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Sphaeranthus indicus: A Review of its Chemical, Pharmacological and Ethnomedicinal Properties

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Abstract: *Sphaeranthus indicus* is a well-known plant used in the Indian system of medicine. The plant is widely distributed throughout the plains and wet-lands of India, Sri Lanka and Australia. Folklore medicine claims its use in epileptic convulsion, mental illness, hemicranias, as a general tonic, deobstruent, aphrodisiac etc. Various biologically active compounds have been isolated from *S. indicus*. This study is an attempt to compile an up-to-date and comprehensive review of *S. indicus* that covers its traditional and folk medicinal uses, phytochemistry and pharmacology.

Key words: *Sphaeranthus indicus*, chemistry, antioxidant, antidiabetic, wound healing

INTRODUCTION

Nature has provided a complete storehouse of remedies to cure ailment of mankind. Medicinal plants have been used for centuries as remedies for disease because they contain component of therapeutic values. According to the WHO, 80% of the world population continues to rely mainly on traditional medicines for their health care (WHO, 1993). Presently there is an increasing interest worldwide in herbal medicines accompanied by increased laboratory investigation into the pharmacological properties of bioactive ingredients and their ability to treat various diseases. Numerous drugs have entered the international market through exploration of ethnopharmacology and traditional medicine. Although scientific studies have been carried out 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 needed to establish and validate evidence regarding safety and practice of Ayurvedic medicines (Cooper, 2004; Patwardhan *et al*., 2005).

Sphaeranthus indicus (Astraceae) commonly known as Gorakhmundi (Hindi) is an annual spreading herb which grow approximately 15-30 cm in height. The plant is distributed throughout the plains and wet-lands of India, Sri Lanka and Australia. Used traditionally for the treatment of jaundice, leprosy, fever, pectoralgia, cough, gastropathy, hernia, haemorrhoids, helminthiasis, dyspepsia, skin diseases and as a nerve tonic, the plant is known to possess varied medicinal properties and is reportedly used in Ayurvedic preparations for treating epileptic convulsions, mental illnesses and hemicranias (Ambavade *et al*., 2006; Jha *et al*., 2010). This study was aimed to present an overview of traditional use, phytochemical and pharmacological investigations of bioactive compounds present in this plant.

ETHNOPHARMACOLOGY

Traditional uses: *S. indicus* is a well known ethnomedicinal plant used in Ayurveda. Its use in the Indian traditional folk medicine is also well documented. The uses of different parts of *S. indicus* in traditional system of medicines are given in Table 1.

Alternative and complementary medicinal uses: Among the various species of *Sphaeranthus*, *S. indicus* is used extensively throughout the world. Formulations of *S. indicus* have been incorporated in a variety of bases for use in the treatment of minor wounds (Sadaf *et al*., 2006).

MORPHOLOGY AND MICROSCOPY

Morphology: *Sphaeranthus indicus* is an annual herb with sessile, decurrent, obovate, bristly serrate, downy, glutinous leaves and globular heads of purple flowers. The stem is greenish in colour; roots are brown externally and internally light brown, tuberous with 10-15 cm in length and 0.1-0.4 cm in diameter with longitudinal striations and transverse scars seen at regular intervals. Odour is characteristic.

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Table 1: Ethnomedicinal uses of *S. indicus*

Plant parts	Traditional uses
Oil of root	Treatment of scrofula, aphrodisiac (Ambavade *et al.*, 2006)
Herb paste	Treatment of pruritus, oedema, arthritis, filariasis, gout, Adenopathy (Ambavade *et al.*, 2006)
Seeds and roots	Stomachic and anthelmintic (Sadaf *et al.*, 2006)
Flower heads	Blood purifier in skin diseases (Sadaf *et al.*, 2006)
Powdered leaves	Treatment of chronic skin diseases, urethral discharges and jaundice (Sadaf *et al.*, 2006)
Leaves	Anxiolytic, macrofilaricidal, antimicrobial, and insecticidal activities (Mishra *et al.*, 2007)
Plant juice	Liver and gastric disorders (Pande and Dubey, 2009)

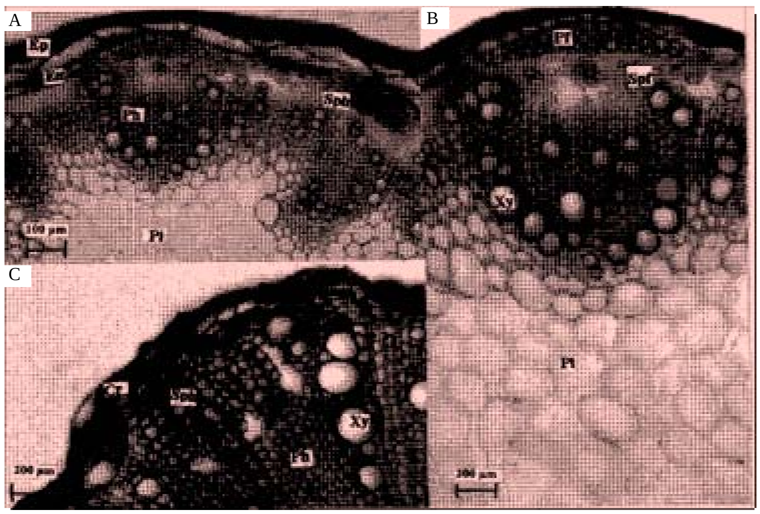

Fig. 1: Microscopy of the stolon and root of *S. indicus*, (A). Photomicrograph showing transverse section of the stolon of *S. indicus*, (B). A portion of vascular bundle of the stolon (enlarged) Ep-epidermis, En-endodermis, Pf-pericyclic fibres, Ph-phloem, Xy-xylem, Pi-pith, Sph-secondary phloem, Spf-secondary phloem fibres and (C). Microscopy of the root of *S. indicus* Cr-cork, Xy-xylem, Ph-phloem, Sph- secondary phloem

Microscopy: The microscopy of the roots and stolon, powder characteristics of this plant were studied. The root showed secondary characters and had a circular outline. The epiblema consisted of a single layer of barrel shaped cells, while endodermis was made up of barrel shaped cells with casparian thickening. Open vascular bundle were observed. Secondary phloem consisted of sieve tubes, companion cells and phloem parenchyma, while secondary xylem consisted of tracheids. The epidemis consisted of a single layer of cells having a cuticular lining on the outer tangential wall. The endodermis consisted of barrel shaped cells with casparian thickening. Pericycle was composed of alternate bands of sclerenchyma and parenchyma with the sclerenchyma patches forming a cap on each vascular bundle. Secondary xylem consisted of tracheids, vessels, fibers and xylem parenchyma (Fig. 1).

Powder microscopy: Lignified fibers, starch grains and calcium oxalate crystals were observed in the powder (Shirwaikar *et al.*, 2006a).

PHYTOCHEMISTRY

Phytochemical analysis of air dried roots and rhizome of *S. indicus* carried out revealed the presence of steroids, fats and oils in petroleum extract; carbohydrates, proteins, amino acids, tannins, phenols, steroids, fats and oils in the methanolic extract and carbohydrates, proteins, amino acids, tannins, phenolic compounds, saponins and alkaloids in the aqueous extract (Shirwaikar *et al.*, 2006a; Ambavade *et al.*, 2006).

A sesquiterpene lactone, 7α-hydroxyfrullanolide was isolated from *S. indicus.* Microorganisms have been utilized to modify the structures of a number of naturally occurring bioactive compounds. Microbial transformations affected by *Aspergillus* species of 7α-hydroxyfrullanolide (1) yielded 7α-hydroxy-11, 13-dihydrofrullanolide (2) and 13-acetyl-7α- hydroxyfrullanolide (3) and their structures were determined spectroscopically (Rahman *et al.*, 1994).

Three eudesmanolides, 11α, 13-dihydro-3α, 7α-dihydroxyfrullanolide, 11α, 13 - dihydro - 7α, 13-

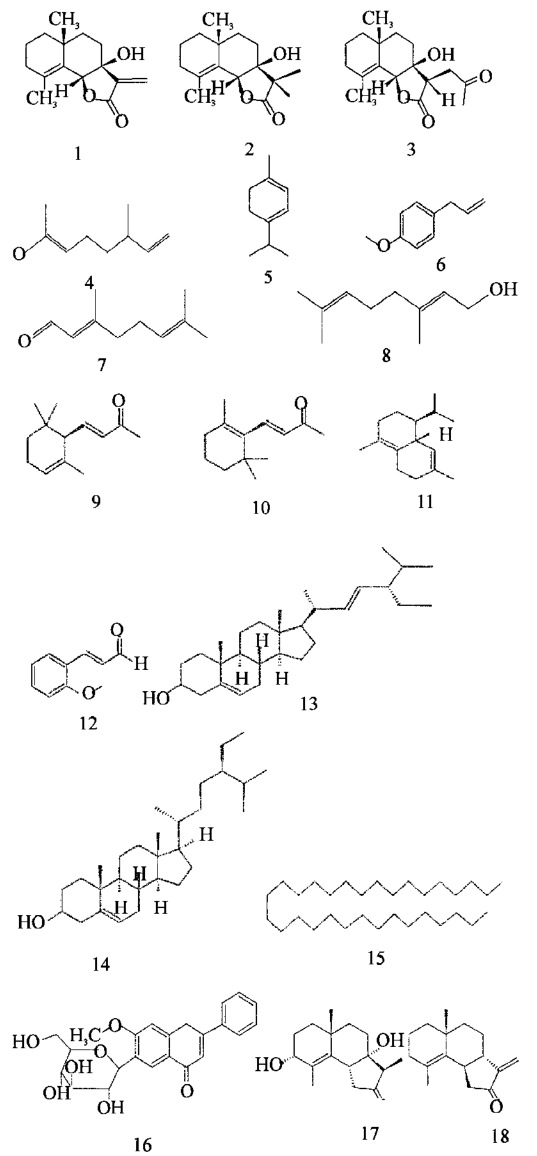

Fig. 2: Biologically active constituents isolated from *S. indicus*

dihydroxyfrullanolide and 11α, 13-dihydroxy-7α-hydroxy-13-methoxyfrullanolide was isolated from the flower heads of *S. indicus*. The IR spectra of all the compounds showed characteristic 5-membered lactone absorptions (1752, 1745 and 1757 cm^{-1}, respectively) and revealed the presence of OH and non-conjugated olefin functions. The overall mass spectrum pattern of these three compounds in comparison to that of 1 indicated that they were all eudesmanolides. The molecular ions were confirmed by Fast Atom Bombardment Mass Spectroscopy (FABMS) and Field Desorption Mass Spectrometry (FDMS). The mass spectrum of 11α, 13-dihydro-3α, 7α-dihydroxyfrullanolide showed a molecular ion at m/z 266. The other prominent peaks appear at m/z 251 ($C_{14}H_{19}O_4$), 248 ($C_{15}H_{20}O_3$), 233 ($C_{14}H_{17}O_3$), 215 ($C_{14}H_{15}O_2$) and 187 $C_{13}H_{15}O_2$ (Shekhani *et al*., 1991).

A large number of constituents have been isolated from the extracts of the whole herb, flowers and leaves. Essential oil, obtained by steam distillation of the whole herb, contains ocimene (4), α-terpinene (5), methyl-chavicol (6), α-citral (7), geraniol (8), α-ionone (9), β-ionone (10), δ-cadinene (11), p-methoxycinnamaldehyde (12) and an alkaloid sphaeranthine. The alcoholic extract of powdered drug contains stigmasterol (13), β-sitosterol (14), hentriacontane (15), n-triacontanol, sesquiterpene lactone, sesquiterpine glycoside, sphaeranthanolide, flavone and isoflavone glycosides (Ambavade *et al*., 2006; Jha *et al*., 2009, 2010).

The aerial parts of *S. indicus* revealed it to be quite rich in essential oils, glycosides and eudesmanolides, along with some uncharacterized sesquiterpenes, phenolic glycosides and sesquiterpene lactones. A novel flavonoid C-glycoside, 5-hydroxy-7-methoxy-6- C-glycosylflavone (16), was isolated from the aerial part of *S. indicus*, along with eight known compounds, namely n-pentacosan, stigmasterol, β-sitosterol, hentriacontane, β-D-glucoside of hentriacontane, n-triacontanol, sphaeranthine and a phenolic glycoside ($C_{22}H_{26}O_{12}$). The structure of 5-hydroxy-7-methoxy-6- C-glycosylflavone was established by Mass Spectroscopy (MS) and Proton Nuclear Magnetic Resonance (^{1}H-NMR) studies (Mishra *et al*., 2007; Duraipandiyan *et al*., 2009).

Two new eudesmanolides were isolated from the aerial part of *S. indicus* and their structures were established as 11α, 13-dihydro-3α, 7α-dihydroxyeudesm-4-en 6α, 12-olide (17) and 4-en-6β, 7α-eudesmanolide (18) on the basis of spectral data and comparison of spectral data with closely related compounds (Jadhav *et al*., 2007). Literature reports on the aerial parts of this plant revealed the presence of an essential oil, glycosides and eudesmanolides. An alkaloid sphaeranthine and an isoflavone 5,4-dimethoxy-3-prenylbiochanin 7-O-β-galactoside with some interesting sesquiterpenes and a new flavone glycoside were isolated from this herb (Tiwari and Khosa, 2010). The few biological active constituents isolated from *S. indicus* are given in Fig. 2.

The hydrodistilled essential oil of *S. indicus* was analyzed by Gas Chromato graphy (GC) and GC/MS. Thirty eight compounds making up 84.0% of the oil were

Table 2: List of biologically active compounds that have been isolated from *S. indicus*

Class	Parts used	Compounds
Essential oil	Plant	Ocimene, α-terpinene, methyl-chavicol, α-citral, geraniol, α-ionone, β-ionone, δ-cadinene, p-methoxyciunamaldehyde, sphaeranthine, stigmasterol, β-sitosterol, hentriacontane, sesquiterpene lactone, sesquiterpine glycoside, sphaeranthanolide, flavone and isoflavone glycosides (Ambavade *et al*., 2006)
Phytochemical evaluation	Aerial parts	5-hydroxy-7-methoxy-6-C-glycosylflavone, n-pentacosan, hentriacontane, n-triacontanol, β-sitosterol, stigmasterol, β-D-glucoside of β-sitosterol, sphaeranthine and a phenolic glycoside (Mishra *et al*., 2007)
Phytochemical evaluation	Flower	Essential oil, alkaloid, tannin, glycoside, reducing sugar, semidrying fatty oil and albumin (Pande and Dubey, 2009)
Isoflavone glycoside and alkaloid	Ariel parts	5,4-dimethoxy-3-prenylbiochanin 7-O-β-galctoside and sphaeranthine (Jadhav *et al*., 2007)
Essential oil	Plant	Methyl chavicol, α-ionone, δ-cadinene, p methoxy-cinnamaldehyde, thymoquinol-dimethyl ether, modephene-2 and T-cadinol (Kaul *et al*., 2005)
Sesquiterpenoids	Flower	Cryptomeridiol and 4-epicryptomeridiol (Bafna and Mishra, 2006)

identified. The major compounds were: 2, 5-dimethoxy-p-cymene (18.2%), α-agarofuran (11.8%), 10-epi-γ-eudesmol (7.9%) and selin-11-en-4α-ol (12.7%), respectively (Kaul *et al*., 2005). List of the biologically active compounds that have been isolated from *S. indicus* are given in Table 2.

Pharmacological properties of *S. indicus*: Pharmacological investigations have confirmed that *S. indicus* exhibit a broad range of biological properties. However, the crude extract of the plant have been used as a traditional medicine for the treatment of various diseases. Some of which are very interesting for possible future development.

Anxiolytic activity: The anxiolytic activity of petroleum ether, alcohol and water extracts of the flower of *S. indicus* using Elevated Plus Maze (EPM), Open Field Test (OFT) and Foot-Shock Induced Aggression (FSIA) experimental model were investigated in mice using diazepam as a standard drug. In EPM study, decrease in aversion to the open arm is the result of an anxiolytic effect, expressed by the increased time spent and entries in the open arm. The petroleum ether and alcohol extracts at doses of 10 and 30 mg kg^{-1} significantly increased the time spent and percent entries in the open arm, with percent decrease in the closed arm. In OFT model all extracts showed significant increase in the ambulation (the number of squares crossed at periphery) and total locomotion (total number of squares travelled). Anxiolytic treatment decreased the anxiety induced inhibition of exploratory behaviour. Experimental data showed that the petroleum ether extract has more prominent anxiolytic activity in the EPM and OFT tests. FSIA test reported that the numbers of fighting bouts (vocalisation, leaping, running, rearing and facing each other with some attempts to attack by biting) were decreased significantly by the petroleum ether and alcohol extracts at 30, 100 and 300 mg kg^{-1}. Results showed that the different flower extracts of *S. indicus* exert significant anxiolytic effects on mice which may underlie the therapeutic action of the plant (Ambavade *et al*., 2006).

Analgesic and antipyretic activity: The analgesic and antipyretic activities of various extracts of whole plant of *S. indicus* were investigated by Eddy's hot plate, Tail immersion and Brewer's yeast induced pyrexia models on albino rats. Diclofenac sodium and paracetamol were used as standard drugs. The petroleum ether, chloroform and ethanol extract doses of 200 and 400 mg kg^{-1} showed significant analgesic and antipyretic activity when compared to standard diclofenac sodium and paracetamol respectively. The chloroform and ethanol extracts showed potential significant antipyretic activity ($p<0.05$) from 1h onwards whereas aqueous extracts exhibited the activity after 2 h. It was suggested that the extracts targeted prostaglandins, which are involved in the late phase of acute inflammation and pain perception, thus suggesting the use of *S. indicus* as an analgesic and an antipyretic (Nanda *et al*., 2009).

Antioxidant activity: A study was carried out to assess the free radical scavenging potential of the ethanolic extract of *S. indicus* by different *in vitro* models like ABTS, DPPH, superoxide dismutase, nitric oxide radical and iron chelating activity. The calculated 50% inhibitory dose (ID_{50}) values were 41.99, 33.27, 25.14 and 22.36% when evaluated in ABTS, DPPH, superoxide dismutase and nitric oxide radical tests respectively. The extract also interfered with the formation of ferrous-0-phenantroline complex, thus suggesting that the extract has metal chelating activity. However extract showed only moderate scavenging activity of iron chelation (14.2%). The total antioxidant activity of the extract was calculated, based on formation of phosphomolybdenum complex, measured at 695 nm and found to be 160.54 nmol g^{-1} ascorbic acid. The results suggested that ethanolic extract of *S. indicus* may play an important role in free radical scavenging. The flavonoids and other constituents were suggested to be essential for strong activity (Shirwaikar *et al*., 2006b).

Another antioxidant investigation was carried out using aqueous extract of this plant. Extract at 1000 μg mL^{-1} showed maximum scavenging of the radical cation, ABTS (26.21%), DPPH (24.95%), superoxide dismutase (17.74%) and nitric oxide radical (10.63%) respectively. However, the extract showed only moderate scavenging activity of iron chelation (9.62%). Total antioxidant capacity of the extract was found to be 127. 85 nmol g^{-1} ascorbic acid. The findings justify the therapeutic applications of the plant in the indigenous system of medicine, augmenting its therapeutic value (Prabhu *et al*., 2009).

Antihyperlipidemic activity: Hyperlipidemia is the most prevalent indicator for susceptibility to atherosclerotic heart disease. The antihyperlipidemic activity of the alcoholic flower head extract of *S. indicus* was investigated in atherogenic diet induced hyperlipidemia in rats. The alcoholic extract when administered at a dose of 500 mg kg^{-1} effectively suppressed the atherogenic diet induced hyperlipidemia. The extract also caused considerable decrease in body weight, total cholesterol, triglyceride, Low-Density Lipoprotein (LDL) and Very Low Density Lipoprotein (VLDL) whereas significant increase was observed in the level of High-Density Lipoprotein (HDL) as compared to control. The extract showed a marked reduction in LDL: HDL-c ratio and atherogenic index. It was concluded that effects of *S. indicus* extract may be due to an increase in the activity of Lecithin: Cholesterol acetyl transferase, which incorporates free cholesterol free LDL into HDL and transfers it back to VLDL and intermediate density lipoprotein. The reduction in the triglyceride level might be due to increase in activity of the endothelium bound lipoprotein lipase. *S. indicus* may, therefore, be capable of exerting a potential protective role in atherosclerosis (Pande and Dubey, 2009).

Antimicrobial activity: The antimicrobial activity of extract of *S. indicus* aerial parts and flowers was tested by *in vitro* disc diffusion method using the following microbial strains viz., *Bacillus subtilis*(MTCC 441), *Staphylococcus aureus* (ATCC25923), *Staphylococcus epidermidis* (MTCC 3615), *Enterococcus faecalis* (ATCC 29212), *Escherichia coli* (ATCC25922), *Pseudomonas aeruginosa* (ATCC 27853), *Klebsiella pneumoniae* (ATCC15380) and fungal strains*Candida albicans* (MTCC 227), *Aspergillus niger* (MTCC 1344) and *Botrytis cinerea*. A principle sesquiterpene lactone, 7-hydroxyfrullanolide isolated from *S. indicus*was found to possess potent antimicrobial effect. The Minimum Inhibitory Concentration (MIC) values for different strains and extracts ranged from 5 to 0.039 mg mL^{-1}. The MIC of hexane extract of *S. indicus* flower was 0.31, 0.15 and 5 mg mL^{-1} for *B.subtilis, S. aureus* and *S. epidermidis*, respectively. On the other hand, the aerial parts showed higher MIC at 2.5 mg mL^{-1} for *B.subtilis,* 5 mg mL^{-1} for *Staphylococcus* spp. and 5 mg mL^{-1} for *E. faecalis* as compared to the flower. Most of the gram negative bacteria showed higher MIC (>5 mg mL^{-1}) for both the extracts of flower and aerial parts. The extract showed pronounced antibacterial and antifungal properties on all the microbes tested (Duraipandiyan *et al*., 2009).

A bicyclic sesquiterpene lactone was isolated from the petroleum ether extract of the aerial part of *S. indicus*. The compound was found to exhibit strong antimicrobial activity against *S. aureus, S. albus, E. coli, Fusarium* sp., *Helminthosporium* sp. and other microorgarisms. The results shows that extract of *S. indicus* were active *in vitro* against tested microorgarisms (Singh *et al*., 1988).

Hepatoprotective activity: Aqueous extract and methanolic extract of the flower heads of *S. indicus* were evaluated for their *in vivo* hepatoprotective and antioxidant effect using paracetamol induced hepatotoxicity in rats. The serum of the methanol extract group at a dose of 300 mg kg^{-1} when analyzed for various biochemical activities of liver marker enzymes viz., SGOT, SGPT), ACP, ALP bilirubin and total protein showed a significant hepatoprotective effect when compared to the same dose of aqueous extract. This was confirmed by studying the liver histopathology of treated animals. Methanolic extract also exhibited a significant change ($p<0.05$) in level of SOD, CAT and GPX by reducing malondialdehyde (MDA) levels and lipid peroxidation level in homogenated liver of rats. The results showed that methanolic extract of *S. indicus* possessed potent hepatoprotective and antioxidant effect in paracetamol induced hepatotoxicity thus suggesting therapeutic usefulness of *S. indicus* in chronic liver disease (Tiwari and Khosa, 2010).

Immunomodulating activity: The effect of bioactive fraction of *S. indicus* along with Cyclophos Phamide (CP) on humoral as well as cellular immunity and in addition to establish its fingerprint profile by HPTLC so as to facilitate the identification and characterization of different components of the fraction. Effect of bioactive fraction and CP on Humoral Antibody (HA) titre and Delayed Type Hypersensitivity (DTH) response was carried out using Sheep Red Blood Cells (SRBCs) as antigen in mice. DTH is antigen specific and causes erythema and induction at the site of antigen infection in immunized animals. The animals were divided into seven groups.

Treatment groups were doses with bioactive fraction (50-800 mg kg^{-1}, p.o.) for 7 days. The standard immunosuppressant drug CP was administered on days 4-6 (50 mg kg^{-1}), while the control group was given sodium carboxy methylcellulose. The animals were immunized by injecting 0.1 mL^{-1} 20% fresh sheep red blood cells suspension via the intraperitonial route. Antibody levels were determined by haemagglutination technique. The difference between the pre and post-challenge foot thickness expressed in millimeters was taken as a measure of delayed type hypersensitivity. The animals receiving bioactive fraction at doses of 200 ($p<0.05$) and 400 mg kg^{-1} ($p<0.001$) treatment along with CP showed a dose dependent increase in HA titre indicating the enhanced responsiveness of macrophages and subsets of T and B-lymphocytes involved in antibody synthesis, while an increase in DTH response at dose of 400 mg kg^{-1} ($p<0.001$) indicated that the drug has a stimulatory effect on lymphocytes and necessary cell types required for the expression reaction. The results suggested that the bioactive fraction influences both humoral and cell-mediated immunity and offers protection against immunosuppression induced by the cytotoxic agent cyclophosphamide (Bafna and Mishra, 2006).

Petroleum ether extract from the flower heads of *S. indicus*Linn was found to be effective in increasing phagocytic activity, HA titer and DTH when tested in mice. Petroleum extract at a dose of 200 mg kg^{-1} showed significant activity. If higher doses the activity was either decreased or showed no change. The results revealed that the drug acts as an immunomodulatory agent, by stimulating humoral and cellular immunity as well as phagocytic function (Bafna and Mishra, 2007).

Wound healing activity: The effect of cream containing ethanolic extract of *S. indicus* was evaluated for wound healing activity by the excision wound method in guinea pigs. The cream was applied *in vivo* on the paravertebral area for 15 days. The cream significantly enhanced the rate of wound contraction and the period of epithelialization and had activity comparable to standard drug, neomycin. Wound contraction was expressed as percentage reduction of original wound size. The healing percentage was found to be 78-89%. In addition to wound healing, the cream was found to be beneficial in treating eye infection in guinea pigs. The results justify the folkloric use of *S. indicus* in the treatment of skin diseases (Sadaf *et al*., 2006).

The wound healing activity of *S. indicus* flower head, ointments of extracts in varying proportions were prepared and tested in albino rats. The efficacy of the extract was investigated on parameters like wound contraction, tensile strength measurement and determination of hydroxyproline content in rats. Constituents of hydroxyproline are a measure of concentration of collagen. Determination of hydroxyproline content in granular tissue was done by colorimetry, the estimation of which helps to clinically assess the progress rate of the healing process in the connective tissue of the wound. The study involved comparison of wound healing activity with various formulations. The formulation comprising of 2% (w/w) alcoholic extract of flower head of *S. indicus* was found to be superior as compared to that of control and standard formulation. The greater hydroxyproline content found in healed wounds as compared to control and standard formulation suggest that alcoholic extract of *S. indicus* play an important role in wound healing (Jha *et al*., 2009).

Psychotropic activity: The hydroalcoholic extract of *S. indicus* was evaluated for its neuropharmacological effects in rats and mice. The extract at doses of 100, 200 and 500 mg kg^{-1} when administered to mice by the oral route, showed significant reduction of spontaneous motor activity, exploratory behaviour and prolonged pentobarbital sleeping time in the mice. Neuroleptic potential of *S. indicus* extract was observed by the results in which *S. indicus* antagonized apomorphine-induced stereotypy in mice, produced catalepsy and potentiated haloperidol-induced catalepsy in rats. Furthermore *S. indicus* had no effect on motor-coordination as determined by the rota-rod test. These results provide evidence that the hydroalcoholic extract of *S. indicus* may contain psychoactive substances that are sedative in nature with possible neuroleptic properties (Galani and Patel, 2009).

Bronchodialatory activity: The bronchodilatory effect of the methanolic extract of the whole plant of *S. indicus* and its various fractions (petroleum ether, benzene, chloroform and ethyl acetate) were investigated in histamine induced acute bronchospasm in guinea pigs. The methanolic extract and its fractions showed significant protection ($p<0.001$) against bronchospasm, induced by histamine in guinea pigs, comparable to with the standard chlorpheniramine maleate (2 mg kg^{-1}), thereby suggesting that the plant *S. indicus* has bronchodilatory activity (Sarpate *et al*., 2009).

Anti-macrofilaricidal activity: Lymphatic filariasis, the second leading cause of permanent and long-term disabilty in the world, is a result of infection with *Wuchereria bancrofti, Brugia malayi* and *Brugia timori.* Twenty methanolic extracts of medicinal plant were

Table 3: Summary of significant research finding on *S. indicus*

Source	Activity	Observations
S. indicus flower extracts (petroleum ether, alcohol and water)	Anxiolytic	All the extracts of the flower showed anxiolytic activity. Petroleum ether extract showed prominent activity (Ambavade *et al*., 2006)
S. indicus whole plant extract of using sodium and paracetamol as standard drugs.	Analgesic and antipyretic	Chloroform and ethanol extracts showed significant antipyretic activity than aqueous diclofenac extracts (Nanda *et al*., 2009)
Ethanolic and aqueous extracts of *S. indicus*	Antioxidant	Extracts showed good to moderate antioxidant activity in ABTS, DPPH, superoxide dismutase, nitric oxide radical and iron chelating models (Shirwaikar *et al*., 2006b; Prabhu *et al*., 2009)
Alcoholic extract of *S. indicus* flower heads	Antihyperlipidemic	Extract showed marked reduction in LDL: HDL-c ratio and atherogenic index (Pande and Dubey, 2009)
S indicus aerial parts and flowers extract	Antimicrobial	Extract showed marked activity against wide range of microorganisms like *S. aureus, S. epidermidis,E. faecalis, P. aeruginosa* and *E. coli* (Duraipandiyan *et al*., 2009)
Petroleum ether extract of *S. indicus* aerial part	Antimicrobial	Extract of *S. indicus* exhibited pronounced inhibitory activity against human pathogen (Singh *et al*., 1988)
Aqueous extract and methanolic extract of the flower heads of *S. indicus*	Hepatoprotective	*S. indicus* flower heads exhibited potent hepatoprotective and antioxidant effect towards paracetamol induced hepatotoxicity (Tiwari and Khosa, 2010)
Bioactive fraction of *S. indicus*	Immunomodulator	Fractions showed promising dose dependent increase in HA titre and DTH response (Bafna and Mishra, 2006)
Petroleum ether extract of *S. indicus* Flower heads	Immunomodulator	Extract showed significant increase in phagocytic activity, HA titer and DTH (Bafna and Mishra, 2007)
Cream containing ethanolic extract of *S. indicus*	Wound healing	*S. indicus* exhibited most active healing potential (Sadaf *et al*., 2006)
Comparison of flower head extracts activity in ointments of in various proportions	Wound healing	Alcoholic extract of flower head of *S. indicus* showed better activity compared with standard formulation (Jha *et al*., 2009)
Hydroalcoholic extract of *S. indicus*	Psychotropic	Extract exhibited neuroleptic potential by antagonizing apomorphine-induced stereotypy in mice (Galani and Patel, 2009)
Methanolic extract of whole plant of *S. indicus* and its various fractions (petroleum ether, benzene, chloroform and ethyl acetate)	Bronchodialatory	Showed significant protection against bronchospasm was comparable with chlorophenarmine maleate the standard drug (Sarpate *et al*., 2009)
Methanolic extract of *S. indicus*	Anti-macrofilaricidal	*S. indicus* exhibit potent inhibition of formazan formation (Nisha *et al*., 2007)
Extract of *S. indicus* whole plant	Mast cell stabilizing	*S. indicus* showed potent mast cell stabilizing effects (Mathew *et al*., 2009)
Dried petroleum ether extract of *S. indicus* of flower head	Anti-diabetic	Extract significantly lowered blood glucose level of the diabetic rats after 6 h (Jha *et al*., 2010)
Alcoholic extract of *S. indicus*	Anti-diabetic	Extract of *S. indicus* showed significant improved in oral glucose tolerance test (Prabhu *et al*., 2008)

screened *in vitro* at doses of 1-10 mg mL^{-1} by worm mortality assay against adult *Setaria digitata*. The methanolic extract of *S. indicus* showed complete inhibition of worm motality and subsequent mortality at 1 mg mL^{-1}. The MTT assay was carried out at 1 mg mL^{-1} and 4 h incubation period. *S. indicus* exhibited 61.20% inhibition in formazan formation as compared to the control (Nisha *et al*., 2007).

Anti-allergic activity: The effects of *S. indicus* on mast cell stabilizing activity were studied. The protective effect of different extracts of the whole plant of *S. indicus* against sheep serum induced mast cell degranulation was evaluated. Ethanol extract of *S. indicus* at doses of 150 and 300 mg kg^{-1} and ethyl acetate extract at the dose of 100, 150 and 300 mg kg^{-1} showed slightly better protection of mast cell degranulation (77-86%) than the standard drug ketotifen (75%) in the sheep serum model. These extracts also showed better mast cell stabilizing activity (77-88%) than the standard drug (69%). These results suggest that *S. indicus* has potent mast cell stabilizing effects thereby inhibiting mediator release from mast cells (Mathew *et al*., 2009).

Antidiabetic activity: The hypoglycemic effects of the dried petroleum ether extracts of the flower head of *S. indicus* were studied in Wistar rats. Various *in vitro* studies showed that alloxan is selectively toxic to pancreatic beta cells, leading to the induction of cell necrosis. Cytotoxic action of alloxan is mediated by reactive oxygen species, with a simultaneous massive increase in cytosolic calcium concentration, leading to a rapid destruction of beta cells. The extract was administered once at a dose of 50, 100 and 200 mg kg^{-1} body weight. The extract at the dose of 200 mg kg^{-1} significantly lowered blood glucose level (107±4.09) of the diabetic rats after 6 h of extract administration. This report endorses the traditional claims of *S. indicus* for its anti-diabetic activity in the Bundelkhand region (Jha *et al*., 2010).

The antidiabetic activity of the alcoholic extract of *S. indicus* was studied on streptozotocin-nicotinamide diabetic rat model. Oral administration of *S. indicus* for 15 days resulted in a significant decrease in blood glucose levels with increases in hepatic glycogen and plasma insulin levels. Fasting normal rats treated with the alcoholic extract of *S. indicus* showed significant improvement in the oral glucose tolerance test. Glibenclamide was used as a reference standard. The findings demonstrate that the alcoholic extract of *S. indicus* may be useful in the treatment of diabetes (Prabhu *et al*., 2008).

CONCLUSION

Sphaeranthus indicus is a plant distributed throughout the plains and wet lands in India, Sri Lanka and Australia. Well-known in the Indian and folkloric system of medicine for several ailments viz. jaundice, leprosy, fever, pectoralgia, cough, gastropathy, hernia, haemorrhoids, helminthiasis, dyspepsia, skin diseases, anthelmintic, as a nerve tonic etc, research carried out using different *in vitro* and *in vivo* techniques of biological evaluation have supported most of these claims.

The oil prepared using the plant root is reportedly useful in treating scrofula and as an aphrodisiac. The external application of a paste of this herb is beneficial in treating pruritus and edema, arthritis, filariasis, gout and cervical adenopathy. It is also useful for the treatment of piles and hepatitis (Ambavade *et al*., 2006). List of the significant research finding concluded on *S. indicus* are given in Table 3.

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