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A Review on Sphaeranthus Indicus Linn: Multipotential Medicinal Plant

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Subject: Biology

Abstract
Many herbal remedies have been employed in various medical systems for the treatment and management of different diseases. The weed herb Sphaeranthus indicus Linn has been used in different system of traditional medication for the treatment of diseases and ailments of human beings. It possesses antimicrobial, wound healing, anti arthritics, immunostimulant, immunomodulatory, antioxidant anxiolytic, neuroleptic, activities. Other applied applications are antifeedant, piscicidal, haemolytic, ovicidal and larvicidal. There are also reports available for the traditional use of this plant. Such review is not available in earlier literature. Therefore this present paper is a compilation of data on experimentally confirmed biological activities.

Keywords: *Sphaeranthus indicus, Pharmacological activities, Traditional Uses.*

Introduction
Plants have played a significant role in maintaining human health and improving the quality of human life for thousands of years and have served humans well as are valuable components of medicines, seasonings, beverages, cosmetics and dyes. Herbal medicine is based on the premise that plants contain natural substances that can promote health and alleviate illness. In recent times, focus on plant research has increased all over the world and a large body of evidence has been collected to show immense potential of medicinal plants used in various traditional systems. Today, we are witnessing a great deal of public interest in the use of herbal remedies. Furthermore, many western drugs had their origin in plant extract. There are many herbs, which are predominantly used to treat cardiovascular problems, liver disorders, central nervous system, digestive and metabolic disorders. Given their potential to produce significant therapeutic effect, they can be useful as drug or supplement in the treatment / management of various diseases. Such have been used and continued to be used as medicine in folklore or food supplement for various disorders. Ethnopharmacological studies on such herbs/medically important plants continue to interest investigators throughout the world. One such plant, Sphaeranthus indicus, invites attention of the researchers worldwide for its biological activities. Sphaeranthus indicus Linn belongs to family Asteraceae; is a medicinally important plant used as folk medicine.

Boatanical Description

Taxonomy

Kingdom:	Plantae
Division:	Phanerogamae
Sub division:	Angiospermae
Class:	Dicotyledonae
Sub class:	Gamopetalae
Order:	Asterales
Family:	Asteraceae
Genus:	Sphaeranthus
Species:	indicus

Synonyms

Sanskrit: mahamundi, mundi, hapusa; Hindi, Bengali, Marathi, Gujarathi: mundi, gorakh mundi; Telugu: Boddatarupu, boddasoramu; Tamil: kottakaranthai; Malayalam: mirangani, adakkamaniyan; Oriya: Murisa, buikadamba, bokashungi; Riya: Murisa, bokashungi; Punjabi: ghundi, khamadrus; Santal: Belaunja; Undari: Mundi
Botanical description

Species of Sphaeranthus - Its species are widely distributed in tropical Asia, Africa and Australia. Other reported species are Sphaeranthus moli, Sphaeranthus microcephalus willd - Java, Sphaeranthus laevigatus wall - Africans, Sphaeranthus suaveolens DC - Afr. Bor - France, Switzerland, Sphaeranthus hirtus willd and Sphaeranthus senegalensis.

Morphological characters

It is a much branched herb, strongly scented annual with winged stem and the wings toothed. Leaves obovate-oblong, narrowed at the base, dentate and serrate. Flowers compound heads, globose avoid, purple. Flowering time November to January in Indian conditions; glandular hairy; Achene staled. This plant known as Gorakmundi in Hindi is found abundantly in the plains all over India, ascending to an altitude of 1500 m in the hills, especially as a weed in the rice fields (Kirtikar and Basu,1935; The wealth of India, 1982).

Ayurvedic Preparations

Mundi Churna, Mundi panchang swarasa, Mundi kvatha.

Uses of plant

Textually a number of uses of this plant are described. All parts of the plant find medicinal uses. The juice of the plant is styptic and said to be useful in liver and gastric disorders (Chadha, 1976). The paste of the herb, made with oil, is as an anthelmintic. A decoction of the root is used in chest-pains, cough, and bowel complaints. The bark, ground and mixed with whey is said to be a useful application in piles. Flowers are credited with alterative, depurative, and tonic properties. Leaf juice is boiled with milk and sugar-candy and prescribed for cough. Antitubercular properties have also been ascribed to the plant (Kirtikar and Basu, 1935; Chopra, 1956). The leaves are eaten as a pot-herb. They are mixed with paddy and rice to prevent damage by insect pests during storage. The herb is employed as a fish-poison. It is also stuffed into nesting furrows of crabs to kill them (Kirtikar and Basu, 1935). Roots and seeds are used as stomachic and anthelmintic (Said, 1956). Although there is a range of potentially useful medicinal substances in plant, the research in this area is scanty.

This plant and its various plant parts used by the traditional peoples, tribes, vaidys to cure various ailments. The details of it summaries as under,

Table 1: S. indicus and its various plant parts used to cure various ailments

Ailments	Plant part	Mode of Application	Reference
Against piles	The bark	Ground and mixed with whey To be a useful application in piles.	Kirtikar and Basu,1935
	Bark	Powder is given orally and applied externally to cure piles.	Nayak et al., 2004
	Leaf, flower and seeds	ground into paste and applied topically to treat skin diseases and piles	Muthu et al., 2006
Pisicidal activity	Whole plant	Fish-poison.	Kirtikar and Basu,1935
Crabicidal	Whole plant	Herb stuffed into nesting furrows To kill crabs.	Kirtikar and Basu,1935
Anthelmintic	Whole plant	Paste of whole plant + oil Is an anthelmintic.	Kirtikar and Basu,1935
	Roots and seeds	Used as stomachic and anthelmintic.	Said, 1956
	Root and seed	Powder is given orally to kill intestinal worms in children.	Nayak et al., 2004
	Leaf	For worm trouble, leaf decoction is taken in the morning 8 time once in 2 day	Samuel and Andrews, 2010
		Whole plant paste with a pinch of common salt is taken as an anthelmintic.	Panda and Misra, 2011
Against cough	Root	Decoction of root useful for Chest-pains, cough, and bowel complaints.	Kirtikar and Basu,1935
	Leaf	Leaf juice is boiled with milk and sugar-candy. Prescribed for cough.	Chopra, 1958
AS tonic	Flowers	Alterative, depurative, and tonic properties.	Chopra, 1958
	Flowers	Alternant, depurative, refrigerant and tonic.	Jeeva et al., 2006
Gastric disorder	Whole plant	The juice of plant is styptic and useful in liver and gastric disorders.	Chadha, 1976
	Whole plant	juice is used for gastric disorders	Bapuji and Ratnam, 2009
	Inflorescence	Paste is given in empty stomach for curing excess bile.	Panda and Misra, 2011
Against Dysurea	Root	Paste of root and black peppers (5 to 7) and taken 2 times a day. Used against dysurea by the people of Bargarh district in Orissa.	Sen et al., 2001
Against Jaundice	Leaves	Decoction of leaves used by the tribes, for the treatment of jaundice.	Wabale and Petkar 2005

Mouth ulcer	Raw leaf	Raw leaf is chewed or leaf juice is administered orally during mouth ulcer, and other mouth diseases	Behera et al.,2006
Stomachache	Root	Amulet of root is worn in Stomachache.	Acharya and Pokhrel, 2006
Leucorrhoea	Root	According the information about one teaspoonful of root powder is taken with a cup of water 2 times daily in the treatment of leucorrhoea for 30 days.	Narain and Singh,2006
Elephantiasis	Leaf	Leaf juice (5ml) with long pepper and common salt (3:1:1) is given for 10 days.	Chakraborty and Bhattacharjee, 2006
Swelling	Whole plant	Plant paste mixed with coconut oil is used for painful swelling.	Jeeva et al., 2006
Scrofula	Root	Oil prepared by using root	Jeeva et al., 2006
Against gray hair	Whole plant	A spoonful of the powdered plant, mixed with water, is taken internally to blacken gray hair	Ganesan et al., 2007
Scabies	Leaf	Leaf juice mixed in water is used for bath	Silja et al., 2008
Skin diseases	Leaf	Powder	Jeeva et al., 2006
	Whole plant	Plant powder is taken internally to treat skin diseases	Kumar et al., 2007
	Leaf ,Flower and seeds	are Ground into paste and applied topically to treat skin disease.	Rajadurai et al., 2009
	Whole plant	Paste is topically applied for skin irritation	Ayyanara and Ignacimuthu, 2011
	Root	Paste is made by grinding root with juice of tender pericarp of coconut or lemon juice.	Bhandary and Chandrashekar, 2011
Diarrhoea and dysentery	Flower, Leaf	Flower paste is given in empty stomach to cure dysentery, diarrhoea and indigestion. Leaf juice is also given to cure diarrhoea and vomiting	Behera et al., 2006
	Leaves	Fresh leaves with cumin seeds are taken internally to treat dydentery.	Kumar et al., 2007
	Whole plant	Children suffering from dysentery are exposed to fumes of whole plant.	Gupta et al., 2009
Eye infection	Inflorescence	Inflorescence + water for whole night. Juice is used as an eye drop for eye infection or eye cleaning.	Gupta et al.,2010
Toothache	Stem and leaf	Stem with leaf is chewed to get relief from toothache.	Panda and Misra, 2011
Blood purifier	Inflorescence	Juice is given orally for purification of blood and itching.	Gupta et al.,2010
Earache	Leaf	Extract mixed with black pepper powder is dropped into ears.	Shukla et al., 2010
Viral hepatitis	Leaf	50g. powdered drug given once a day with water to cure viral hepatitis**.**	Yadav and Khan, 2012
Aphrodisiacs	Shade dried plant at flowering stage	Powder with Deshi ghee and honey taken orally for 38 days to develop sexual power	Katewa and Galav, 2005
	Root	Powder mixed in hot Sesamum indicum (Til) oil is massaged on male sex organ for perfect erection	Katewa and Galav, 2005
For retaining pregnancy	Leaf	Handfull of leaves made in to juice, taken 200 ml internally for three days to retain pregnancy.	Sandhya et al., 2006
Rheumatic pains	Leaf	Leaf is cooked together with rice and eaten to check rheumatic pains.	Prusti and Behera, 2007
Polyherbal Unani formulation			
Efficacy in Scabies	Whole plant (Decoction)	The study showed significant reduction in the signs and symptom of scabies after 15 days of treatment.	Ali et al., 2006

Therefore, number of researchers work on this plant experimentally and proved its efficacy against various disorders, here, some Pharmacological Activities of this plant are summarized below**:**

Table 2: Number of researchers work on S. indicus experimentally and proved its efficacy against various disorders

Name of activity	**Plant part used (Extract)**	**Observation**	**Reference**
Antiviral	Methanolic	The minimum concentration of extracts required to completely inhibit viral cytopathic effect (CPE) that is MIC_{100} values (low MIC_{100} and broad spectrum of activity) was obtained from S. indicus which showed anti-MCV (mouse corona virus, the surrogate for human SARS virus) and anti-HSV (Herpes simplex virus) activities at a concentration as low as 0.4µg/ml.	Vimalanathan et al., 2009
	Whole	The plant also showed antiviral activity against vaccinia and ranikhet viruses	Dhar et al., 1968
Antibacterial and antifungal	Leaves (Essential oil)	S. indicus exhibited antifungal activity	Garg and Kasera, 1982
	Leaves (Essential oil)	The organisms tested have been found more or less susceptible to the oil. Overall results suggest that except Salmonella paratyphi C and Shigella Somnei all the test bacteria are comparatively more susceptible to the neat oil than the control antibiotic.	Garg and Kasera, 1983
	Flower (50% ethanol)	S. indicus showed the broad spectrum antibacterial activity against gram –ve and gram + bacteria.	Naqvi et al., 1985
	Flower (Alcoholic and alkaloids isolated from it)	Crude extract and isolated two alkaloid s exhibited broad spectrum antibacterial activity.	Shaikh D. et al., 1986
	Aerial part (Petroleum ether)	Isolated bicyclic sesquiterpene lactone demonstrated strong antimicrobial activity against Staphylococcus aureus, S. albus, Escherichia coli, Fusarium sp., Helminthosporium sp. and other microorganisms.	Singh et al., 1988
	Flower	7-Hydroxyfrullanolide, a sesquiterpene lactone showed antimicrobial activity	Attaurrahman et al., 1989
	Flower (Alkaloid isolated from methanolic extract)	Alkaloid isolated from methanolic extract of the flower of S. indicus exhibits the antibacterial activity against 18 bacteria.	Naqvi, 1997
	Flowers (Benzene, chloroform, acetone and ethanol)	The Benzene extract of S. indicus exhibited the highest activity followed by chloroform, acetone and ethanol extract against all test bacteria.	Mahajan et al., 1999
	Whole plant (Alcoholic, aqueous)	Crude extract of the plant is highly effective against Alternaria soloni, Fusarium oxysporum and Penicillium pinophilum by preventing their growth to a greater extent.	Dubey et al., 2000
	Whole plant (Ethanolic)	Significant inhibitory effect against four bacterial and one fungal human pathogens.	Ram et al., 2004
	Flower (Petroleum ether, acetone, methanol (90%) and aqueous)	Flower of S. indicus exhibited remarkable antibacterial and strong antifungal activities.	Lalla and Ukesh, 2005
	Aerial parts [Dichloromethane and methanol (1:1)]	S. indicus have significant antimicrobial activity.	Kumar et al., 2006
	Terphenoidal compound)	Terphenoidal compound isolated from S. indicus showed activity against Bacillus subtilis.	Dubey et al., 2007

	Whole plant (Petroleum ether, chloroform, benzene, ethyl acetate methanol and hot water)	The methanolic extract of S.indicus showed considerably more activity when compared to other all the solvents. Maximum antibacterial activity was shown against Streptococcus pyrogens, followed by S. aureus and B.subtilis.	Doss et al., 2008
	Aerial and flowers (n-hexane, benzene, chloroform, ethylacetate and acetone)	Significant antibacterial and antifungal activity was observed in hexane extract of flower and aerial parts. The flower extract showed Minimum Inhibitory Concentration (MIC) as 0.15 mg/ml against Staphylococcus aureus and the highest MIC (5 mg/ml) was noted for S. epidermidis. The n-hexane extracts of flower and aerial parts showed MIC as 0.15 and 1.25 mg/ml respectively against Candida albicans. Finally they concluded that, the S. indicus flower n-hexane extract seems to be a promising antimicrobial agent.	Duraipandiyan et al., 2009
	Whole plant and flower (methanol, ethanol, acetone and aqueous)	Ethanol extract of S. indicus has strong antibacterial activity.	Tambekar and Khante, 2010
	Leaves (ethanol, chloroform and petroleum ether)	The chloroform extract of S .indicus exhibited comparably more activity against Escherichia coli, Pseudomonas aeruginosa, Salmonella typhi, Klebsiella sp., Candida albicans and Cryptococcus neoformans than the ethanol and petroleum ether extract.	Sangeetha et al., 2010
	Entire part including flower heads (hexane, chloroform, ethyl acetate, ethanol, methanol and aqueous)	The chloroform, methanol and aqueous extracts showed high antibacterial activity against S. aureus; chloroform, methanol and ethanol extract against P. aeroginosa, methanol, chloroform and hexane against B. substilus, aqueous, methanol, ethyl acetate and chloroform against E. coli.	Zachariah et al., 2010
	Flower (Aqueous)	The extracts showed significant inhibition against coli form strains.	Upadhyay and Mishra, 2011
	Leaves, flower stem and roots (methanol, ethanol, chloroform, petroleum ether and hot water)	Leaves extracts showed significant amount of phytochemicals and hence antimicrobial studies of leaves extracts were carried out against bacterial species such as Bacillus sp. Staphylococcus sp., Klebsiella sp., E. coli, Pseudomonas sp., using filter paper and agar well diffusion method at 4 different concentrations. MES and AQS of leaf showed the highest inhibitory effect compared to all other extracts and it showed good inhibitory activity against Bacillus sp., followed by Staphylococcus sp.	Selvi et al., 2011, John and Tamilmaraiselvi, 2011
	Whole plant (Alcoholic and aqueous)	Alcoholic extract of Sphaeranthus indicus showed the best antibacterial activity.	Singh and Jain, 2011
	Leaves [Crude extracts (Butanol, Ethanol and Methanol) and solvent fractions (PF,CF,HF and DF)]	All the crude extracts and solvent fractions showed varying degrees of inhibition on tested microorganisms where gram-positive bacterial strains were more susceptible as compared to gram-negative.	Thakur et al., 2012
	Leaf, flower, stem and root (methanolic)	The highest zone was exhibited by the flower extract of 8 against Staphylococcus aureus.	Krishna et al., 2013
	Leaves (Ethanolic)	Significant antibacterial and antifungal action was observed in Ethanolic extract of leaves against B.subtilis, S.aureus and Candida respectively.	Meher et al., 2013
	Leaves (Methanolic,	Out of the four extract the methanolic extract possessed higher degree of antibacterial activity against Escherichia coli. However against	Irfan et al., 2014

	ethanolic, chloroform and aqueous extract)	Klebsiella pneumonia ethanolic extract of plant showed higher activity than any other extract, whereas against Proteus mirabils, Chloroformic extract show similar inhibition zone as that with Kanamycin. It is also observed that against Acetobector and Pseudomonas methanolic and ethanolic extract shows similar activity, however it was higher than chloroform extract	
Antiprotozoal	Flower (Ethanolic)	Entamoeba histolytica, Trypanosoma savansi, Trypanosoma cruzi, Plasmodium berghci and Babesia rhodaini. Entamoeba histolytica was found to be inhibited by the ethanolic extract of flower of S. indicus.	Naqvi, 1997
	Flower (Methanolic and semipurified alkaloidal fraction)	There was no significant activity against the tested protozoa.	Nemade et al., 2012
Anthelmintic	Whole plant (Ethanolic and aqueous)	Both extracts exhibited anthelmintic activity in a dose-dependent manner.	Sharma et al., 2011
Macrofilaricidal	Leaves (Methanolic)	Complete inhibition of worm motility and subsequent mortality was observed at 1mg/ml for S. indicus 3-[4,5- dimethylthiazol-2-yl]-2,5-diphenyl tetrazolium bromide (MTT) reduction assay was carried out at 1mg ml^{-1} and 4-h incubation period, and the result showed that S. indicus exhibited 61.20% inhibition in formazan formation compared to the control.	Mathew et al., 2006
Neuroleptic	Flowers (Petroleum ether, Aqueous and alcoholic)	The petroleum extract reduced total time spent in apomorphine induced cage climing. Aqueous and alcoholic extracts showed catalepsy, while petroleum ether extract did not.	Mhetre et al., 2006
Anxiolytic	Flowers (Petroleum ether, alcoholic and water)	Petroleum ether extract (10 mg/kg), alcoholic extract (10 mg/ kg) and water extract (30 mg/kg) resulted in prominent activity in the mice. Petroleum ether correspondence to: extract (10 mg/kg) resulted in more prominent anxiolytic activity in the EPM (Elevated plus maze) and OFT (open field test) than ethanolic or water extracts, but was less than that produced by diazepam (1 mg/kg).	Ambavade et al., 2006
	Whole plant (Hydroalcoholic)	S. indicus demonstrated anxiolytic, central nervous depressant and anticonvulsant activities in rodents; thus, supporting the folk medicinal use of this plant in nervous disorders.	Galani and Patel, 2010
Neuropharmacological effect	Whole plant (Aqueous)	The extract (50 and 100 mg/kg p.o.) produced reduction in spontaneous motor activity, exploratory behaviour and motor coordination and prolonged pentobarbital sleeping time.	Amos et al., 2001
Neuroprotective effect	Flower heads [Petroleum ether (SIP), methanolic (SIM) and aqueous extract (SIA)]	SIM and SIA were found to be an effective neuroprotective agent which could reverse D-galactose-induced oxidative damage and acceleration of aging.	Ambikar and Mohanta, 2013
Central nervous depressant and anticonvulsant activities	Whole plant (Hydroalcoholic)	Hydroalcoholic extract decreased locomotor activity but did not affect emotional activity parameters in the open field test, suggesting a possible central nervous depressant activity. Hydroalcoholic extract also increased the immobility time in the forced swimming test at an oral dose of 500 mg/kg but did not significantly modify the activity in the tail suspension test. Hydroalcoholic extract protected rats against MES-induced convulsions and mice against PTZ-induced convulsions.	Galani and Patel, 2010
	Whole parts of the plant (Petroleum ether, Benzene, Chloroform, Ethanol and	Ethanol extract (200- 400 mg/kg) significantly reduced the duration of seizures induced by maximal electroshock (MES). However, only 200 and 400mg/kg of the extract conferred protection (25 and 50%, respectively) on the mice. The same doses also protected animals from pentylenetetrazole-induced tonic seizures and significantly delayed the onset of tonic seizures produced by picrotoxin and N-	Nanda et al., 2010

	water)	methyl-dl-aspartic acid. The extract had no effect on bicuculline-induced seizures. The aqueous extract (400mg/kg) significantly reduced the latency, but did not alter the incidence of seizures elicited by maximal electroshock to any significant extent	
Antiamnesic effect	Whole plant (Ether)	Ether extract of Sphaeranthus indicus (EESI) at a doses of 150 and 300 mg/kg significantly (P<0.01) enhanced the learning and memory activities against the scopolamine induced dementia after 9 days of treatment. Further, extract had produced a significant (P<0.05) decrease in Acetylcholinesterase level in cortex, midbrain, medulla and cerebellum of brain in animals which led us to conclude that the memory enhanced activity.	Aravind et al., 2010
	Flower heads (petroleum ether fraction)	The petroleum ether fraction (10 mg/kg, p.o.) administration significantly reversed cognitive impairments in mice by passive avoidance test (P < 0.05). It also reduced escape latencies in training trials and prolonged swimming times in the target quadrant during the probe trial in the water maze task (P < 0.05).	Patel and Amin, 2012
Psychotropic activity/ Sedative effect	Whole plant (Hydroalcoholic)	Extract of S. indicus significantly reduced spontaneous motor activity and prolonged pentobarbital induced hypnosis. It might be working as mild neurosedative agent. The hydroalcoholic extract of S. indicus also reduced exploratory behavior and decrease the sedative activity.	Galani and Patel , 2009
Antiasthmatic	Aerial parts (Methanolic)	The result showed that it significantly increased preconvulsion dyspnoea (PCD) time, decreased differential leukocyte counts and serum bicarbonate level, which is beneficial in asthma. Further in histopathological study of lung, the treatment with the drug prevented inflammation and bronchoconstriction.	Prajapati et al., 2010.
Antiussive	(Methanol)	The methanolic extract of (200, 300 and 400 mg/kg) showed maximum inhibition of cough by 71.24%, 76.84% and 77.92% and also exhibited significant synergistic effect (P < 0.001) at the dose levels of 200, 250 and 300 mg/kg.	Nayak et al., 2010
Bronchodilatory	Whole plant (Methanolic)	The methanolic extract and its fractions viz. petroleum ether, benzene, chloroform and ethyl acetate exhibited significant protection against bronchospasm, induced by histamine in guinea pigs.	Sarpate, 2009
Hepatoprotective activity	Flower (Aqueous and methanolic)	As compared to aqueous extract, significant decrease in liver function markers such as serum glutamate oxaloacetate transaminase (SGOT), serum glutamate pyruvate transaminase (SGPT), acid phosphatase (ACP) and alkaline phosphatase (ALP), bilirubin and total protein, was observed while using methanolic extract of S.indicus with same dose.	Nayak et al., 2007
	(Methanolic)	The toxic group which received CCl_4 alone exhibited significant increase in serum alanine amino transferase(ALT), aspartate amino transferase(AST), alkaline phosphatase(ALP) and total bilirubin levels. The groups received pretreatment of methanolic extract of S. indicus had controlled the AST, ALT, ALP and total bilirubin levels and the effects were comparable with standard drug.	Pavan et al., 2008
	Flower heads (Methanolic)	It showed a significant protective effect by lowering the serum aspartate aminotransferase, alanine aminotransferase and alkaline phosphatase (ALP).	Tiwari and Khosa, 2008
	Flowers (Aqueous and methanolic)	Activities of liver marker enzymes, glutamate-oxaloacetate transaminase (SGOT), glutamate pyruvate transaminase (SGPT), acid phosphatase (ACP) and alkalone phosphatase (ALP) bilirubin and total protein at an oral dose of methanolic extract (300mg/kg) showed a significant hepatoprotective effect in comparison with the same dose of aqueous extract.	Tiwari and Khosa, 2009
	Herbal formulation of Sphaeranthus indicus (East Indian globe thistle) and other plants with	The toxic effect of carbon tetrachloride was controlled significantly by restoration of the levels of total bilirubin, serum glutamate pyruvate transaminase (SGPT), serum glutamate oxaloacetate transaminase (SGOT), alkaline phosphatase (SALP) and liver weight as compared to the normal (control) and the standard drug (Liv52) treated groups. Histology of the liver sections of the animals treated with the test formulation showed the presence of normal hepatic cords, absence of	Shafiuddin et al., 2009

	water	necrosis and fatty infiltration.	
	Aerial parts (Ethanolic)	300 mg/kg of extract showed significant protection against paracetamol-induced hepatocellular injury.	Sundari et al., 2011
	Root (Aqueous)	The activity of 300 mg/kg of the extract was comparable to standard drug, silymarin (50 mg/kg body weight)	Sundari and Govindaraju, 2012
	Stems and leave s (Methanol)	Treatment of rats with two doses (500 mg/kg and 750mg/kg) of extract after CCl_4 dosing statistically restored the serum liver enzyme, total protein and antioxidant levels. Histopathological studies supported the biochemical assessment.	Mathews et al., 2012
	(Ethanolic and aqueous)	Oral administration of ethanolic and aqueous extract of S. indicus to the paracetamol induced rats' showed increase of both enzymatic and non-enzymatic antioxidant status and decreased lipid peroxide level. For proteomic approach, identified the four differential spots were expressed in paracetamol induced and S. indicus treated rats through 2D gel. The expressions of these protein spots were further confirmed by MALDI-TOF-MS i.e. Heat shock protein, Liver transferrin, Glutathione-S-Transferase and Carnitine palmitoyl transferase. These identified proteins involved in many cellular activities like maintain cellular integrity, iron transport, free radical scavenging activity and β oxidation of fatty acids. These results were given more information about antioxidant activity of extracts	Sundari et al., 2013
Antidiabetic	Flower head (Ethanolic)	They found that blood glucose level was reversal near to control values by treatment with insulin, S. indicus, however, the effect of maximum dose 300 mg/kg was closer to insulin as compared to minimum dose (200 mg/kg).	Kannojia et al., 2007
	(Alcoholic)	Fasting normal rats treated with the alcoholic extract of S. indicus showed significant improvement in oral glucose tolerance test.	Prabhu et al., 2008
	Flower (Petroleum ether, chloroform, alcoholic and aqueous)	Petroleum ether, chloroform, alcoholic and aqueous extracts of flowers of Sphaeranthus indicus showed significant antidiabetic results.	Pramod et al., 2008
	Flower head (Petroleum ether)	The oral administration of flower head extract at dose of 200 mg/kg lead to a significant blood glucose reduction.	Jha et al., 2010
	Aerial part (Ethanol)	S. indicus increased the uptake of glucose by isolated rat hemi-diaphragm significantly and was found to be more effective than insulin.	Pareek et al., 2010
	(Methanol)	The S. indicus extract showed significant decrease in plasma glucose and serum triglyceride levels at doses, of 400 and 800 mg/kg, p.o. and stimulated insulin assisted and non-insulin assisted glucose uptake in skeletal muscle. The extract significantly restored dexamethasone induced body weight loss thereby suggesting its effect in the treatment of type II diabetes mellitus	Ghaisas et al., 2010
	Root (Ethanolic)	Administration of ethanolic extract of Sphaeranthus indicus root (EESIR) 100 and 200 mg/kg to the STZ-induced diabetic rats showed significant reduction in blood glucose and increase in body weight compared to diabetic control rats.	Ramachandran et al., 2011
	(Methanolic)	The extract at the dose of 300 mg/kg body weight significantly reduced the blood glucose level, plasma total cholesterol, triglycerides and low density lipoprotein (LDL) in treated rabbits as compared to diabetic rabbits; also significantly increased the level of high density lipoprotein (HDL) (36.95 ± 2.95); SGOT and SGPT also significantly decreased.	Muhammad et al., 2011
	Flower (Ethyl acetate, methanolic and hydroalcoholic)	Ethyl acetate, methanolic and hydroalcoholic extracts of flower of S. indicus, given orally at doses of 200 mg/kg/day for 15 days, were found to be produced significant antihyperglyceamic action in alloxan induced diabetic rats	Kharkar et al., 2013
Anti - ulcer activity	whole plant	The antiulcer activity was significant with the test extracts. In aspirin	Malairajan et al.,

	(ethanol)	plus pylorus ligation method ALSI pretreated animal showed significant reduction in gastric volume, free acidity, total acidity, and ulcer index. The ulcer protection of the extract was found to be 82.9% and 85.3%, whereas the standard drug ranitidine showed 92.6%).	2013
Inhibit hyaluronidase	Extract	The extract of the S. indicus was found to inhibit hyaluronidase.	Nanba et al., 1995
Haemolytic activity	Flowers (total aqueous)	The haemolytic activity was found to be a dose dependent. Highest lysis was seen in the R.B.Cs. treated with extract of S. indicus.	Patole and Mahajan, 2004
	Flowers (semi alkaloidal fractions)	SiN showed moderate activity at a dose 500 and 1000 µg/ml (74.67%) and (100.5%) respectively as compared with D.W. control group. However, the fraction obtained from it, SiJ, showed highest lysis in the R.B.Cs 145.5% and 170.5% at a dose 100 and 200 µg/ml respectively. Whereas, SiR, the fraction obtained from SiJ exhibit lowest activity 22.56%, 22.56% and 86.36% at a dose 100, 200 and 300 µg/ml respectively as compared with SiN, SiJ and D.W. control group.	Nemade et al., 2010
Haemostatic effect	Flower (Alcoholic)	Alcoholic extract of S. indicus exhibited hypotensive, peripheral vasodilatory and cathartic activities.	Srivastwa et al., 1971
Immunostimulatory activity	Flower (sesquiterpene glycoside, Sphaeranthanolide)	The compound exhibited immune stimulating activity.	Shekhani et al., 1990.
	Flower heads (Methanolic)	Significant stimulation with respect to these parameters was obtained with methanol extract, it's petroleum ether and remaining methanol fraction while benzene, chloroform fractions showed insignificant changes.	Bafna and Mishra, 2004
	Flower heads (Bioactive fraction)	Bioactive fraction of S. indicus acts as potentiator of DTH	Bafna and Mishra, 2006
	Flower heads (petroleum ether)	The drug shows good promise as an immunomodulatory agent, which acts by stimulating both humoral and cellular immunity as well as phagocytic function.	Bafna and Mishra, 2007
Antihyperlipidemic activity	(Aqueous)	Significant decrease in serum TC, TG, LDL, VLDL and there was no significant change in the level of HDL. Atherogenic index also reduced significantly.	Tenpe et al., 2008
	Flower heads (Alcoholic extract)	Marked decrease in body weight, total cholesterol, triglyceride, and low-density lipoprotein and very low density lipoprotein whereas significant increases in the level of high-density lipoprotein were obtained after treatment with Sphaeranthus indicus extract.	Pande and dubey, 2009
	Root (Ethanolic)	Administration of ethanolic extract of Sphaeranthus indicus root (EESIR) 100 and 200 mg/kg to the STZ-induced diabetic rats showed significant ($P < .01$) alteration in elevated lipid profile levels than diabetic control rats.	Ramachandran et al., 2011
Anti-allergic activity/Mast cell stabilizing effect	Whole plant (Ethanol, petroleum ether, ethyl acetate and water)	These extracts also showed better mast cell stabilizing activity (77-88%) than the standard drug (69%) when peritoneal mast cells were treated with compound 48/80.	Mathew et al., 2009
Wound healing	Aerial parts (Ethanolic)	The surface area of the 2.5 and 5% S. indicus treated wound was reduced by 94 and 98% on the day 16th as compared to control (89%) was found to be significant. Tensile strength was found significant than control. No change in DNA, Vitamin C and Glucosamine content were found, whereas protein, RNA and hydroxyproline content increase significantly.	Sadaf et al., 2006
	Flower head (Ethanol)	Based on the comparison of wound healing activity of various formulations, the formulation comprising of 2% (w/w) alcoholic extract of flower head of sphaeranthus indicus found to be superior to that of control and standard formulation. In addition to greater	Jha et al., 2009

		hydroxyproline content found in healed wounds as compared to control and standard formulation	
	Flower (Alcoholic)	The contraction rate increased in SiE II group of animals compared with SiE I and control group of animals, which was significant and statistically showed dose dependent activity.	Chopda et al., 2010
Efficacy in cervical erosion with cervicitis	Flower (Powder+water)	In the test group, 8 (26.7%) patients demonstrated complete healing of erosion, where as none of the patient had healing in the control group with P < 0.05, statistically significant.	Hashmi et al., 2011
Effect on psoriasis	Standardized extract	The significant effect of S. indicus on psoriasis.	Sharma, 2010
Anti-inflammatory	Root (Aqueous)	S. indicus caused a smaller, still significant suppression of ROS. In the case of proinflammatory cytokine-induced monocytes, maximum suppression was shown by Azadirachta indica and S. indicus. Thus this herb shows anti-inflmmatory activity by suppressing the capacity of P. acnes-induced ROS and pro-inflammatory cytokines, the two important inflammatory mediators in acnes pathogenesis.	Jain and Basal 2003
	whole parts (Petroleum ether, Benzene, Chloroform, Ethanol and triple distilled water)	The ethanol and petroleum ether extracts showed significant (p<0.05) anti inflammatory activity in both doses, 200mg/kg and 400mg/kg body weight from 1 hour onwards as compared to the standard drug diclofenac sodium, where as aqueous extracts exhibit activity from 2 hours onward as compared to the standard drug amongst various extracts.	Nanda et al., 2010
	Fruit [Sesquiterpene lactone, 7-hydroxyfrullanolide (7HF)]	7HF significantly and dose-dependently diminished induced and spontaneous production of TNF-α and IL-6 from freshly isolated human mononuclear cells, synovial tissue cells isolated from patients with active rheumatoid arthritis and BALB/c mice. Collectively, these results provide evidence that 7HF-mediated inhibition of pro-inflammatory cytokines functionally results in marked protection in experimental models of acute and chronic inflammation.	Fonseca et al., 2010
	Leaves (Ethanolic)	The extract in different doses (100, 200 and 400 mg/kg, p.o.) exhibited dose dependent and significant anti-inflammatory activity in acute (carrageenan induced hind paw edema, P < 0.05) and chronic (cotton pellet granuloma formation, P < 0.05) model of inflammation.	Meher et al., 2011.
	Flower (Ethanolic)	At the end of one hour the inhibition of paw edema was 42.66 and 50.5% at doses of 300 and 500 mg/kg respectively. Flower of S. indicus has significant anti-inflammatory action	Ali et al., 2011
	Flowering and fruiting heads [Standardized herbal extract (NPS31807)]	NPS31807 treatment reduced levels of pro-inflammatory cytokines from human macrophages and activated epidermal keratinocytes in a dose dependent manner. In summary, NPS31807, an extract from Sphaeranthus indicus can be used as therapeutic option in inflammatory and auto-immune conditions such as psoriasis.	Chakrabarti et al., 2012
Antipyretic activity	Whole parts (Petroleum ether, Benzene, Chloroform, Ethanol and triple distilled water)	The chloroform and ethanol extracts showed potential significant antipyretic activity from 1 h onward whereas aqueous extracts exhibited activity from 2 h onward as compared to the standard drug paracetamol amongst various extracts	Nanda et al., 2009.
Analgesic activity	Whole parts (Petroleum ether, Benzene, Chloroform, Ethanol and triple distilled water)	The petroleum ether, chloroform and ethanol extracts showed significant (p<0.001 & p<0.01) analgesic activity in both doses, 200mg/kg and 400mg/kg body weight from 1 hour onwards as compared to the standard drug diclofenac sodium.	Nanda et al., 2009.
	Whole plant (Ethanol)	The ethanol extracts of the whole plant S. indicus Linn. exhibited dose dependent analgesic activity with 66.6 and 67.4% of protection	Malairajan et al., 2012
	leaves (ethanolic)	The ethanolic extract S. indicus in different doses (100,200, and 400mg/kg, p.o) exhibited dose dependent and significant analgesic	Meher et al., 2011

		activity in both models of pain.	
	Flower (Ethanolic)	At the end of one hour the percentage of protection from writhing was 62.79 and 68.21 at doses of 300 and 500 mg/kg respectively.	Ali et al., 2011
Nephroprotective activity	Entire plant (Ethanol)	The findings suggest that the ethanol extract of S. indicus possesses nephroprotective activity with minimal toxicity and could offer a promising role in the treatment of acute renal injury inflicted by adverse effects of drugs like gentamicin.	Srinivasan et al., 2008
	Entire plant (Ethanol)	The extract significantly reduced the elevated serum creatinine and urea levels. Renal antioxidant defence systems, such as superoxide dismutase, catalase, glutathione peroxidase activities and reduced glutathione level that are depleted by cisplatin therapy were restored to normal by treatment with the extract.	Mathew et al., 2012
Attenuating effect on prostatic hyperplasia	Flower head (Petroleum ether, ethanolic and aqueous)	The petroleum ether extract exhibited the best activity, although the ethanol and aqueous extracts also exhibited significant activity. Urine output was also improved significantly.	Nahata and Dixit, 2011
Antiarthritic activity	Flower (Petroleum ether)	The petroleum ether extract of S. indicus at a dose of 100mg/day p.o. showed significant antiarthritic activity.	Badgujar et al., 2009
Antioxidant activity	Underground portion (Ethanolic)	The ethanolic extract at 1000 µg/ml showed maximum scavenging of the radical action, 2,2-azinobis-(3-ethylbenzothiazoline-6-sulphonate) (ABTS) observed up to 41.99% followed by the scavenging of the stable radical 1,1-diphenyl, 2-picryl hydrazyl (DPPH) (33.27%), superoxide dismutase (25.14%) and nitric oxide radical (22.36%) at the same concentration. However, the extract showed only moderate scavenging activity of iron chelation (14.2%). However, the extract showed only moderate scavenging activity of iron chelation (14.2%). Total antioxidant capacity of the extract was found to be 160.85 nmol/g ascorbic acid.	Shirwaikar et al., 2006
	Flower heads (Aqueous and methanolic)	Methanolic extract exhibited a significant effect showing increasing levels of superoxide dismutase (SOD), catalase (CAT), and glutathione peroxides (GPx) by reducing malondialdehyde (MDA) levels.	Tiwari and khosa, 2009
	Underground portions (Aqueous)	The Inhabitory Concentration (IC_{50}) in all models viz. ABTS, DPPH, superoxide dismutase, nitric oxide and iron chelating, were found to be 26.21, 24.95, 17.74, 10.63 and 9.62 respectively. Total antioxidant capacity of extract was found to be 127.85 nmol/g ascorbic acid.	Prabhu et al., 2009
	Root (Ethanolic)	Administration of ethanolic extract of Sphaeranthus indicus root (EESIR) 100 and 200 mg/kg to the STZ-induced diabetic rats produced significant increase in superoxide dismutase (SOD), catalase (CAT), glutathione peroxidase (GPx) and decrease in thiobarbituric acid reactive substances (TBARS) levels than diabetic control rats. Administration of EESIR 200 mg/kg produced significant ($P < .01$) higher antioxidant activity than EESIR 100 mg/kg.	Ramachandran et al., 2011
	Stems and leave s (Methanol)	At the dose of 1ml/kg, CCl_4 induced liver damage in rats as manifested by statistically significant increase in serum alanine amino transferase (ALT), aspartate amino transferase (AST) and alkaline phosphatase (ALP). Significant decrease in total protein and antioxidant levels of SOD, CAT and GST were also noted in the liver injured rats.	Mathews et al., 2012
	Leaf, flower, stem, root (Methanolic)	Among the extracts tested flower and leaf extracts were exhibited highest scavenging activity at 150 µg/ml concentrations.	Krishna et al., 2013
Anticancer	Flower head (Petroleum ether, ethanolic, and aqueous)	Potent cytotoxicity was noted in petroleum ether extract of S indicus (SIP), which inhibited proliferation of various cancer cell lines.	Nahata et al., 2013

On the basis of traditional uses and experimental work number of Pharmaceutical companies manufactures some drugs and market them, some of them are mentioned hereunder,

Table 3: Pharmaceutical companies manufacture some drugs using S. indicus

Sr. No.	Name of product	Name of manufacturer	Indications
1.	Sarsi	Patiala Ayurvedic Pharmacy, Sirhind, Punjab, India.	Skin diseases
2.	Divya Mahamanjishtharistha	Baba Ramdev Medicine, Haridwar, India.	Blood purifier in Eczema, psoriasis and skin diseases
3.	Raktashodhak Bati	Shree Baidyanath Ayurved Bhawan Private Limited Jhansi, Uttar Pradesh, India.	Blood purifier in Eczema and skin diseases
4.	Strikalp capsule	Surya Herbal Ltd Noida, Uttar Pradesh, India.	Weakness, backache, anemia, leucorrhoea, calcium deficiency
5.	Punarnnavadi Choornam	GK Ayurvedic Medicine, Moolad, Kozhikode, India	Urinary tract infection and as diuretic
6.	Panchjeeraka Gudam	Chamakkatt Herbal Products, Thrissur, Kerala, India.	Bronchial and asthmatic complains, fever, Hiccup
7.	Kadukkai Legiyam	Aravindh Herbal Labs (P) Limited, Mudangiar road, Rajapalayam, India.	Constipation, gas trouble, laxative, ulcer
8.	Muscle Pain Relief oil	Renovision Exports Pvt. Ltd., Patana, India.	Muscle pain relief
9.	Shiva Gutika	Bhardwaj Ayrvedic Pharmacy, Indoor, India.	Good rejuvenator, tuberculosis, vaginal disorder, malignancy of liver
10.	B-kleen- Blood Purifier	Shelter Pharma Ltd., Ahmedabad Gujarat, India.	Acne,Repetitive mouth ulcer, diseases due to impurities in blood
11.	Mahamanjishta Rista	Planet Ayurveda Wellness Center and Spa.	Skin disorders like eczema, soriasis and dermatitis
12.	Himalaya Geriforte	Himalaya Drugs, Mangaluru, India.	Daily health tonic, Geriatric stress, stress related anxiety
13.	Goitre Drug	Shilpachem, Indore, India.	Goitre specifically due to hyporthyrodism & of non-toxic nature & others
14.	Diabecon	Himalaya Drugs, Mangaluru, India.	Promotes ß-cell repair/regeneration
15.	Maha vishgarba Oil	Bhardwaj Ayrvedic Pharmacy, Indoor, India.	Sciatica pain, severe paralytic conditions of total body, convulsions, neuropathy and in all joint and muscle disorders.
16.	Somalipure	Somax Pharmaceuticals Private Limited , Kharar, India.	Skin troubles, blood purifier
17.	Unjha Rakat Shodhak Sarbat	Unjha Pharmaceuticals pvt. Ltd., Thaleja, Ahmedabad. (Gujarat) India.	Boils, impetigo, scabies, itching, urticaria, pimples, acne, mouth ulcers, darkening of body skin.
18.	Safi	Hamdard Laboratories (WAQF) Bangladesh.	Boils, pimples, skin problems, constipation
19.	Arter Care	Herbal Supplements Care, Flushing, NY, USA	Cardio enricher
20.	Acne Tablets	Super care products Manchester, United Kingdom	Acne
21.	Himalaya, Derma care	Himalaya, USA	Skin diseases
22.	Anti-Gout pack-Herbal remedies for Gout	Planer Ayurveda	Gout and high uric acid

23.	Meratrim	RE-BODY	Safe and effective for weight management.

Very extensive work on this plant is carried out on pharmacological activities, however, some other allied activities of this plant were also worked by scientist and prove this plant as a medicinal plant, the details are summarized below:

Table 4: Some other allied activities of S. indicus were also worked by scientist

Name of activity	Plant part used (Extract)	Observation	Reference
Bactericidal activity	Leaves (Aqueous)	Under in vitro test , the crude extrac , at a concentration of 0.5% inhibited the growth of Ralstonia solanacearum. Under field conditions, extract significantly reduced the disease incidence and the population of Ralstonia solanacearum in the soil.	Suprapta et al., 2003
Insecticidal	Flower (Aqueous)	The aqueous extract of S. indicus was found toxic to invertebrate animals like insects Cockroach (Periplaneta americana), the stored grain pests viz. Pulse beetle (Callosobruchus chinensis), Rice weevil (Sitophilus oryzae)	Patole et al., 2008
	Whole plant (Acetone)	At 3% concentration of acetone extract of S. indicus showed highest mortality (90%) of Callosobruches maculates	Singh and Shrivastava, 2012
	Whole plant (Hexane, chloroform, ethyl acetate)	Maximum mortality (34%) was observed in chloroform extract.	Pugazhvendan et al., 2012
Biocidal	Flower (Aqueous)	It was toxic to invertebrate animals like insects, Cockroach, the stored grain pests Pluse beetle, rice weevil, Mosquito larvae, House fly larvae, crab and aquatic vertebrates like tadpole larvae of frog, fresh water fish species viz. Naemacheilus evezardi Day, Naemacheilus sinuatus Peters, Lepidocephalichthys guntea Ham-Buch and Lebistus reticulatus Peters.	Patole et al., 2008
Larvicidal	Whole plant (Petroleum ether purified fraction)	Purified fraction showed toxic effect to the second and fourth instar larvae of Culex Quinquefasciatus ranging from 100 to 500 ppm concentrations. Fourth instar larvae are more susceptible than the second instar larvae. The extract also showed pupal intermediates and half acdysed.	Sharma and Saxena, 1996
	Leaves and roots (Acetone)	Root extract caused more than 50% mortality in all early instars, exhibiting more toxic potential than the leaf extracts	Hameed at el., 2003
	Leaf	The mortality rate of each instar increased with an increase in leaf extract concentration, where 750 and 1000 ppm caused 20-60 % and 50-80 % mortality respectively.	Hameed et al., 2003
	Flower (Total aqueous)	Potent larvicidal activity 66.67% at high dose (50mg/ml) was detected in S.indicus extract.	Patole and Mahajan, 2007
	Whole plants (Hexane, diethyl ether, dichloromethane and ethyl acetate)	Potent larvicidal activity of Hexane 590.06; Diethyl ether 838.35; Dichloromethane 1311.98; Ethyl acetate 526.50 ppm respectively.	Arivoli et al., 2012
	Whole plant (Hexane, diethyl ether, dichloromethane and ethyl acetate)	The ethyl acetate extract of Sphaeranthus indicus (201.11ppm) was found to be effective	Tennyson et al., 2012
	Whole plant (Hexane, diethyl ether, dichloromethane	In diethyl ether, dichloromethane and ethyl acetate extracts of Sphaeranthus indicus, 100 per cent mortality was recorded after 48 h exposure.	Tennyson et al., 2012

	and ethyl acetate)		
	Leaf (hexane, chloroform and ethyl acetate)	LC_{50} values of hexane, chloroform and ethyl acetate extracts were 544.93, 377.86 and 274.79 ppm and LC_{90} values were 1,325.32, 1,572.55 and 1,081.29 ppm at 24 h respectively.	Kovendan et al., 2012
	Whole plant (Flavonoid)	Flavonoid extract of S. indicus proved to be a very effective mosquito larvicide.	Saxena et al., 2013
Piscicidal	Flower (Total aqueous extract)	Extract showed the significant pisicidal activity.	Patole et al., 2004

Not only the pharmacological and allied activities, workers can work on its use in agricultural field too. Some experimentally proved Agricultural activities of this plant are summarized below:

Table 5: Some experimentally proved Agricultural activities of S. indicus

Name of activity	Plant part used (Extract)	Observation	Reference
Direct Organogenesis	Leaf explants	A rapid multiplication rate could be obtained from leaf explants by combining the hormones, BA and IAA. This protocol has great potential for rapid multiplication and conservation of S. indicus.	Yarra et al., 2010
Effect on urea hydrolysis and nitrification in soils	Flowers	The process of nitrification was slightly inhibited. S. indicus treatments proved to be the effective for reducing N losses.	Ahmedani et al., 2007
Effect on seed germination and early seedling growth	Capitula (Petroleum ether)	Germination per cent and seedling growth were decreased with increase in concentration of extract.	Lodha , 2004
Nematicidal	Dried fruit (Methanolic)	Methanolic extract of S. indicus exhibited nematocidal activity.	Ali et al., 1991
Antifeedant	Aerial parts (Fraction isolated from petroleum extract)	Antifeedant activity was noted at 0.05% concentration when beetles were exposed to treated seeds of green gram (Vigna radiata).	Baby, 1994
	(Compounds isolated from methanolic extract)	7-hydroxyfrullanoide had the highest antifeedant activity.	Ignacimuthu, 2006
	Whole plant (Hexane, Diethyl ether, Dichloromethane and Ethyl acetate)	Hexane extract of S. indicus showed the 25% antifeedant activity.	Arivoli and Tennyson, 2013
Repellent activity		They found significant repellent activity.	Tiwari and Saxena, 1993
	Aerial parts (Fraction isolated from petroleum extract)	Isolated fraction showed strong repellent activity of 0.01% concentration on filter paper.	Baby, 1994
	Flowers (Aqueous, alcoholic and	The alcoholic extract was most effective than other extract treated.	Patole et al., 2008

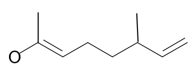
	acetone extracts)		
	Whole plant (Hexane, chloroform, ethyl acetate)	Repellant activities of ethyl acetate extract of S. indicus at 2.5% was - 0.65 at 6 hr.	Pugazhvendan et al., 2012
Oviposition	Flowers (Aqueous, alcoholic and acetone extracts)	The alcoholic extract was most effective than other extract treated.	Patole et al., 2008
	Whole plant (Hexane, Diethyl ether, Dichloromethane and Ethyl acetate)	S. indicus showed no oviposition activitiy.	Arivoli and Tennyson, 2013
Ovicidal activitiy	Flowers (Aqueous, alcoholic and acetone extracts)	The alcoholic extract was most effective than other extract treated.	Patole et al., 2008
	Whole plant (Hexane, Diethyl ether, Dichloromethane and Ethyl acetate)	S. indicus showed 25-50% ovicidal activity.	Arivoli and Tennyson, 2013

Chemistry

The essential oils of flowers, roots and herb (stems with leaves) of Sphaeranthus indicus Kurz. (Asteraceae) from southern India were investigated by gas chromatographic-spectroscopic (GC-FID and GC-MS) and olfactoric methods to identify those compounds responsible for the characteristic odor as well as partly for the folk medicinal use of this plant. More than 95 volaliles were found to be constituents of the three essential S. indiciis oils with following composition of main components: flower oil: β-eudesmol (21.4%), 2,5-dimethoxy-p-cymene (16.2%), β-caryophyllene (7.8%), τ-cadinol (7.2%). caryophyllene oxide (6.9%) and α-eudesmol (4.5%); root oil: 2,5-dimethoxy-p-cymene (28.3%), τ-cadinol (25.3%), (Z)-arteannuic alcohol (10.1%), β-maaliene (3.9%) and caryophyllene oxide (3.1%): herb oil: 2,5-dimethoxy-p-cymene (27.0%), τ-cadinol (12.5%), β-eudesmol (9.1%), α-eudesmol (7.0%) and caroyphyllene oxide (4.7%). In addition, the odor impressions of the samples are described and the possible use of the essential Sphaeranthus indicus oils in medicinal, cosmetic and food flavoring discussed by Jirovetz et al., 2003. Apart from this researchers not stop their work to this end, they also search out the active ingredients present in it. It is seen from published data, isolated products are terpenoids, flavonoids and steroids. These diverse groups of natural products are reported in literature by various authors. No report appeared in literature on the various biological activities except antimicrobial, immune stimulating, anticancer and antitumor activities of the flower of S. indicus, though these compounds are present in it. The detail of such isolated compounds is stated in Fig. 1.

Essential oil, obtained by steam distillation of the whole herb, contain ocimene (1), α-terpinene (2), methylchavicol (3), α-citral (4), geraniol (5), α-ionone (6), β-ionone (7), δ-cadinene (8), p methoxycinnamaldehyde (9) (Baslas, 1959). The alcoholic extract of powdered drug contains stigmasterol (10), β-sitosterol (11), hentriacontane (12), n-triacontanol, sesquiterpene lactone (Gogate et al., 1986). In 1988 Sohoni et al., isolated sesquiterpene lactone, 2-hydroxycostic acid (13), β-eudesmol (14) and known ilicic acid (15). Rahman et al., (1989) isolated antimicrobial sesquiterpene lactone, 7-hydroxyfrullanolide (16). A sesquiterpen glycoside, sphaeranthanolide (17) having immune stimulating activity has been isolated from ethanolic extracts of flowers of S. indicus and its chemical nature is 7- hydroxylated eudesmanolides (Shekhani et al., 1990). Three new eudesmanolides, 11α,13-dihydro-3α,7αdihydroxyfrullanolide (18); 11α,13-dihydro-7α, 13-dihydroxyfrullanolide (19) and 11α,13-dihydro-7α-hydroxy-13-methoxyfrullanolide (20) were isolated from flowers 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 comparision to that of 7-hydroxyfrullanolide indicated that they are all eudesmanolides. The molecular ions are confirmed by Fast Atom Bombardment Mass Spectroscopy (FABMS) and Field Desorption Mass Spectrometry (FDMS) (Shekhani et al., 1991). From ethanolic extract of flowers of S. indicus, Shah (1991) isolated 7α-Hydroxyeudesm-4-en-6,12-β-olide (21) an anticancer, antifungal and antimicrobial compound and another known compounds Caryophyllene-α-oxide (22) and 24S-stigmsta-5,22E-dien-3β-ol (23) detected for the first time from S. indicus. Rojatkar and Nagasampagi (1992) isolated two new eudesmanolides (24 and 25) and two sesquiterpenoids, cryptomeridiol (26) and 4-epicryptomeridiol (27) from S. indicus. A sesquiterpene lactone, 7α- hydroxyfrullanolide showed pronounced cytotoxicity and antitumor activity against a number of human cancer cell lines. Microorganisms have been utilized to modify the structures of a number of naturally occurring bioactive compounds. Microbial transformations resulted by Aspergillus species of 7α- hydroxyfrullanolide yielded 7α-hydroxyl-11, 13-dihydroxyfrullanolide (28) and 13-acetyl-7α- hydroxyfrullanolide (29) and their structures were determined spectroscopically (Rahman et al., 1994). After the photo-oxidation of 7-hydroxyeudesmanolide (30) a 5α, 7-dihydroxyeudesmanolide (31) have been obtained (Rojatkar et al., 1994). A flavones glycoside, 7-hydroxy-3',4',5,6-tetramethoxy flavones, 7-o-β-D-(1-4)-diglucoside (32) was obtained from stems (Yadav and Kumar, 1998). Isoflavonoid, 5,4'-dimethoxy-3'-prenylbiochanin 7-O-β-D-galactoside (33) isolated from the leaves of S. indicus, acid hydrolysis of this compound gave 5,4'-dimethoxy-3'-prenylbiochanin 6 (34) and galactose. Permethylation followed by acid hydrolysis yielded 3'-prenyl-5,4',5'-trimethoxy-7-hydroxyisoflavone (35) (Yadava and Kumar, 1999). Chemical investigation of acetone extract of S. indicus has led to the isolation of three eudesmanoids and their structures have been established as 11α,13-dihydro-3α,7α-dihydroxy-4,5-epoxy-6β,7-eudesmanolide (36); 11α,13-dihydro-7α-acetoxy-3β-hydroxy-6β,7-eudesm-4-enolide (37) and 3-keto-β-eudesmol (38) by spectral methods (Pujar et al., 2000). A eudesmanolide, 2α-7α-dihydroxy-4-en-11,13-dihydroeudesmen-6,12-olide (39) has been isolated from the aerial part of S. indicus. The structure and stereochemistry of compound has been established by detailed spectral analysis and comparison of this compound with 11α,13-dihydro-3α,7α-dihydroxyfrullanolide (18) and 2α-hydroxycostic acid (13) (Jadhav et al., 2004). Two eudesmanolides have been isolated from the aerial part of S. indicus and their structures have been established as 11α,13-dihydro-3α,7α-dihydroxyeudesm-4-en 6α,12-olide (40), this compound having trans lactone ring in 7-hydroxyeudesmanolide for the first time in this plant extract. Another compound 4-en-6β, 7α-eudesmanolide (41) is very rare having 6β, 7α lactone ring junction in the eudesmanolide skeleton (Jadhav et al., 2007). A flavonoid C-glycoside, 5-hydroxy-7-methoxy-6-C-glycosylflavone (42) together with eight known compounds, namely n-pentacosan, hentriacontane, n-triacontanol, β-sitosterol, stigmasterol, β-D-glucoside of β-sitosterol, sphaeranthine and a phenolic glycoside ($C_{22}H_{26}O_{12}$) were isolated from the aerial part of S. indicus (Mishra et al., 2007).

Active principles isolated from S. indicus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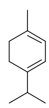
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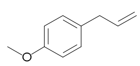
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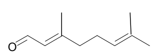
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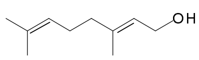
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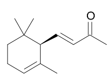
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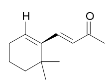
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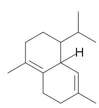
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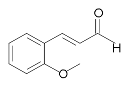
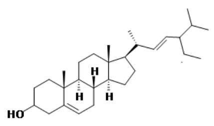
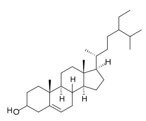


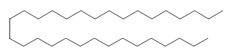
Pmethoxycinnamaldehyde (9)



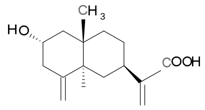
Stigmasterol (10)



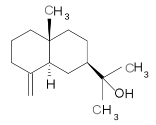
β-sitosterol (11)



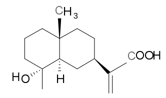
Hentriacontane (12)



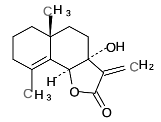
2-Hydroxycostic acid (13)



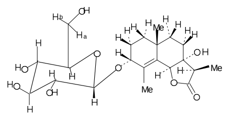
β-
Eudesmol (14)



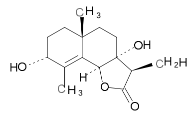
Ilicic acid (15)



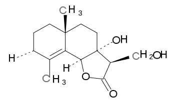
7-
hydroxyfrullanolide (16)



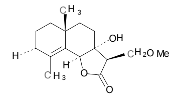
Sphaeranthanolide (17)



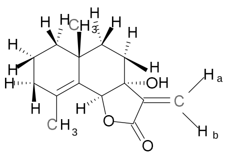
11α, 13-dihydro-3α,7α-dihydroxyfrullanolide (18)



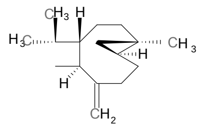
11α,13-dihydro-7α,13-dihydroxyfrullanolide (19)



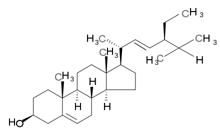
11α, 13-dihydro-7α-hydroxy-13-methoxyfrullanolide (20)



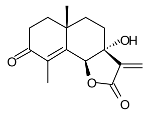
7α-Hydroxyeudesm-4-en-6,12-β-olide (21)



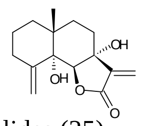
Caryophylline α-oxide (22)



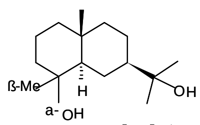
24S-Stigmsta-5,22E-dien-3β-ol (23)



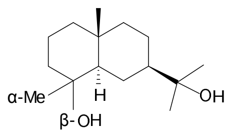
eudesmanolides (24)



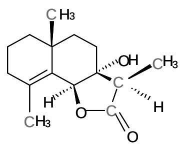
eudesmanolides (25)



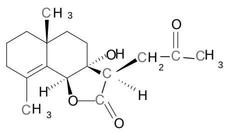
Cryptomeridiol (26)



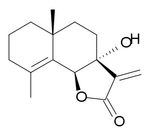
4-Epicryptomeridiol (27)



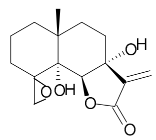
7α-hydroxy-11,13-dihydroxyfrullanolide (28)



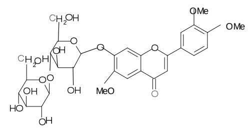
13-acetyl-7α-hydroxyfrullanolide(29)



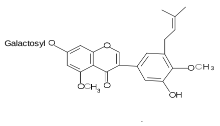
7α-hydroxyeudesmanolide (30)



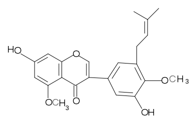
5α, 7-dihydroxyeudesmanolide (31)



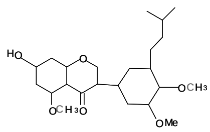
7-hydroxy-3’,4’,5,6-tetramethoxy flavones, 7-o-β-D-(1-4)-diglucoside (32)



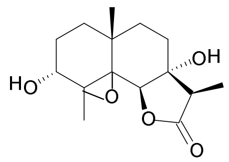
5,4’-dimethoxy-3’-prenylbiochanin 7-O-β-D-galactoside (33)



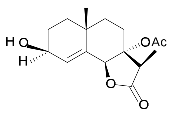
5,4’-dimethoxy-3’-prenylbiochanin 6 (34)



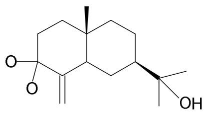
3’-prenyl-5,4’,5’-trimethoxy-7-hydroxyisoflavone (35)



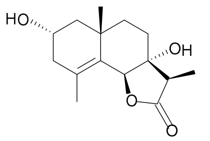
11α,13-dihydro-3α,7α-dihydroxy-4,5-epoxy-6β,7- Eudesmanolide (36)



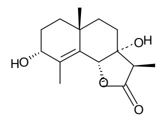
11α,13-dihydro-7α-acetoxy-3β-hydroxy-6β,7-eudesm-4-enolide (37)



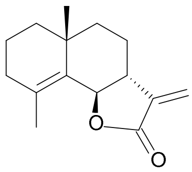
3-keto-β-eudesmol (38)



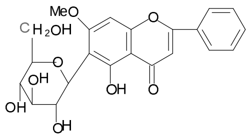
2α-7α-dihydroxy-4-en-11,13-dihydroeudesmen-6,12-olide (39)



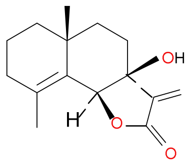
11α, 13-dihydro-3α, 7α-dihydroxyeudesm-4-en 6α, 12-olide (40)



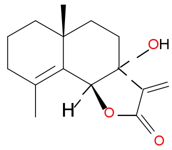
4-en 6β, 7α-eudesmanolide (41)



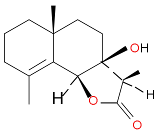
5-hydroxy-7methoxy-6-C-glycosylflavone (42)



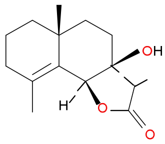
Lactone 1(43)



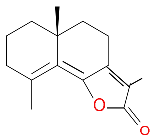
Lactone 2 (44)



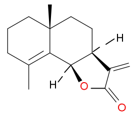
Lactone 3 (45)



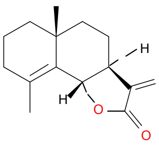
Lactone 4 (46)



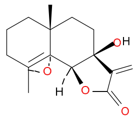
Lactone 5 (47)



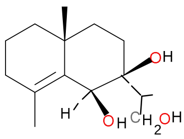
Lactone 6 (48)



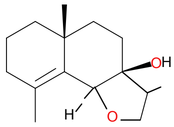
Lactone 7 (49)



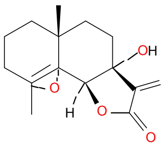
Lactone 8 (50)



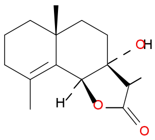
Lactone 9 (51)



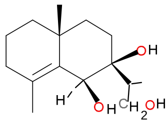
Lactone 10 (52)



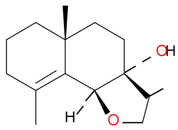
Lactone 11 (53)



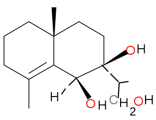
Lactone 12 (54)



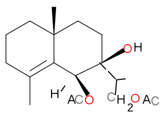
Lactone 13 (55)



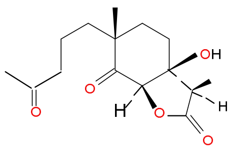
Lactone 14 (56)



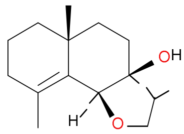
Lactone 15 (57)



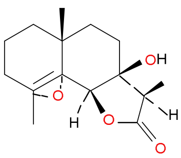
Lactone 16 (58)



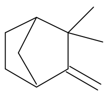
Lactone 17 (59)



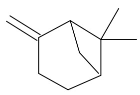
Lactone 18 (60)



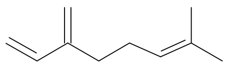
Lactone 19 (61)



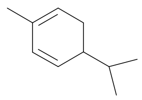
Camphene (62)

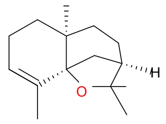


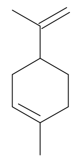
β-Pinene (63)

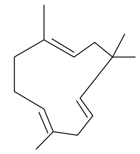


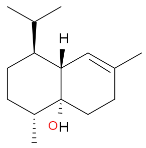
Myrcene (64)

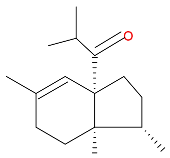

αPhellandrene (65)

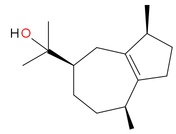

αAgarofuran (66)

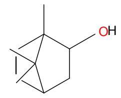

Limonene (67)

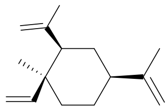

αHumulene (68)

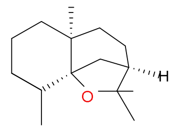

Cubenol (69)

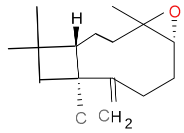

Indipone (70)

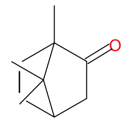

Guaiol (71)

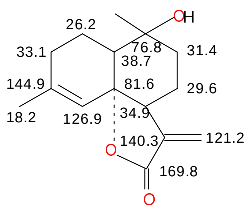

Borneol (72)

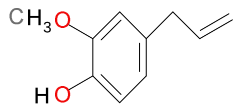

β-Elemene (73)

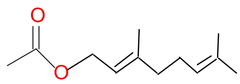

Dihydroagarofuran (74)

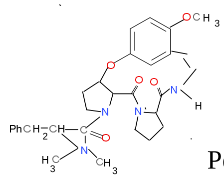

Caryophyllene oxide (75)


Camphor (76)


Sesquiterpene lactone (77)


Eugenol (78)


Geranyl acetate (79)


Peptide alkaloid (80)

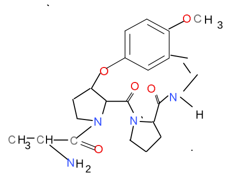

Peptide alkaloid (81)

Fig. 1 Active principles isolated from S. indicus

The chloroform extract was found to contain three crystalline sesquiterpene lactones [1, 2, and 3(43,44,and 45)] all with an unusually located tertiary hydroxyl group. Two of the lactones (1 and 2) also contained α-methylene-γ-lactone moiety and third (lactone3) was a saturated lactone with a methyl group. On catalytic hydrogenation of lactone 1 in ethanol over PtO_2 it absorbed one mol of hydrogen to give a crystalline dihydro- γ-lactone [lactone 4,(46)]. Treatment of lactone 4 with $POCl_3$ and pyridine resulted in a mixture of products, from which via chromatography an unexpected but conspicuous, known, trienelactone [lactone 5(47)] with high laevorotation was obtained and characterized. Similarity of the chemical shift of the C-10 methyl protons in 1 and those of the model compounds (lactone 6(48)] and (lactone 7(49)] (β-stereochemistry) indicated that the C-10 methyl in lactone 1 had β-stereochemistry. The lactone 1 on treatment with 1 mol of perbenzoic acid at 0^o in chloroform yielded a crystalline monoepoxide (lactone 8(50)]. Lactone 4 on reduction with lithium aluminium hydride (LAH) gave a crystalline triol (lactone 9(51)]. The triol (lactone 9) on treatment with p-toluenesulphonyl chloride and pyridine did not give any tosyl derivative, instead the oxide (lactone 10(52)] was obtained, on prolonged heating on a water-bath. The signal of the C-6 proton in the PMR spectra of lactone 2 and of its various derivatives such as the monoepoxide (lactone11(53)], dihydro derivatives (lactone 12(54)], triol (lactone 13(55)] and oxide (lactone 14(56)] were closely similar to that of lactone 1 and its corresponding derivatives. On reduction (LAH/THF) lactone 3 gave a triol (lactone 15(57)] which on acetylation (Ac_2O/Py) gave a complex mixture, from which the diacetate (lactone 16(58)] was isolated. The lactone 3 yielded a ring-cleaved lactone 17 (59) on ozonolysis. After crystallization of triol (lactone 15) oxide (lactone 18(60)] was formed. Lactone 19 (61), monoepoxide was prepared from lactone 3 (Gogte et al., 1986). The hydro distilled essential oil of S. indicus was analyzed by gas chromatography (GC) and GC/mass spectrometry. Thirty-eight compounds making up 84.0% of the oil were identified. The major compounds were: 2,5-dimethoxy-ρ-cymene (18.2%), α-agarofuran (11.8%) (66), 10-epi-γ-eudesmol (7.9%) and selin-11-en-4α-ol (12.7%). Other detected compounds were (Z)-3-hexenol, (E)-2-hexenol, α-pinene, camphene (62), 6-methyl 5-hepten-2-one, β-pinene (63), myrcene (64), α-phellandrene (65), ρ-cymene, limonene (67), α-ρ-dimethylstyrene, linalool, camphor (76), borneol (72), terpinen-4-ol, nerol, neral, geraniol, geranial, maaliene, β-cubebene, β-elemene (73), β-caryophyllene, 2,5-dimethoxy-1-isopropenyl-4-isopropylbenzene, α-humulene (68), dihydroagarofuran (74), indipone (70), caryophyllene oxide (75), globulol, cis-arteannuic alcohol, guaiol (71), trans-arteannuic alcohol, cubenol (69), α-muurolol, α-eudesmol and valianol (Kaul et al., 2005). A bicyclic sesquiterpene lactone (77) has been isolated from the petroleum ether extrac of the aerial part of the S. indicus. (Singh et al.,1988). The Capitula of Sphaeranthus indicus gave 0.06-0.08 percent of essential oil having characteristic sweet aromatic odor. GC/MS examination of the oil has shown 15 constituents. The main constituents were cadinene, ocimene, citral, p-methoxycinnamaldehyde, geraniol, eugenol (78) and geranyl acetate (79) (Lodha, 2003). Two Sphaeranthus peptide alkaloids (1 and 2) (80, 81) have been isolated from flowers. (Chughtai et al.,1992).

Summary

S. indicus is a weed possesses diverse group of biological activities both in medicine as well as agricultural practices. Antiseptic, antifungal, immunomoduatory, immunostimulant, antioxidant, neuroleptic, wound healing, anti-inflammatory and aphrodisiac are commandale medicinal properties of this plant. However, the importance of such activities in health products and food supplement is ignored. Additionally this weed excellent store grain protectant, antifeedant, ovicidal, provokes its use in agricultural applications. The benefit of the vigorous nature of S. indicus and its wide geographical distribution gave an opportunity to agro and pharma industries. Thus, this article offer excellent accessible source for study on active compounds for traditional medicine and allied applications.

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