of the two glycosides, the more effective macrofilaricide was asperoside which was active at 50 mg kg<sup>-1</sup> orally against *L. carinii* in cotton rats (>90%), *B. malayi* in mastomys (>70%) and *Acanthocheilonemaviteae* in mastomysnatalensis (>70%). The glycosides were also active *in vitro* against all the three filarial species. Significantly weak activity was detected in glycon and aglycon portions of the parent glycosides (asperoside and streblaside). Several cardiac glycosides of other

origins did not show any comparable antifilarial efficacy. The aglycosidic portion of the extract, however, showed poor adulticidal activity (44.5% activity at 1 g kg<sup>-1</sup> against *L. carinii*) [16]. *Streblus asper* has been used in the preparation of a few formulations also. Shakhotaka Ghana Vati prepared from its stem bark was found to be useful in filariasis [17]. Besides this, another safe and effective filaricide from the stem bark of *S. asper*, 'Filacid' has also been reported. A series of extraneous investigations involving hundreds of patients infested with filarial parasites have also established its efficacy against filariasis [18].

The effect of aqueous and alcoholic extract of *S. asper* was also studied on the spontaneous movements of the whole worm and nerve-muscle preparation of *Setariacervi*, the bovine filarial parasite, and on the survival of microfilariae *in vitro*. Aqueous as well as alcoholic extract caused inhibition of spontaneous motility of the whole worm and the nerve-muscle preparation of *S. cervi* characterized by decreased tone, amplitude and rate of contractions. The concentration required to inhibit the movements of the nerve-muscle preparation was 1/25 for aqueous and 1/160 for alcoholic extract suggesting a cuticular permeability barrier. The stimulatory response of acetylcholine was blocked by alcoholic and not by aqueous extract of *S. asper*. Both alcoholic as well as aqueous extracts caused death of microfilariae *in vitro*, LC<sub>50</sub> and LC<sub>90</sub> being 90 and 33.5 ng ml<sup>-1</sup>, respectively [19]. The *in vitro* effects of asperoside and streblaside on *S. cervi* females were also studied. Both asperoside and streblaside caused death of the worms within 2–3 h at concentrations of 10 g ml<sup>-1</sup> (1.7 pmol) and were found to inhibit motility and glucose uptake of the parasites at lower concentrations (0.1 g ml<sup>-1</sup>; 0.17 pmol). These glycosides also inhibited the incorporation of [U-14] C-glucose into macromolecules of *S. cervi* females. Parasites preincubated with either asperoside and streblaside had lowered profiles of glucokinase (EC 2.7.1.2), malate dehydrogenase (EC 1.1.1.37) and succinate dehydrogenase (EC 1.3.99.1) activities, suggesting that the lethal effects of the glycosides were owing to effects on glucose metabolism [20]. It was found that asperoside and streblaside interfere with the glutathione metabolism of the adult *S. cervi*, which cause disturbance in various vital activities of the parasites that ultimately results in the death of the parasites [21]. A preliminary study of *S. asper* (shakhotak) as an antilymphoedematous agent was carried out by Baranwalet *al.* [22].

### 5.3 Anticancer Activity

*Streblus asper* has been reported to possess anticancer activity [23]. KB cytotoxicity was found to be concentrated sequentially in the methanol and dichloromethane extracts of *S. asper* stem bark. Two cytotoxic cardiac glycosides, streblaside and mansonin, were isolated which displayed significant activity in KB cell culture system with ED<sub>50</sub> values of 0.035 and 0.042  $\mu\text{g ml}^{-1}$ , respectively. An isolate is considered to be active in this system if it shows an ED<sub>50</sub> of  $\leq 4 \mu\text{g ml}^{-1}$ .

The volatile oil from fresh leaves of *S. asper* showed significant anticancer activity (ED<sub>50</sub> << 30  $\mu\text{g ml}^{-1}$ ) from cytotoxicity primary screening tests with P388 (mouse lymphocytic leukemia) cells but no significant antioxidant activity (IC<sub>50</sub> values >> 100  $\mu\text{g ml}^{-1}$ ) in a DPPH radical scavenging assay.

### 5.4 Antimicrobial Activity

Different studies were carried out to determine the antimicrobial potential of leaves of *S. asper* [24–30]. Ethanol extracts from the sticks and leaves of *S. asper* have been shown to inhibit the growth of *Streptococcus mutans* [24].

### 5.5 For Oral Hygiene

Studies demonstrated the antimicrobial activity of *S. asper* leaf extract upon various microorganisms involving oral and nasopharyngeal infections, especially *S. mutans*. Bactericidal activity was found in the 50% ethanol (v/v) extract of *S. asper* leaves. The extract possessed a selective bactericidal activity towards *Streptococcus*, especially to *S. mutans* which has been shown to be strongly associated with dental caries. The extract had no effect on cultures of *Escherichia coli*, *Staphylococcus aureus* and *Pseudomonas*

*aeruginosa*, *Staphylococcus* coagulase positive, *Staphylococcus* coagulase negative, *Serratiamarcescens*, *Klebsiellapneumoniae*, *Enterobacter*, *P. aeruginosa*, *Burkholderia pseudomallei* and *Candida albicans*. The minimum growth inhibitory concentration and the minimum bactericidal concentration of *S. asper* extract against  $10^8$  CFU per ml of *S. mutans* was  $2 \text{ mg ml}^{-1}$  [25].

*In vitro* study was carried out to determine the effects of a sublethal concentration of *S. asper* leaf ethanolic extract on adherence of *C. albicans* to human buccal epithelial cells (HBEC). The findings indicated that the sublethal concentration of this extract may modulate candidal colonization of the oral mucosa thereby suppressing the invasive potential of the pathogen [26]. An *in vivo* one group time series design and single blind study was carried out to determine the antimicrobial effectiveness of a mouthrinse containing *S. asper* leaf extract on *S. mutans* and total salivary bacteria following single 60 s rinse. The results concluded that the mouthrinse containing *S. asper* leaf extract can reduce *S. mutans* without changing an oral ecology [27]. *Streblus asper* extract solution at 0.5% concentration (w/v) was investigated for inhibitory effect on adherence of *S. mutans* on glass surfaces. However, it did not show significant inhibitory effect on bacterial adherence to glass surfaces [28]. A single blind and crossover design study was also carried out to study the effect of the mouthrinse containing *S. asper* leaf extract on gingivitis and plaque formation [29]. The results revealed that when used in mouthrinse the *S. asper* leaf extract significantly affected only the gingival health. It reduced the gingival index but no significant effect was seen on plaque growth.

#### 5.6 Against Anaerobic Bacteria

*In vitro* study was also carried out to determine the antibacterial effects of leaf extract of koi (*S. asper*) against the following six anaerobic bacteria: *Porphyromon asgingivalis* W50, *Prevotella intermedia*, *Actinomyces naeslundii* (T14V), *Pepto streptococcus micros*, *Actinobacillus actinomycetem comitans* ATCC 43717 and ATCC 43718 [30]. It was demonstrated that  $15 \mu\text{l}$  of the leaf extract at 250 and  $500 \text{ mg ml}^{-1}$  had inhibitory effects towards all bacterial strains tested except *A. actinomycetem comitans* ATCC 43717. The extract had no bactericidal activity against *P. intermedia* and *A. naeslundii* (T14V). Although the extract did not show inhibitory effect towards *A. actinomycetem comitans* ATCC 43717 by disc diffusion method, but it did inhibit growth of *A. actinomycetem comitans* ATCC 43717 by using broth microdilution method.

#### 5.7 Anti-allergic Activity

*Streblus asper* showed promising anti-allergic activity in experimental models. Anti-PCA (passive cutaneous anaphylaxis) and mast cell stabilizing activity of *S. asper* were investigated in mice and rats. Disodium cromoglycate (DSCG) was used as standard anti-allergic drug. *Streblus asper* ( $50\text{--}100 \text{ mg kg}^{-1}$ , p.o.) in mice showed 60–74% anti-PCA activity. In rats it showed dose-dependent ( $50\text{--}200 \text{ mg kg}^{-1}$ , p.o.) anti-PCA activity (56–85%). The mast cell stabilizing activity in rats ( $10 \text{ mg kg}^{-1}$ , p.o.  $\times$  4 days) showed 62% protection against comp. 48/80 induced degranulation. In egg albumin induced degranulation in sensitized rats there was 67% protection with *S. asper*. These results were comparable with that of DSCG ( $50 \text{ mg kg}^{-1}$ , i.p.) [31].

#### 5.8 Insecticidal Activity

Insecticidal effects have been shown in extracts of the *S. asper* stem [32]. Extracts from the stem bark of *S. asper* possess insecticidal activity against the fifth instar of *Dysdercus cingulatus*. Methanolic extract showed an  $\text{LC}_{50}$  value of  $5.56 \mu\text{g}$  per insect. Partition with chloroform increased the insecticidal activity ( $\text{LC}_{50}$   $2.01 \mu\text{g}$  per insect). Three polyphenolic rich fractions were obtained from silica gel column chromatography of the chloroform fraction and found to have noteworthy insecticidal activity ( $\text{LC}_{50}$ : 1.82, 2.70 and  $2.26 \mu\text{g}$  per insect) by topical application. This may provide a useful beginning for the development of biopesticides [33].

#### 5.9 Antiparasitic

*In vitro* antitrypanosomal activity of aqueous extract of leaves of *S. asper* was studied at 5, 50, 500 and  $1000 \text{ mg ml}^{-1}$  [34].

However, it did not show any significant activity and was thus not taken up for *in vivo* studies. Das and Beuria [35] have studied the antimalarial property of the extract of *S. asper* in murine malaria. Giving the stem bark extract of *S. asper* intraperitoneally has been shown to stimulate a host immune response against *Plasmodium berghei* in mice.

## 6. Conclusion

*Streblus asper* is a well-known plant used in the Indian System of Medicine. In Ayurveda, the use of *S. asper* stem bark is recommended against elephantiasis for which there is no effective cure in the modern system of medicine. Besides this, folklore medicine also claims its use in cancer, ulcer, diarrhea, dysentery, toothache, etc. Research carried out using different *in vitro* and *in vivo* techniques of biological evaluation support most of these claims. Filariasis, a disease of considerable public health importance, is a vector-borne helminthic infection occurring in tropical and subtropical regions of the world. Diethylcarbamazine (DEC) and ivermectin, the drugs used commonly for filariasis are insufficient because of their inadequate effect on the adult parasites.

Numerous drugs have entered the international market through exploration of ethnopharmacology and traditional medicine. Although scientific studies have been done on a large number of Indian botanicals, a considerably smaller number of marketable drugs or phytochemical entities have entered the evidence-based therapeutics. Efforts are therefore needed to establish and validate evidence regarding safety and practice of Ayurvedic medicines.

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