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The genus *Sida* L. a traditional medicine: Its ethnopharmacological, phytochemical and pharmacological data for commercial exploitation in herbal drugs industry

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ABSTRACT

Ethnopharmacological relevance: Sida L. (Malvaceae) has been used for centuries in traditional medicines in different countries for the prevention and treatment of different diseases such as diarrhea, dysentery, gastrointestinal and urinary infections, malarial and other fevers, childbirth and miscarriage problems, skin ailments, cardiac and neural problems, asthma, bronchitis and other respiratory problems, weight loss aid, rheumatic and other inflammations, tuberculosis, etc.

Aims of this review: To assess the scientific evidence for therapeutic potential of *Sida* L. and to identify the gaps of future research needs.

Methods: The available information on the ethnomedicinal uses, phytochemistry, pharmacology and toxicology of *Sida* species was collected via a library and electronic searches in SciFinder, PubMed, ScienceDirect, Google Scholar for the period, 1933 to 2015.

Results: A variety of ethnomedicinal uses of *Sida* species have been found in India, China, Afrian and American countries. Phytochemical investigation of this genus has resulted in identification of about 142 chemical constituents, among which alkaloids, flavonoids and ecdysteroids are the predominant groups. The crude extracts and isolates have exhibited a wide spectrum of *in vitro* and *in vivo* pharmacological effects involving antimicrobial, analgesic, anti-inflammatory, abortifacient, neuroprotective, cardiovascular and cardioprotective, antimalarial, antitubercular, antidiabetic and antiobesity, antioxidant and nephroprotective activities among others. Ethnopharmacological preparations containing *Sida* species as an ingredient in India, African and American countries possess good efficacy in health disorders. From the toxicity perspective, only three *Sida* species have been assessed and found safe for oral use in rats.

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Conclusions: Pharmacological results supported some of the uses of *Sida* species in the traditional medicine. Alkaloids, flavonoids, other phenolics and ecdysteroids were perhaps responsible for the activities of extracts of the plants of this genus. No clinical study was reported. The detailed study on mechanism of action of isolates and extracts and their clinical study are needed for their use in modern medicine. More attention should be paid to *S. acuta*, *S. cordifolia*, *S. spinosa*, *S. rhombifolia* and *S. veronicaefolia* in the domain of diarrhea, dysentery, gastrointestinal and urinary infections, skin ailments, asthma, bronchitis and other respiratory problems, malaria, childbirth and miscarriage problems, cardiac and neural problems, weight loss aid, and rheumatic and other inflammations, etc. Furthermore, detailed study on quality and safety assurance data on available ethnopharmacological preparations is needed for their commercial exploitation in local and global markets.

Abbreviations used: ABTS, 2,2'-azinobis-3-ethylbenzothiazoline-6-sulfonic acid; AGS, human gastric adenocarcinoma; AIU, aspirin induced ulcer; ALP, alkaline phosphatase; ALT, serum alanine aminotransferase; AP, aerial part; APPLIU, aspirin plus pylorus ligation induced ulcer; ASA, ascorbic acid; AST, serum aspartate aminotransferase; BHT, di-*tert*-butylhydroxytoluene; BUN, blood urea nitrogen; bw, body weight; CAT, catalase; CD, concentration required to double induction; CIOA, Collagenase type-II induced osteoarthritis; CK-MB, creatinine phosphokinase-MB; CPT-1, carnitine palmiloyltransferase-1; dd, dose dependent; DCM, dichloromethane; DMBA, 7,12-dimethylbenz[a]-anthracene; DPPH, 2,2-diphenyl-1-picrylhydrazyl; EIU, ethanol induced ulcer; FAS, cell surface death receptor; FFA, plasma free fatty acid; FIRI, fasting insulin resistance index; fr, fraction; FRAP, ferric ion reducing antioxidant powder; FST, forced swim test; GAE, Gallic acid equivalent; GPX, glutathione peroxidase; GSH, reduced glutathione; HCEIU, HCl-ethanol induced ulcer; HDL, high density lipoproteins; HFD, high fat diet; IC_{50}, concentration that causes 50 % inhibition; IRI, ischemia reperfusion injury; ISO, isoproterenol; LC_{50}, concentration that kills 50 % of larvae within 24 h; LD_{50}, dose of extract in g/kg body weight of mice / rat to kill 50 % of tested animal; LDH, lactate dehydrogenase; LDL, low density lipoprotein; LEP, leptin; L-NAME, N^{w}-nitro-L-arginine methyl ester; LOX, lipoxygenase; MHA, Muller-Hinton agar; MIC, minimum inhibitory concentration; MMOC, mouse mammary organ culture; MTT, 3-(4,5-dimethylthiazol-2-yl)-2,5-diphenyltetrazolium bromide; NASH, non-alcoholic steatohepatitis; NC, negative control; N/S, not stated; o.t, orogastic tube; PC, positive control; PE, petroleum ether; PGI_2, prostacyclin; PM, phosphomolybdenum; p.o., post oral; $PPAR\gamma_2$, peroxisome proliferator-activated receptor gamma-2; QR, quinone reductase; RES, residual ethanol extract; SDA, Sabouraud dextrose agar; SGOT, serum glutamate oxaloacetate transaminase; SGPT, serum glutamic pyruvate transaminase; SOD, superoxide dismutase; SREBP1c, sterol regulatory element binding protein

1c; STZ, streptozotocin; TAB vaccine, typhoid paratyphoid A and B vaccine; TC, total cholesterol; TG, triglyceride; TRAIL, tumour necrosis factor (TNF) related apoptosis inducing ligand; TST, tail suspension test; VLDL, very low density lipoproteins; WISIU, water immersion stress induced ulcer; WP, whole plant; XO, xanthine oxidase.

Keywords:
Sida L.,
Traditional medicine,
Phytochemistry,
Pharmacology,
Ethnopharmacology.

1. Introduction

Sida L., an ethnomedicinally important genus of about 200 species of herbaceous plants, belongs to the Malvaceae family (Sivarajan and Pradeep, 1996). Plants of this genus are widely distributed as weeds in pasture and waste lands of tropical and subtropical regions of the world. The different parts of *Sida* plants have been widely used in indigenous medicine systems for thousands of years in the treatment of neurological and uterine disorders, headache, tuberculosis, diabetes, malarial fever, piles, ulcers, wounds, rheumatic and cardiac problems, diarrhoea and dysentery, skin diseases etc. (Kirtikar and Basu, 1987; Parrotta, 2001; Mills, 1994). Some of the *Sida* species namely, *S. acuta*, *S, cordifolia*, *S. rhombifolia*, *S. spinosa* and *S. veronicaefolia* are widely used in Indian (including ayurvedic and Siddha), Chinese, American and African traditional medicines. Different extracts and isolated compounds from these plants showed antimicrobial, anti-inflammatory and analgesic, hepatoprotective, antiulcer, cytotoxic, cardioprotective, neuroprotective, antitubercular, antioxidant, nephroprotective, antidiabetic and antiobesity, abortifacient, antipyretic activities supporting the traditional claims of the plants by the people of different countries (Galal et al., 2015; Srinithya and Muthuraman, 2014; Pradhan et al., 2013; Ajithabai et al., 2012).

About 142 chemical constituents have been identified from different *Sida* species, among which alkaloids, flavonoids and ecdysteroids are the predominant groups. Several herbal formulations have been patented using *S. cordifolia / S. rhombifolia / S. acuta* as one of their ingredients for the use as weight reduction aid, health promoter, neurological and rheumatic complaints and antimalarial drugs. The objective of this review is to provide an overview of the

traditional uses and scientific facts, clinical findings and the current issues about the *Sida* herb and to touch on the prospects for its future utilization in the herbal drugs industry.

2. Taxonomy and geographical distribution

The plants of genus *Sida* are annual or perennial herbs, undershrubs or shrubs, 0.5 – 2.0 m high with stellate, simple and/or granular hairs. The leaves of the plants are simple, narrowly ovate to lanceolate with entire leaf blade and without foliar nectarines. Flowers are solitary or paired, axillary or subterminal with campanulate or cup-shaped calyx and yellow or white corolla, mericarps with or without awns, and filament tube pubescent or glabrous with free petals. Fruits are 5-carpeled with slender mericarps and relatively large calyces that enclose and conceal the fruits (Tang et al., 2007; Krapovickas, 2006; Fryxell, 1992; Fryxell, 2009). The botanical morphological characteristic features of some common ethnomedicinally important *Sida* species are provided (Table 1).

Sida L. is distributed in both hemispheres including Africa, Asia, Australia, North, Central and South America and Pacific islands; about 17 species in India, 14 species in China, 7 species in Taiwan, 12 species in Pakistan, 35 species in Australia, 95 species in Brazil, 20 species in Mexico, 24 species in Colombia, 27 species in Argentina, 14 species in Bolivia, 20 species in Cameroon, 10 species in Nigeria and 2/3 of reported species in America (Lutterodt, 1988a; Chang, 1993; Fuertes Aguilar, 1995; Sivarajan and Pradeep, 1996; Tang et al., 2007; Shaheen et al., 2009; Klitgard et al., 2010; Bovini, 2013). The geographical distribution of three common available *Sida* species namely, *S. acuta* Burm. f., *S. cordifolia* L. and *S. rhombifolia* L. in Asian, African, North American and European, Central American and Carribbean, South American and Oceanic countries is provided (Table 2).

3. Ethnopharmacological usage

The ethnomedicinal uses of the genus *Sida* L. are listed in Table 3. Some plants of this genus, namely, *Sida acuta* Burm. f., *S. cordifolia* L., *S. rhombifolia* L., *S. alnifolia* var. *alnifolia*, *S. spinosa* L. and *S. veronicaefolia* L. have abundant ethnobotanical usage for centuries in many Asian, African and American countries. Different parts of *Sida acuta* have been used for various purposes such as neurological disorders, headache, leucorrhoea, tuberculosis, diabetes, malarial and other fevers, uterine disorders, rheumatic problem, renal inflammation,

asthma, ulcers, childbirth and worms, etc (Wake, 2011; Coee and Anderson, 1996a). *S. cordifolia* L. has been used for the treatment of chronic dysentery, asthma, gonorrhea, blennorrhea, oral mucosa, nervous disorders, stomatitis and nasal congestion (Chopra et al., 1992; Balbach, 1978; Franzotti et al., 2000; Rastogi and Malhotra, 1985). *S. rhombifolia* L. has been used for the treatment of gonorrhea, piles, gout and rheumatism and as nutritive tonic, diuretic and aphrodisiac, etc (Nadkarni, 1982; Gonzaalez et al., 1995). *S. spinosa* L. has been used in traditional medicine for treatment of diarrhea and dysentery, skin diseases, asthma and other chest ailments, snakebite, etc.(Darwish and Reinecke ,2003). *S. veronicaefolia* L. has been used in childbirth to reduce the pain of labour and in treatment of rheumatic and abdominal pains, boils, diarrhea, cut and bruishes, leucorrhea and as purgative, tonic, facilitator for production and ejection of milk in the nursing mothers, etc. (Lutterodt, 1988a; Khare, 2008). *S. alnifolia* L. has been used as abortive and in the treatment of asthma and other chest ailments, ulcer, skin and urinary infections, fever, leprosy (Lutterodt, 1988a; Khare et al., 2002; Ajithabai et al., 2012).

In Nigeria, antimalarial drug '*Malatreat*' is marketed by Paxherbals, Ewu using leaves, stems and roots of *Sida acuta* along with barks of *Alstonia boonei* and leaves of *Tridax procumbens* (Tor-Anyiin and Danisa, 2012).

In India, *Sida cordifolia*, known as 'Chitramutti' in the Siddha system of medicine, has been used as one of the ingredients for several Siddha formulations such as '*Vaathasura kudineer*', '*Chitramutti thailam*', '*Sarapungavilvaathi legyam*', '*Dhirakshathi chooranam*', etc. for treatment of joint pains, sinusitis, menstrual problems and stress, piththa diseases (Anonymous, 2007). Both *S. cordifolia* and *S. rhombifolia* are used as ingredients in the preparation of Ayurvedic medicines such as '*Baladikwath*', '*Baladya ghirt*', '*Baladyarista*', '*Chandanbala lakshadi taila*', '*Sudarshan churna*' and '*Kukuvadi churna*', to alleviate pain and swelling in rheumatic disorders, muscular weakness, tuberculosis, heart diseases, bronchitis, wounds in urinary tract, neurological problems, etc. (Dhiman and Kumar, 2006). Tibetan herbal mixture PADMA 28, containing *Sida cordifolia* as an ingredient, is used to treat intermittent claudication, atherosclerosis, scleroderma, multiple sclerosis and chronic hepatitis. It influences the apoptosis of leukaemia CEM C7H2 cells (Jenny et al., 2005). In United States, an herbal mixture containing *Sida cordifolia* as an ingredient is patented for use in the reduction of sympathomimetic induced side effects (Almanda, 2002).

4. Methodology

The literature search was conducted *via* SciFinder (http://cas.org/products/scifinder/index.html) covering the period from 1933 to 2015. Additional information was collected from PubMed (http://www.ncbi.nlm.nih.gov/pubmed), Science Direct, Google Scholar, journals and books.

5. Scope of the review

The multipurpose traditional uses, widespread geographical distribution in different Asian, African, North, Central and South American and Oceanic countries and promising phytochemical profile and pharmacological studies on some of the species of *Sida* L. have created an opportunity for greater development of the medicinal properties of the plants for formulation of herbal drugs in both local and international levels. Hence, a critical review of these plants is needed. Previous review articles on these plants by Khare et al. (2002), Venkatesh et al. (1994), Karou et al. (2007), Jain et al. (2011), Pradhan et al. (2013), Ajithabai et al. (2012) and Galal et al. (2015) have highlighted primarily the taxonomy and ethnobotany and partially the phytochemistry and pharmacology of these plants. Galal et al. (2015) in their review on *Sida cordifolia* emphasized the presence or absence of ephedrine was the key factor for the utility of the plant as weight loss aid. Infact, ephedrine is one of the components present in the plant that are involved in weight loss process. Other ephedrine bases also contribute significant synergistic effects in weight loss along with caffeine or other compound (Astrup et al., 1992). Moreover, the pharmacological potential of the plant depends also on other phytochemicals present in the plant. The amount of ephedrine bases should be restricted in formulations of weight loss drugs for long-term safety of the patients. None of these articles discussed the details of ethnobotany, phytochemicals, pharmacology and future course of studies on these plants. Therefore, in this review, we highlight the detailed traditional uses, scientific data on phytochemistry, pharmacology, toxicity and clinical studies, current issues and future perspectives regarding research and precautionary measures for commercial utilization of these plants in modern medicines.

6. Chemical constituents and their structures

Table 4 and Fig. 1 summarize the phytochemicals with chemical structures that have been reported from different species of *Sida* L. to date. These include the following: 23 alkaloids, 19 flavonoids, 16 ecdysteroids, 5 terpenoids, 4 tocopherols, 3 lignans, 4 coumarins, 12 steroids, 10 phenolics, 22 aliphatics, 4 phaeophytins, 16 amino acids and 4 other compounds. Each phytochemical is numbered (**1** to **142**) (Fig. 1) and is cited in the text. With respect to isolated phytochemicals of the genus, aerial parts were the most common targets of investigation of the plants for isolation of bioactive principles and most of these compounds are reported from *Sida acuta*, *S. cordifolia*, *S. rhombifolia*, *S. glutinosa* and *S. spinosa*. Alkaloids, ecdysteroids and flavonoids are the most abundant constituents of this genus. Alkaloids and flavonoids are the major bioactive principles of the extracts.

6.1. Alkaloids

Up to now, *β*-phenethylamines, 2-carboxylated tryptamines, quinazoline and quindoline alkaloids have been reported from *S. cardifolia* and *S. rhombifolia* (Ghosal et al., 1975; Prakash et al., 1981; Sutradhar et al., 2007a; Chaves et al., 2013); *β*-phenethylamine and quindoline alkaloids from *S. acuta* (Gunatilaka et al., 1980; Jang et al., 2003; Banzouzi et al., 2004); quinazoline alkaloid from *S. glutinosa* (Das et al., 2011); indole alkaloids from *S. cordifolia* (Sutradhar et al., 2007a) and indolizidine alkaloid from *S. carpinifolia* (Colodel et al., 2002) (Table 4). Quindoline alkaloids, quindolinone (**18**), cryptolepine (**17**), cryptolepinone (**19**), 11-methoxyquindoline (**20**) and quindoline (**21**) from *S. acuta* (Jang et al., 2003; Banzouzi et al., 2004; Karou et al., 2005) and β-phenethylamine and quinazoline alkaloids, (-) ephedrine (**2**), *ψ*-ephedrine (**3**) and vasicinone (**10**) from *S. cordifolia* (Ghosal et al., 1975) are therapeutic principles of the plant extracts. . Quindolinone (**18**), cryptolepinone (**19**) and 11-methoxyquindoline (**20**) from *S. acuta* exhibited potent quinone reductase activity in Hepa1c1c7 cancer cells (Jang et al., 2003). Cryptolepinone (**19**) also showed significant vasorelaxant activity (Chaves et al., 2013). Cryptolepine (**17**) from *S. acuta* showed potent antimalarial activity (Banzouzi et al., 2004).

6.2. Flavonoids

All the reported flavonoids are flavones, flavonols and their glycosides. Some of the flavonoids namely, 5,7-dihydroxy-3-isoprenylflavone (**26**), 5-hydroxy-3-isoprenylflavone (**27**)

and 3'- (3",7"-dimethyl-2",6"-octadiene)-8-C-*β*-D-glucosyl-kaempferol 3-*O*-*β*-D-glucoside (**34**) isolated from *S. cordifolia* exhibited analgesic and anti-inflammatory activities in animal models (Sutradhar et al., 2006a; Sutradhar et al., 2008). Glutinoside (**31**) and chrysin (**24**) from *S. glutinosa* showed significant antioxidant activity in DPPH assay (Das et al., 2012).

6.3. Ecdysteroids

Ecdysteroids are steroid hormones and its presence in plants provides a protection to some extent against non-adapted phytophagus insects (Bergamasco and Horn, 1983). Among the investigated *Sida* species (Table 4), 9 ecdysteroids from *S. rhombifolia* (Prakash and Ghosal, 1979; Jadhav et al., 2007a), 6 ecdysteroids from *S. spinosa* (Darwish and Reinecke, 2003), 2 from *S. cordifolia* (Ghosal, 1976) and 1 from *S. glutinosa* (Das et al., 2011) have been reported. These ecdysteroids may be useful candidates for successful insect control agents (Dhadialla et al., 1998).

6.4. Monoterpenoids

Two monoterpenoids (**59** and **60**) have been reported from *S. acuta* (Table 4*)* (Jang et al., 2003). Both the compounds exhibited weak quinone reductase effect against cultured mouse Hepa1c1c7 cells with CD values of 6.1 and 5.2 μg/mL, respectively (Jang et al., 2003).

6.5. Triterpenoids

Three triterpenoids (**61** - **63**) have been reported from *S. acuta* (Rao et al., 1984; Chen et al., 2007) (Table 4). Bioefficacies of these compounds have not yet been evaluated.

6.6. Tocopherols

Four tocopherols from *S. acuta* (Table 4) and their antioxidant activity in DPPH assay have been reported (Chen et al., 2007). Their antioxidant efficacies suggested their possible role as anti-inflammatory principles of the extract.

6.7. Lignans

Only 3 lignans from *S. acuta* have been reported (Cao and Qi, 1993; Jang et al., 2003) (Table 4). Bioactivity of 4- ketopinoresinol (**68**), isolated from other plant has been reported elsewhere.

6.8. Coumarins

Only 4 coumarins have been reported (Table 4). Bioactivities of these coumarins isolated from other plants have been reported elsewhere.

6.9. Steroids

12 steroids have been reported from different *Sida* species (Table 4). Antimicrobial activity of *β*-sitosterol and stigmasterol has been reported (Woldeyes et al., 2012).

6.10. Phenolics

10 Phenolic compounds including phenolic acids and esters have been reported (Table 4). Cancer chemopreventive activity of *N-trans*-feruloyltyramine (**88**) and evofolins A and B (**89** & **90**) in MMOC bioassay has been reported (Jang et al., 2003).

6.11. Aliphatics

22 Aliphatic compounds have been reported (Table 4). (10*E*, 12*Z*)-9-Hydroxy-octadeca-10,12-dienoic acid (**109**) possessed significant anti- HIV activity by nuclear export signal (NES) antagonistic inhibitory property in Rev-export inhibitory assay (Tamura et al., 2010).

6.12. Phaeophytins

Four phaeophytins have been reported (Table 4) (Chaves et al., 2013). Bioactivity of these compounds has not been evaluated.

6.13. Amino acids

16 Amino acids have been reported (Table 4). Some of these are essential amino acids. The presence of high amount of amino acids, glycine, 6.42; aspartic acid, 5.70; proline, 5.64; glutamic acid, 4.87 and alanine, 4.40 mg in bound form / 100 g of dry plant material, in Virginia *Sida, S. hermaphrodita*; and phenyl alanine, 6.13; asparagine, 9.8; glutamine, 7.4; valine, 1.5 and leucine 1.7 % in the leaves of *S. rhombifolia* suggested their qualities as fodder plants (Bhatt et al., 1983; Ligai and Bandyukova, 1990).

6.14. Others

Among 4 other compounds (Table 4), di-(2-ethylhexyl) phthalate (**141**) possessed significant lipoxygenase inhibitory activity and it could be useful in treatment of rheumatoid arthritis, psoriasis, and myocardial ischaemia (Preethidan et al., 2013). Phenylethyl-*β*-D-glucopyranoside (**142**) exhibited larvicidal activity against Filaria vector, *Culex quinquefasciatus* larvae (Ekramul Islam et al., 2003a).

7. Pharmacological activities

7.1. Antimicrobial activity

The flavonoid extracts of *S. acuta* stem, leaf and root exhibited strong antifungal activity against *Candida albicans* and these activities were comparable to that of standard drug terbinafine (Table 5). The flavonoid compounds from these extracts could be a source of new antibiotics for treatment of candidiasis (Jindal et al., 2012a). The alkaloid extract of *S. acuta* aerial parts showed good antimicrobial activity against several microorganisms (Table 5). The MIC values of the extract against the tested microorganisms were in the range of 16–400 μg/mL. Among the tested microorganisms, *E.coli*, *Staphylococcus aureus*, *Shigella dysenteriae* and *Enterococcus faecalis* were more sensitive. The alkaloid extract containing cryptolepine and quindoline as major constituents could be useful in the treatment of diarrhea and dysentery, urinary and respiratory infections (Karou et al., 2005). Methanolic extract of *S. acuta* whole plant exhibited significant antibacterial activity against several pathogenic bacteria (Table 5) (Anani et al., 2000; Saganuwan and Gulumbe, 2006). The significant antimicrobial activity of ethanol and aqueous extracts of *S. acuta* leaves against 45 clinical *Staphylococcus aureus* strains isolated from HIV/AIDS affected patients has been reported. 86% of the *S. aureus* isolates used in the study were susceptible to ethanol extract, where as 80% were to linomycin (PC) (Iroha et al., 2009). Antimicrobial activity of the $CHCl_3$, EtOH and aqueous extracts of *S. acuta* leaves was also evaluated against bacterial and fungal microorganisms isolated from skin infected and uninfected patients (Ekpo and Etim, 2009; Akilandeswari et al. 2010a). Polyphenol extract from *S. acuta* whole plant showed significant activity against enterobacteria, *Salmonella* and *Shigella* spp (Table 5) and could be useful for gastrointestinal infections of children (Karou et al., 2005). Alkaloid extract of *S. cordifolia* whole plant exhibited strong antifungal activity against five

Candida strains (Table 5) with MIC values in the range 8.33–12.5 μg/mL and MFC (minimal fungicidal concentration) values in the range 29.17–41.67 μg/mL , which were comparable to that of positive control antifungal drugs nystatin and clotrimazole (Ouedraogo et al., 2012). The significant antimicrobial activity of $CHCl_3$, MeOH and aqueous extracts of S. *cordifolia* leaf, root and seed was evaluated (Table 5) (Prabhakar et al., 2007a; Mahesh and Satish, 2008; Ternikar et al., 2010; Reddy et al., 2012). Significant antimicrobial activity of the extracts of *S. rhombifolia* leaf, aerial part and whole plant was reported (Mishra and Chaturvedi, 1978; Caceres et al., 1987; Maunza et al., 1994; Ekramul Islam et al., 2003b; Assam et al., 2010). *n*-Hexacos-11-enoic acid (**110**), *β*-sitosterol (**77**) and stigmasterol (**78**) from *S. rhombifolia* fruits and root showed moderate antibacterial activity (Woldeyes et al., 2012; Biftu et al., 2014). Significant antibacterial and antifungal activity of the EtOH extract of *S. spinosa* leaf and whole plant was reported (Table 5) (Selvadurai et al., 2011; Navaneethakrishnan et al., 2011). Antimicrobial activity of *S. rhombifolia* 50% ethanolic leaf extract against gonorrhea causing bacteria, *Neisseria gonorrhoeae* isolated from symptomatic gonorrhea patients has been evaluated (Caceres et al., 1995). Significant antimicrobial activity of the extracts from different *Sida* plant parts against *Shigella*, *Staphylococcus*, *Streptococcus*, *Bacillus*, *Salmonella*, *Micrococcus*, *Mycobacterium*, *Proteus*, *Candida* and *E. coli* strains advocates the traditional use of the plants in the treatment of skin and mucosa diseases including diarrhea and dysentery, gastrointestinal, urinary and respiratory infections.

7.2. Antiplasmodial activity

The chloroform, ethanol and aqueous extracts of *S. acuta* aerial parts/whole plant exhibited significant antiplasmodial activity against *Plasmodium falciparam* (Table 5) (Karou et al., 2003; Banzouzi et al., 2004). Cryptolepine (**17**) isolated from the most bioactive MeOH fraction of EtOH extract of *S. acuta* aerial parts showed potent antiplasmodial activity against *P. falciparam* (Table 5) (Banzouzi et al., 2004). Aqueous methanol extract of *S. rhombifolia* leaf showed *in vivo* antimalarial activity against *P. berghei* in mice (Baye Akele, 2012). Strong antiplasmodial activity of the extracts of *S. acuta* aerial parts supports the traditional use of the leaf/ whole plant of *S. acuta* in malarial fever by the people of Nigeria and Ivory Coast.

7.3. Larvicidal and repellant activities

The methanol extract of *S. acuta* leaf showed larvicidal and repellant activities against mosquitoes, *Culex quinquefasciatus*, *Aedes aegypti* and *Anopheles stephensi* (Table 5) (Govindarajan, 2010). Phenylethyl-*β*-D-glucopyranoside (**142**) isolated from *S. rhombifolia* stem bark showed larvicidal activity against Filaria vector, *Culex quinquefasciatus* (Ekramul Islam et al., 2003a).

7.4. Anti-ulcer activity

The ethanol extract of *S. acuta* whole plant exhibited moderate anti-ulcer activity in APPLIU, HCEIU and WISIU ulcer models in rats (Table 5) (Malairajan et al., 2006). The ethanol extract of *S. acuta* leaf also exhibited antiulcer activity in APPLIU, AIU and EIU ulcer models in rats (Akilandeswari et al., 2010b). MeOH extract of *S. cordifolia* aerial parts showed antiulcer activity in aspirin plus ethanol induced ulcer model in rats (Philip et al., 2008). Antiulcer activity of *S acuta* leaf extract advocates the traditional use of the plant leaf in gastric disorders and ulcers.

7.5. Cytotoxic activity

Methanol extract of *S. cordifolia* leaf exhibited significant cytotoxicity against HeLa cancer cells at 150 μg/mL (Joseph et al., 2011). GCMS-analysis of the extract indicated the presence of vasicinol and ephedrine as major constituents, and vasicinone and hypaphorine as minor constituents. Methanol extracts of *S. acuta* and *S. rhombifolia* whole plants exhibited moderate cytotoxic activities against HepG2 cells (Pieme et al., 2010). Alkaloid cryptolepine (**17**) isolated from *S. acuta* showed strong cytotoxic effect in the induction apoptosis of TRAIL sensitive human gastric adenocarcinoma (AGS) cells through caspase-3/7 activation in a dose dependent manner. At the 5 μM concentration, it increased 2.3 fold caspase-3/7 activity in presence of TRAIL (100 ng/mL) compared with the control after 12 h. The positive control luteolin produced about 50% more inhibition along with TRAIL than the agent alone at 17.5 μM whereas cryptolepine (**17**) showed the same inhibition along with TRAIL than the agent alone at 2.5 μM (Ahmed et al., 2011). Alkaloid, cryptolepinone (**19**) and phenolic compound, *N-trans*-feruloyltyramine (**88**) isolated from *S. acuta* showed significant cytotoxicity by inhibition of DMBA-induced preneoplastic lesions in MMOC assay (Table 5) (Jang et al., 2003). Alkaloids quindolinone (**18**), cryptolepinone (**19**) and 11-methoxy quindoline (**20**) isolated from *S. acuta*

showed significant cytotoxicity in cultured Hepa 1c1c7 (mouse hepatoma) cells by induction of quinone reductase (QR) activity (Jang et al., 2003). Cytotoxicity of leaf and aerial parts of *S. rhombifolia* in the brain shrimp lethality assay was evaluated (Table 5) (Ekramul Islam et al., 2003b; Rahman et al., 2011). Cytotoxic activity of the extracts of *S. acuta, S. cordifolia* and *S. rhombifolia* justified the traditional claim in the use of these plants in cancers.

7.6. Hepatoprotective activity

Methanol extract of *S. acuta* root at the dose of 200 mg/kg exhibited significant hepatoprotective activity in paracetamol induced hepatotoxic rats (Table 5). Ferulic acid present in the MeOH extract might have hepatoprotective role (Rajagopalan et al., 2004; Sreedevi et al., 2009). The hydroalcoholic extract of *S. cordifolia* root exhibited hepatoprotective effect by decreasing the mRNA levels of cytochrome P450 2E1, NF-κB, TNF-α and TGF-β1, and increasing the levels of antioxidant enzymes, SOD, GSH and CAT in alcohol-induced hepatotoxic rats (Table 5) (Rejitha et al., 2012). Aqueous leaf extract of *S. cordifolia* showed partial liver regeneration after removal of about 67% of liver from rats (Table 5) (Silva et al., 2006). Aqueous extract of *S. rhomboidea* (= *S. rhombifolia*) exhibited hepatoprotective activity in high fat diet induced NASH in mice (Table 5) (Thounaojam et al., 2012). Methanol and aqueous extracts of *S. rhombifolia* root and aerial parts showed significant hepatoprotective activity in CCl_4, paracetamol and rifampicin induced hepatotoxic rats (Table 5) (Rao and Mishra, 1997). Ethanolic leaf extract of *S. cordata* exhibited significant hepatoprotective effect in CCl_4-induced hepatotoxic rats (Mistry et al., 2013). Ethanol and aqueous extracts of *S. veronicaefolia* (= *S. cordata*) leaf showed significant hepatoprotective activity (Table 5) (Sharma et al., 2012a). Hepatoprotective activity of *S. cordifolia* roots supported the use of this plant root in the treatment of jaundice in India.

7.7. Analgesic and anti-inflammatory activities

Ethyl acetate and methanol extracts of *S. cordifolia* root and aerial parts exhibited significant analgesic activity in acetic acid induced writhing test and hot plate model in mice (Ravi Kant and Diwan, 1999; Momin et. al., 2014). The significant analgesic activity of aqueous leaf extract of *S. cordifolia* in acetic acid induced writhing test in mice and arachidonic acid induced rat edema model, and anti-imflammatory activity in carrageenan induced rat edema

model was reported (Franzotti et al., 2000). The analgesic activity of aqueous acetone extract of *S. cordifolia* whole plants was also evaluated (Konate et al., 2012a). Ethanolic extract of *S. cordifolia* leaf and its $CHCl_3$ and MeOH fractions exhibited orofacial anti-nociceptive effect in glutamate and formalin test in mice (Bonjardim et al., 2011). In the glutamate induced nociception test, only $CHCl_3$ and MeOH fractions reduced the orofacial nociceptive behavior dose dependently with inhibition of 48.1, 56.1 and 66.4 % by $CHCl_3$ fraction at 100, 200 and 400 g/kg, respectively; and 48.2 and 60.1 % by MeOH fraction at 200 and 400 g/kg, respectively. Analgesic activity of the methanolic, ethanolic and aqueous extracts of *S. rhombifolia* root and aerial parts was evaluated (Table 5) (Rao and Mishra, 1997; Rahman et al., 2011; Logeswari et al., 2013). Analgesic activity of ethyl acetate and butanol extracts of *S. rhomboidea* (= *S. rhombifolia*) leaf was reported (Venkatesh et al., 1999).

Ethyl acetate and methanol extracts of roots and aerial parts, aqueous leaf extract, petroleum ether extract of seeds and aqueous acetone extract of whole plants of *S. cordifolia* showed significant anti-inflammatory activities in carrageenan-induced rat paw edema model (Table 5) (Ravi Kant and Diwan, 1999; Franzotti et al., 2000; Ternikar et al., 2010; Konate et al., 2012a). The anti-inflammatory activity of the ethanolic root extract of *S. cordifolia* in quinolinic acid induced neurotoxic rats was evaluated (Swathy et al., 2010). The anti-inflammatory activities of ethyl acetate and butanol extracts of leaf, methanolic, ethanolic and aqueous extracts of roots and aerial parts of *S. rhombifolia* in carrageenan induced rat edema model have been reported (Venkatesh et al., 1999; Rao and Mishra, 1997; Rahman et al., 2011; Logeswari et al., 2013).

Flavonoids, 5,7-dihydroxy-3-isoprenylflavone (**26**) and 5-hydroxy-3- isoprenylflavone (**27**) and 3- (3",7"-dimethyl-2",6"-octadiene)-8-C-*β*-D-glucosyl-kaempferol 3-*O*-*β*-D-glucoside (**34**) and alkaloid **14** isolated from *S. cordifolia* aerial parts exhibited significant analgesic and anti-inflammatory activities in tail flick latency, carrageenan induced paw edema and acetic acid induced writhing models in rats at the doses of 25 and 50 mg/kg bw (Sutradhar et al., 2006a; Sutradhar et al., 2006b; Sutradhar et al., 2008).

Analgesic and anti- inflammatory activities of *S. cordifolia* and *S. rhombifolia* extracts supported the traditional use of these plants in the prevention and treatment of rheumatic and other inflammations and pains by the people of India, and other countries.

7.8. Anti-pyretic activity

The methanol extract of *S. cordifolia* aerial parts showed significant antipyretic activity in TAB vaccine-induced pyrexia in rats (Philip et al., 2008). The ethanolic extract of *S. acuta* leaf showed anti-pyretic effect in Brewers' yeast induced pyrexia in rats (Sharma et al., 2012b). Antipyretic activity of *S.acuta* leaf extract supported the traditional use of the plant in febrile illness.

7.9. Anti-tubercular activity

The ethyl acetate leaf extract of *S. rhombifolia* showed anti-tubercular activity against clinical isolate of *Mycobacterium tuberculosis* resistant to streptomycin, isoniazid, rifampicin and ethambutol with 67.18 and 83.61% reduction in Relative Light Units (RLU) at 100 µg/mL and 500 µg/mL concentrations, respectively in luciferase reporter phage (LRP) assay. This EtOAc extract also exhibited antitubercular activity against standard strain of *M. tuberculosis* H37Rv with 45.69 and 61.72% reduction in RLU at 100 and 500 µg/mL concentrations, respectively. The phytochemicals present in this extract could be responsible for this activity (Papitha et al., 2013). Anti- tuberculosis activity of *S. rhombifolia* leaf extract justified the traditional use of the plant in the treatment of pulmonary tuberculosis by the people of Malaysia.

7.10. Anti-gout activity

The flavonoid fraction from the aqueous methanolic extract of *S. rhombifolia* aerial parts of Indonesian origin exhibited significant antigout activity by inhibition of the activity of xanthine oxidase (XO) (Table 5). The kinetic inhibition assay of various fractions of the flavonoid crude extract from methanol extract on XO indicated that most of the fractions exhibited competitive inhibition and the inhibitory effect (79.1%) of one fraction was better than that of positive control allopurinol (68.1%) at the dose of 300 mg/L (Iswantini and Darusman, 2003; Iswantini et al., 2009). The DCM and EtOAc fractions of *S. acuta* whole plants exhibited antigout activity in *in vitro* XO inhibitory assay (Table 5) (Konate et al., 2010). Antigout activity of *S. rhombifolia* aqueous methanol extract of the aerial parts supported the traditional use of the plant in the treatment of gout by the people of Indonesia.

7.11. Anti-viral activity

The replication of HIV-1 virus occurs by its gene expression on viral regulatory protein, Rev and hence inhibition of the function of Rev is the attractive strategy for prevention of acquired immuno deficiency syndrome (AIDS). The transport of Rev in the host cell is mediated by a receptor protein, chromosomal region maintenance 1 (CRM1), through an interaction to a specific leucine-rich nuclear export signal (NES) of Rev. A fatty acid, (10*E*,12*Z*)-9-hydroxyoctadeca-10,12-dienoic acid (**109**), isolated from the methanol extract of *S. cordifolia* whole plant of South American origin, exhibited significant inhibitory activity for nuclear export of Rev in HeLa cells (IC_{50} value of 7.2 μM) (Table 5). This compound could be a potent lead drug for discovery of anti-AIDS drugs and could be a candidate for treatment of AIDS (Tamura et al., 2010).

7.12. Vasorelaxant activity

The aqueous fraction of the ethanol extract of *S. cordifolia* leaf showed significant vasorelaxant activity in superior mesenteric artery model of rats (Santos et al., 2006). Alkaloid cryptolepinone (19) isolated from *S. rhombifolia* aerial parts exhibited significant vasorelaxant activity in rat mesenteric artery rings (Table 5) (Chaves et al., 2013).

7.13. Anti-arthritic activity

The aqueous and ethanol extracts of *S. rhombifolia* aerial parts showed antiarthritic activity in adjuvant and motor performance induced arthritic rats as well as in mean distance travelled by rats (Table 5) (Gupta et al., 2009). Anti-arthritic effect of the ethanol extract of *S. rhombifolia* root and stem in adjuvant-induced arthritis in rats model was also reported (Narendhirakanan and Limmy, 2012). Anti-inflammatory effect of the alcoholic extract of *S. rhombifolia* root was evaluated in adjuvant-induced arthritic rats by assay of increasing antioxidant potentials and lowering of lipid peroxide content (Table 5) (Gangu et al., 2011). Anti-osteoarthritic activity of *Sida cordifolia* whole plant powder against collagenase type-II induced osteoarthritis in rats was observed from the significant reduction of paw volume and prevention of body weight loss and knee swelling (Nirmal et al., 2013).

7.14. Cardiovascular and cardioprotective activities

Methanolic extract of *S. acuta* whole plant showed significant hypotensive cardiovascular activity by decreasing heartbeat rate and blood flow in cardiac cycle in Zebrafish embryos model (Table 5) (Kannan and Vincent, 2012). The hydroalcoholic leaf extract of *S. cordifolia* exhibited hypotensive and bradycardiac effects in rats by producing hypotension and bradycardia in both direct stimulation of endothelial vascular muscarinic receptors and indirect cardiac muscarinic activation through vagus nerve (Medeiro et al., 2006).

Methanolic leaf extract of *S. cordifolia* exhibited cardioprotective effect in isoproterenol and ischemia reperfusion injury-induced myocardial injury in rats (Kubavat and Asdaq, 2009). Ethanolic leaf extract of *S. rhomboidea* at the dose of 400 mg/kg showed significant cardioprotection in isoproterenol-induced myocardial necrosis in rats by decreasing heart weight, plasma lipids, TC, TG, LDL and VLDL and plasma cardiac injury marker enzymes CK-MB, LDH, ALT, AST, ALP, Ca^{2+} ATPase and increasing HDL, SOD, CAT, GSH, Na^{+}-K^{+} ATPase and Mg^{2+} ATPase levels (Table 5) (Thounaojam et al., 2011a). Possibly the extract provides cardioprotection by improving the status of enzymatic and nonenzymatic antioxidants and preventing the oxidation of –SH group of cardiac ATPases. Cardioprotective activity of *S. cordifolia* and *S. rhombifolia* extracts justified the traditional use of these plants in cardiac problems by the people of India.

7.15. CNS depressive and antidepressive activities

The hydroalcoholic leaf extract of *S. cordifolia* at a dose of 1 g/kg showed significant CNS-depressive activity in mice model by reduction of spontaneous activity at 30 and 60 min without interfering the motor coordination and thus justified its extensive use by the northeast Brazilian population (Table 5) (Franco et al., 2005).

Residual ethanol extract of *S. tiagii* fruits, obtained after fractionation of ethanol extract with hexane and ethyl acetate exhibited antidepressant activity in mice in dose-dependent manner by significantly reducing the immobility times of mice in both FST (Forced swim test) and TST (Tail suspension test) without effecting the locomotive activity. The efficacy of the extract was comparable to that of imipramine (15 mg/kg, *p.o.*) and fluoxetine (20 mg/kg, *p.o.*). Possibly the extract exhibited antidepressant activity by inhibiting monoamine oxidase (MAO) and lipid peroxidation (Table 5) (Datusalia et al., 2009).

7.16. Anti-diabetic and antiobesity activities

Ethanolic and methanolic leaf extract of *S. acuta* showed significant hypoglycaemic and hypolipidaemic effects in alloxan-induced diabetic rats (Table 5) (Ekor et al., 2010). Ethanol,methanol and aqueous extracts of *S. cordifolia* aerial parts exhibited antidiabetic effect in streptozotocin-induced diabetic rats by normalizing the levels of total cholesterol, triglycerides, low density lipids (Kaur et al., 2011; Ahmad et al., 2014). Ethyl acetate and methanol extracts of *S. cordifolia* roots also exhibited hypoglycaemic effect in rats (Ravi Kanth and Diwan, 1999). Aqueous leaf extract of *S. rhomboidea* showed antidiabetic effect in both *in vitro* and *in vivo* assays. The *in vitro* assay was performed using 3T3L1 preadepocyte differentiation and leptin release models. The *in vivo* assays were done in high fat diet (HFD)-induced obesity and insulin resistance in mice, HFD induced- hyperlipidemic rats, and triton and oral lipid emulsion- induced hypertriglyceridemic rats models (Table 5) (Thounaojam et al., 2009a; Thounaojam et al., 2009b; Thounaojam et al., 2010b; Thounaojam et al., 2011b). Significant antidiabetic effect of the methanolic extract of *S. rhombifolia* aerial parts in streptozotocin-induced diabetic rats was evaluated (Ghosh et al., 2011). Ethanolic extract of *S. spinosa* whole plant exhibited antidiabetic effect in alloxan-induced diabetic rats (Selvadurai et al., 2012). Anti diabetic activity of *S. rhomboidea* and *S. cordifolia* extracts supported their ethnobotanical uses in weight loss.

7.17. Neurological and Neuroprotective activities

Ethanolic leaf extract of *S. acuta* exhibited hyperplasia and hypertropy of neural cells in cerebral cortex of rats in a dose-dependent manner (Table 5) (Eluwa et al., 2012).

Aqueous extract of *S. cordifolia* whole plant and its aqueous fraction showed significant neuroprotective activity in rotenone-induced oxidative stress model of Parkinson disease in rats (Table 5) (Khurana and Gajbhiye, 2013). Neuroprotective effect of *S.cordifolia* extract supported the traditional use of the plant in neurological disorders and Parkinson's disease by the people of India.

7.18. Anti-oxidant activity

Ethyl acetate and dichloromethane fractions of aqueous acetone extract of *S. alba* and *S. acuta* whole plants showed significant *in vitro* antioxidant activity in DPPH, ABTS, FRAP and

lipoxygenase inhibitory assays (Table 5) (Konate et al., 2010). Ethanolic and aqueous extracts of *S. cordifolia* whole plants exhibited antioxidant activity in ABTS, DPPH, reducing power, NO, and H_2O_2 scavenging assays (Table 5) (Auddy et al., 2003; Pawar et al., 2011). Antioxidant efficacy of the alkaloid fraction from *S. cordifolia* aerial parts was reported in DPPH, ABTS and FRAP assays (Ouedraogo et al., 2012). The ethanolic extracts of root, stem, leaf and whole plant of *S. rhombifolia* exhibited antioxidant activity in DPPH, reducing power, superoxide, NO and lipid peroxidation assays (Table 5) (Dhalwal et al., 2007). The antioxidant activity of the methanolic leaf extract of *S. rhombifolia* was reported (Thounaojam et al., 2010c). Three phytochemicals, glutinoside **(31**), chrysin (**24**) and 24(28)-dehydromakisterone A (**50**) isolated from *S. glutinosa* exhibited significant antioxidant activity in DPPH assay (Das et al., 2012). Di (2-ethylhexyl) phthalate (**141**) isolated from *S. cordifolia* and three other *Sida* spp. (Table 5) exhibited moderate antioxidant activity against soyabean lipoxygenase (LOX) (Preethidan et al., 2013). Antioxidant activities of the plant extracts supported the traditional use of the plants in different kinds of inflammations and oxidative stress related diseases.

7.19. Abortifacient and contraceptive activities

The aqueous fraction of EtOH extract of *S. veronicaefolia* leaf and shoot showed significant abortifacient effect and foetal death in pregnant rats. Moreover, the average weights of the litters decreased with increasing the dose of the extract (Lutterodt, 1988a).

The ethanol extract of *S. acuta* leaf showed anti-implantation activity in female rats and estrogenic activity in immature overiectomized female rats (Londonkar et al., 2009). Both aqueous and ethanolic extracts of *S. rhombifolia* whole plants exhibited anti-plantation effect in female rats (Satthawongsakul, 1980). Anti- implantation activity of the extracts of *S. acuta* and *S. veronicaefolia* supported their traditional uses in abortion.

7.20. Spasmogenic activity

The aqueous fraction of the EtOH extract of *S. veronicaefolia* leaf and shoot showed maximum contraction response in isolated guineapig and isolated rabbit duodenum at the concentration of 0.14 ± 0.03 μg/mL in presence of antagonists, mepyramine, atropine and

hexamethonium bromide. Possibly for this reason, the midwives in Ghana frequently use the slimy bruished leaves in their hands to remove dead stillborn babies from the womb (Lutterodt, 1988b). The aqueous extract of *S. corymbosa* whole plant showed 32.8 % increase of uterine contractility at a dose of 200 µg/mL in *in vitro* collagen gel uterine contractility assay (Attah et al., 2012).

7.21. Antivenom activity

The ethanol extract of *S. acuta* whole plant at a dose of 4 mg/mouse exhibited moderate neutralization of the haemorrhagic effect of the venom of the snake species *Bothrops atrox asper*, frequently found in Antioquia and Choco, North-western Colombia, inflicts about 50% of the bites in this region (Otero et al., 2000). Antivenom activity of *S. acuta* extract justified the traditional use of the plant in snake bite by the people of Northwest Colombia, India, Burkina Faso and Taiwan.

7.22. Nephroprotective effect

Significant nephroproective effect of aqueous root extract of *S. cordifolia* was reported (Table 5) (Makwana et al., 2012). Nephroprotective effect of both ethanolic and aqueous extracts of *S. cordifolia* leaf has been evaluated (Lovkesh et al., 2012). Ethanolic leaf extract of *S. rhomboidea* exhibited significant nephroprotective effect (Thounaojam et al., 2010a). Nephroprotective effect of the extracts of *S. cordifolia* and *S. rhombifolia* supported to some extent the traditional use of the plants for treatment of urinary inflammations by the people of Guatemala, Benin, Mexico and India.

7.23. Toxicological effect

Saanen goats fed with *S. carpinifolia* daily faced neurological disorders including apathy, ataxia, muscular tremors, hypermetria, standing-up deficit resulting from the induction of α-mannosidase activity (Table 5). After 5th day of consumption of the plant, the enzyme activity was 288±13 nM 4MU/h/mg protein and it returned to normal level (114±7 nM 4MU/h/mg protein) 2 d after the withdrawal of the plant from diet. The bioactive chemical present in *S. carpinifolia* could be useful to treat human *α*-mannosidosis when patients suffering from *α*-mannosidase deficiency. Alkaloid swainsonine (**23**), isolated from *S. carpinifolia*, caused

reduction of α-mannosidase activity in human lymphoblast culture cells (Dorling et al., 1980) . Possibly *S. carpinifolia* possesses other compounds that act on the α-mannosidase enzyme in leukocytes in a competitive manner with swainsonine (Dorling et al., 1980; Colodel et al., 2002; Ikeda et al., 2003; Bedin et al., 2009; Bedin et al., 2010).

7.24. Immunostimulating activity

The alkaloid fraction from the ethanol extract of *S. cordifolia* aerial parts exhibited mild immunostimulating effect in cyclosporine- induced immune system in rats (Ouedrago et al., 2012).

7.25. Wound healing activity

The methanol extract of *S. acuta* whole plants showed wound healing activity in both excision and incision wound models in rats and this activity was comparable to that of nitrofurazone used as positive control (Table 5). The reference drug nitrofurazone and 5% MeOH extract required 18±2 d for complete wound healing in excision model (Akilandeswari et al., 2010c). The ethanolic extract of *S. cordifolia* ointment in soft paraffin base showed significant wound healing in excision, incision and burn injury models in rats (Pawar et al., 2013). Wound healing activity supported the traditional use of the plants in the treatment of wounds by the people of Nigeria and Mexico.

7.26. Antidiarrheal activity

Methanol extract of *S. rhombifolia* root showed significant antidiarrheal effect in castor oil-induced diarrhea in rats and mice (Table 5) (Sarangi et al., 2011). Antidiarrheal activity of the plant supported its traditional use in diarrhea by the people of Australia, Cameroon and Papua New Guinea.

7.27. Antistress and adaptogenic activity

The ethanol extract of *S. cordifolia* root exhibited significant antistress and adaptogenic activity in cold restraint stress and swim indurance models in mice (Table 5) (Sumanth and mustafa, 2009).

7.28. Anthelmintic activity

The aqueous extract of *S. cordifolia* whole plants showed anthelmintic effect against earthworm, comparable to that of anthelmintic drug albendazol (Table 5) (Pawar et al., 2011).

7.29. Diuretic activity

The chloroform, ethyl acetate and methanol extracts of *S. cordifolia* root exhibited significant diuretic effect by increasing the levels of Na^+, K^+ and Cl^- and volume of urine (Table 5) (Prabhakar et al., 2007b). The aqueous and ethanol extracts of *S. spinosa* leaf also showed significant diuretic activity comparable to that of positive control furosemide (Narendra Naik et al., 2011). Diuretic effect of *S. cordifolia* extract supported the ethnomedicinal use of the plant as diuretic by the people of Mauritius.

7.30. Anti-atherosclerotic activitity

Aqueous leaf extract of *S. rhombifolia* exhibited *in vitro* anti-atherosclerotic activity in copper and cell mediated oxidized LDL induced macrophage apoptosis (Table 5) (Thounaojam et al., 2011c).

7.31. Anti-anxiety activity

The ethanol extract of *S. rhombifolia* whole plants exhibited significant anti- anxiety activity in mice (Table 5) (Sundaraganapathy et al., 2013).

8. Toxicity studies

Several research groups have evaluated the acute toxicity and safety of the extracts from different *Sida* species. Administration of aqueous leaf extract of *S. cordifolia* at oral doses of 0.5, 1, 2 and 3 g/kg to Wistar rats for the period of 48 h, did not produce any behavioral changes or mortality. Hence, the oral dose of 3 g/kg of the leaf extract from *S. cordifolia* was safe to use in rats (Franzotti et al., 2000). Later on, aqueous ethanol extract of *S. cordifolia* leaf was administered to Swiss mice intraperitonally (*i.p.*) (500–3000 mg/kg) and orally (*p.o.*) (500–5000 mg/kg) and observed for 48 h. Mortality was not observed in orally administered group of mice and thus 5 g/kg oral-dose was not lethal to mice. The LD_{50} value was found to be 2639 mg/kg for

i.p. administration to mice (Franco et al., 2005). Oral administration of petroleum ether, chloroform and methanol extracts of *S. rhombifolia* root in both Wistar rats and Swiss mice at the doses 100, 250, 500, 1000, 1500 and 2000 mg/kg bw for a period of 72 h did not show any signs of toxicity and mortality. Therefore, the oral dose of 2000 mg/kg of the extract was safe in mice and rats for consumption (Sarangi et al., 2011). No adverse reactions and mortality were observed in the tested mice after oral administration of aqueous leaf extract (3000 mg/kg) from *S. rhomboidea* suggesting its low toxicity and safe for consumption of mice (Thounaojam et al., 2010d).

For a long term toxicity assay, the aqueous acetone extracts of *S. acuta* and *S. cordifolia* whole plants were administered intraperitoneally to Swiss mice at the doses of 1, 2, 2.5, 3, 4 and 5 g/kg and the animals were observed for 14 d for any morbidity and mortality. The LD_{50} values were found to be 3.2 and 3.4 g/kg for *S. acuta* and *S. cordifolia*, respectively (Konate et al., 2012a). Administration of the aqueous methanol extract of *S. rhombifolia* whole plant to Wistar rats at the doses of 4, 8, 12 and 16 g/kg *i.p*. for a period of 8 days, showed no toxic effect on the basis of mortality and LD_{50} was found to be 5 g/kg (Assam et al., 2010). The acute toxicity of aqueous root extract of *S. rhombifolia* was evaluated by oral administration of a single dose of 5000 mg/kg in rats for 14 d and no sign of toxicity, behavioral change and mortality were observed. The sub-chronic toxicity of aqueous root extract of *S. rhombifolia* was determined by oral administration at the doses of 300, 600 and 1,200 mg/kg bw in both male and female rats for 90 d. A satellite group of rats was also kept for another 28 d post treatment. No sign of toxicity and mortality was observed. The results of toxicity studies suggested that the aqueous root extract at the dose of 1.2 g/kg was safe for consumption of rats (Sireeratawong et al., 2008). The long term acute toxicity of aqueous acetone extract of *S. rhombifolia* whole plant was evaluated by oral administration at doses 1-6 g/kg bw in mice and no toxic symptoms was observed upto 14 d. The LD_{50} value was greater than 5000 mg/kg. The sub-acute toxicity was also determined at tested doses of 100, 200 and 300 mg/kg in rats for 28 d. The body weight of the tested group was decreased but not mortality was observed. Thus, *S. rhombifolia* extract of whole plant was not toxic to rats up to the dose of 5g/kg (Ouedraogo et al., 2013).

Thus, the oral dose of 3.2 g/kg of aqueous acetone extract of *S. acuta*, 5 g/kg of aqueous ethanolic leaf extract of *S. cordifolia*, 3.0 g/kg of aqueous leaf extract and 5 g/kg of

aqueous methanolic extract of whole plants of *S. rhombifolia* are safe for oral consumption of rats.

9. Clinical studies

To date, no human clinical trials using either crude extracts/isolates or ethnopharmacological preparations from *Sida* L. have been reported in the literature.

10. Discussion

Among the several species of genus *Sida*, phytochemistry and pharmacological studies have been reported to only nine species namely, *S. acuta* Burman f., Fl. Indica: 147(1768) (syn. *S. carpinifolia* sensu Masters (L.f)., *S. carpinifolia* (L.f) K. Schum, *S. carpinifolia* var. *acuta* (Burm.f.) Kurz, *S. lanceolata* Retz., *S. pancifolia* DC, *S. acuta* var. *intermedia* Hu, *S. scoparia* Lour); *S. cordifolia* Linnaeus, Sp. Pl., 2:684(1753) (syn. *S. cordifolia* var. *altheifolia* (Sw) Griseb, *S. cordifolia* var. *conferta* (Link) Griseb, *S. cordifolia* var. *potentilloides* (A.St.-Hil) Griseb, *S. cordifolia* var. *variegata* Griseb); *S. cordata* (N. L. Burman f.) Borssum Waalkes, Blumea 14:182(1966) (syn. *S. veronicaefolia* Lamk., *S. humilis* Cav., *S. radicans* Cav., *S. multicaulis* Cav., *S. morifolia* Cav., *S. beddomei* Jacobe); *S. rhombifolia* Linnaeus, Sp. Pl. 2:684 (1753) (syn. *S. rhomboidea* Roxb. ex Fleming, *S. rhombifolia* var. *rhomboidea* (DC) Masters, *S. rhombifolia* var. *obovata* Wall. ex Masters, *S. rhombifolia* var. *peduncularis* Hochr., *S. rhombifolia* var. *retusa* (L.) Mast.); *S. corymbosa* R.E.Fr (syn. *S. hyssopifolia* C. Presl), Bull Herb Boiss II, 6, 998(1907); *S. glutinosa* Roxburgh, Fl. Indica, ed. (1832), 3:172(1832) (syn. *S. mysorensis* Wt & Arn, *S. urticifolia* Wt & Arn, *S. glomerata* Cav.); *S. spinosa* Linnaeus, Sp. Pl. 2:683(1753) (syn. *S. alba* L.), *S. galheirensis* Ulbr**.,** TRO**,** floradobrasil.jbrj.gov.br/2010 and *S. hermophrodita* Rusby (syn. *S. napaea* Cav.), TRO (Deb, 1981; Rastogi and Mehrotra, 1993; Tang et al., 2007).

S. acuta and *S. cordifolia* contain high amounts of alkaloids. Ephedrine and ψ-ephedrine are the major bases in the aerial parts of *S. cordifolia*; whereas these bases are present in roots as minor amounts. The amount of alkaloids present in *S. cordifolia* depends on the age of the plant. For instance, the roots of 6 month old plants contain quinazoline as major alkaloids and only traces of carboxylated tryptamines, whereas the situation is reversed in roots of 2 year old plants which contain carboxylated tryptamines as major alkaloids. Moreover, the amount of alkaloids

declines in older plants (Ghosal et al., 1975). Vasicine (**11**) and vasicinone (**10**) are present in good amounts in the roots of *S. cordifolia* (0.010% and 0.0061%, respectively) and *S. acuta* (0.008% and 0.0023%, respectively) as determined in HPLC method (Dhalwal et al., 2010). Air-dried leaves of *S. cordifolia* (known as Indian Ephedra) contained about 0.28% of ephedrine (**2**) and pseudoephedrine (**3**) and the stem and whole plant about 0.22% and 0.112% of ephedrine respectively (Khatoon et al., 2005; Jain et al., 2011). Ephedrine (**2**) and its congeners are also present in good amounts in the aerial parts of *S. rhombifolia* and *S. acuta*. Cryptolepine (**17**) and quindoline (**21**) are the major bases in the aerial parts of *S. acuta* but these are not found in the aerial parts and roots of *S. rhombifolia* and *S. cordata* (Banzouzi et al., 2004; Karou et al., 2005; Chatterjee et al., 2013). Cryptolepine (**17**) was present in high amount (0.0017 %) in the aerial parts of *S. acuta* (Chatterjee et al., 2013). Ecdysteroids are major constituents of *S. rhombifolia* and *S. spinosa* (Jadhav et al., 2007a; Darwish and Reinecke, 2003). *S. acuta* also contains phenolics and triterpenoids in good amounts (Jang et al., 2003); whereas *S. cordifolia* contains flavonoids as second major constituents (Sutradhar et al., 2006; Sutradhar et al., 2007b; Sutradhar et al, 2008). The amount of phenolic content in *S. spinosa*, *S. acuta*, *S. cordifolia*, *S. rhombifolia* and *S. urens* are 32.53, 15.35, 10.25, 5.75 and 4.21 mg GAE/100mg extract, respectively (GAE = Gallic acid equivalent) (Buhner, 2012). The seeds of *S. acuta* and *S. rhombifolia* contain appreciable amount of 20- hydroxyecdysone (**44**) (Dinan et al.,2001). The alkaloids and phenolics in *S. acuta* have major contribution in the bioefficacy of the plant; whereas both alkaloids and flavonoids are the major bioactive principles in *S. cordifolia* (Jang et al., 2003; Ghosal et al., 1975; Sutradhar et al., 2008). Possibly, alkaloids in all *Sida* species play key roles in the main pharmacological activities of the extracts. Ephedrine may be considered as chemotaxonomic marker of this genus. Isolation of these alkaloids from crude plant material involves acid/base extraction procedure (Reti, 1953). (-) Ephedrine (1*R*-2*S*-2-methylamino-1-phenylpropan-1-ol) (**2**) is currently used as CNS stimulant and in the treatment of bronchial asthma, simple obesity and urinary incontinence (Hoffman and Lefkowitz, 1996), whereas the most popular application of (+)-pseudo- ephedrine (1*S*-2*S*-2-methylamino-1-phenylpropan-1-ol) (**3**) is in flu medications to relieve nasal decongestion due to its vasoconstrictive and anti-inflammatory effects (Hoffman and Lefkowitz, 1996; Hikino et al., 1980). Long term and high dose use of (-) ephedrine (**2**) results hypertension and other cardiovascular diseases (including myocardial infarction, stroke), glaucoma, diabetes, genitourinary, hyperthyroidism, insomnia,

dizziness, dry exfoliating skin and kidney failure in patients (Fetrow and Avila, 1999; Kurashima et al., 2004). (-) Ephedrine is metabolized to norephedrine in the body, which acts as sympathomimetic agonist for stimulation of α- and β- adrenergic receptors, and CNS (Dollery, 1991). Recently the use of ephedrine containing products as dietary supplements has increased in the US and other developed countries for its weight loss and performance enhancement activities (Pasquali et al., 1985). Semisynthetic drug deoxyephedrine (= methamphetamine) commonly known as meth, is widely consumed as illicit drug similar to cocaine in clubhouses and its usage caused serious psychotic behavior and damage of heart and brain. Several complaints on the adverse effects primarily on cardiovascular and CNS systems in the use of ephedrine containing products were received by the US Food and Drug Administration and Canada Food Directorate. As a safety measure, Health Canada has published a guide for ephedrine labeling in the ephedrine containing dietary supplements that limits the dosage to 8 mg of (-) ephedrine every 6-8 hours (max. 32 mg/day) (Cabrera, 1998). Similarly, the US FDA adopted the limit of dosage to 10 mg of total ephedrine alkaloids per dose (40 mg/day) for ephedrine containing dietary supplements (Blumenthal, 1997). Therefore it is very much essential to quantify the ephedrine alkaloids in ephedrine containing dietary supplements of global market for their safety assurance. A faster validated reversed phase HPLC method may be used for the determination of ephedrine, methyl ephedrine, pseudoephedrine, methylpseudoephedrine and their congeners in dietary supplements containing *Sida* or *Ephedra* herbs (Gurley et al., 1998). Ephedrine alkaloids were detected in UV detector at 208 nm and the limit of quantification was 6.25 μg/mL.

Among the isolated chemical constituents from the extracts of *Sida* plants, the alkaloids, flavonoids, phenolics and ecdysteroids mainly exhibited various pharmacological properties such as antimalarial, analgesic, anti-inflammatory, cytotoxic and vasorelaxant, etc. The alkaloid cryptolepine (**17**) isolated from *S. acuta* exhibited potent *in vitro* antiplasmodial activity against *P. falciparam*, main parasitic species of malaria. Possibly this alkaloid exerted cytotoxic effect to the parasite by inhibition of DNA synthesis *via* the formation of stable topoisomerase II-DNA complex followed by internucleosomal fragmentation of DNA in the parasite cells (Bonjean et al., 1998; Dassonneville et al., 1999; Lisgarten et al., 2002). Cryptolepine (**17**) also induced apoptosis of HL-60 leukaemia cells (Dassonneville et al., 2000). Phytochemical scopoletin (**71**) isolated from *S. acuta* and plants of other genus was found to have anti-hyperlipidemic (Yang et al., 2007), cytotoxic against tumoral lymphocytes, osteosarcoma and leukemic CEM/ADR 5000

cells (Moon et al., 2007; Taka-aki et al., 2007; Manuele et al., 2006), antithyroid and antihyperglycemic activities (Panda and Kar, 2006), amelioration of insulin resistance in HepG2 cells (Zhang et al., 2010) and memory improving property (Hornick et al., 2011). 20-Hydroxyecdysone (**44**) isolated from different *Sida* species and other plants were found to possess pesticidal, wound healing, hepatoprotective, immunomodulatory and erythropoietic activities (Jadhav et al., 2007b). The bronchodilator activity of vasicinone (**10**), vasicine (**11**) and vasicinol (**12**) might be useful for treatment of bronchial diseases (Amin and Mehta, 1959; Lahiri and Pradhan, 1964; Ghosal et al., 1975). Vasicine (**11**) is known to possess oxytocic and abortifacient activity and hence its use should be restricted to bronchial pregnant women (Gupta et al., 1978; Atal, 1980). 4-Ketopinoresinol (**68**) isolated from *S. acuta* and plants of other genus exhibited significant cytoprotective effect by suppressing oxidative stress-induced DNA damage and cell death by upregulation of heme oxygenase-1 (HO-1) and activation of P12K/AKT signaling (Chen et al., 2012).

Three common *Sida* species, *S. acuta* Burm. f., *S. cordifolia* L. and *S. rhombifolia* L. as well as *S. spinosa* and *S. veronicaefolia* have been extensively prescribed in traditional medicine in India, China, American and African countries for a wide range of indications including bronchitis, asthma, nasal congestion, rheumatism, renal inflammation, diarrhea and dysentery, malaria, neurodegenerative diseases, skin diseases, jaundice, tuberculosis, gonorrhea, cardiac diseases and child birth problems. Most of these traditional claims have been supported by the pharamacological activities of the plant extracts. Additionally, these plants possess antiviral, analgesic, antipyretic, wound healing, diuretic, contraceptive, antiarthritis, antigout, antivenom, antidiabetic, vasorelaxant and antituberculer properties. These plants having versatile pharmacological properties can be harvested as chemopreventive pharmaceutical and nutraceutical products. Most of these medicinal properties are related to the presence or absence of ephedrine type, vasicine type and cryptolepine type alkaloids, flavonoids and ecdystroids. Therefore, a broad scheme for thorough studies of a large number of samples of different *Sida* species collected from different geographical regions at different ages of the plants and in different seasons is essential to confirm the extent of presence or absence of these alkaloids and other bioactive principles before their use in herbal drug formulations. The promising pharmacological activities of these plants may be translated in the utilization of these plants as potential pharmaceutical and nutraceutical products in the following areas:

Extensive use of the plants, *S acuta*, *S. cordifolia*, *S. cordata*, *S. rhombifolia* and *S. spinosa* in different countries in dysentery, diarrhea and other gastrointestinal tract associated ailments indicates their potential effectiveness in symptomatic relief from these diseases. The emerging knowledge about the etiology of dysentery and diarrhea (Collins, 2014) gives a new concept for therapeutic development of this traditional medicine. Diarrhea is one of the most infant mortality diseases in the world in the developing countries, kills more than 6 million of children in the world with 7.7% and 8.5%, respectively in Africa and Southeast Asia (Dupeyron, 1997). WHO estimated about 80 million cases of bacillary dysentery and about 700,000 deaths form shigellosis annually (WHO, 2005). The strains of *E. coli*, *Shigella*, *Salmonella*, *Proteus*, *Klebsiella*, *Citrobactor* and *Enterococcus* are mostly responsible for outbreak of diarrhea and dysentery, and disfunctioning of kidney in some cases (Howard and Christian, 1995; Guerrant et al., 1976). Leaves and aerial parts of these plants have potential activity against these microbials (Karou et al., 2005; Ekramul Islam et al., 2003b; Assam et al., 2010). The alkaloid fraction from aerial parts of *S. acuta* was more susceptible to *Shigella dysenteriae* and *E. coli* and showed no viability of microorganisms after 5 hours exposition (Karou et al., 2005). Further research on the influence of enteropathogenic microorganism growth and influence of chemicals on intestinal muscle tone are needed to understand the etiological facts participating in the development of diarrhea and dysentery and to utilize these plant extracts as effective drugs for its prevention.

Second frequent application of the plants, *S. acuta*, *S. cordifolia*, *S. rhombifolia* and *S. spinosa* is in the mucosa ailments such as throat infections, nasal congestion, asthma and bronchitis. Ephedrine and vasicine type alkaloids are the main therapeutic principles of the plant extracts for their potential vasoconstrictor and bronchodialator efficacies (Ghosal et al., 1975). Ephedrine alkaloids in high doses are toxic and hence precautionary measures should be taken to maintain their dose limits below 10 mg/day, well below safety limits in the preparation of ethnomedicines using these plants with efficacies upto the mark.

Third frequent application of the *S. acuta*, *S. cordifolia*, *S. rhombifolia* and *S. spinosa* is in the treatment of malarial and other fevers. According to the recent estimate of WHO, about 198 million people are suffering from malaria globally, leading to 5, 84,000 deaths. Surprisingly, 90% of these malaria deaths occur in African countries and children aged less than 5 years account for 78% of the deaths (WHO, 2014). Traditional healers of malaria commonly use these plants for treatment of malaria and other febrile illnesses (Kerharo and Adam, 1974). Alkaloid

cryptolepine (**17**) was found to be the major active constituent in *S. acuta* and was more sensitive to Cameroon *Plasmodium falciparum* strains compared to reference antimalarial drug chloroquine (Banzouzi et al., 2004). Further study on the toxicity and adverse effects of cryptolepine and the extracts containing this alkaloid, is needed before their commercial exploitation as lowcost herbal drugs in febrile illnesses.

Fourth, comparative low content of ephedrine type alkaloids in *S. cordifolia, S. rhombifolia* and *S. acuta* compared to *Ephedra* species, may be utilized to formulate for potential weight loss aid and physical performance drugs. As per factsheet report of WHO, 2015 (Factsheet no. 310) 600 million of people in the world are suffereing from obesity due to consumption of food of high calorific values.

Fifth frequent use of the plants *S. acuta, S. rhombifolia, S. corymbosa* and *S. veronicaefolia* in India, Tanzania, Cameroon, Ghana and Philippines is for the habitual abortion and childbirth. Possibly some mucilagenic polysaccharides or polypeptides present in the plant extracts, sensitize the uterus similar to oxytocin and induce abortion or labour. Further research in this area is needed to discover the uterotonic principles from these plant extracts for their potential application as drugs in childbirth and miscarriage (Lutterodt and Oppong-Bawuah, 1976).

Sixth important application of the plants, *S. acuta, S. rhombifolia, S. cordata* and *S. spinosa* is in the external treatment of skin diseases, skin bleeding, boils and abscesses. It would be a good approach for preparation of ointment for relief from these skin ailments as these plants have potential antimicrobial activity against *Candida* and *Streptococcus* strains among other strains (Iroha et al., 2009; Ouedraogo et al., 2012).

Seventh important application of *S. cordifolia* and *S. rhombifolia* is in the treatment of rheumatic and other inflammations and pains may be utilized for formulation of anti-inflammatory drug. Pharmacological studies on these plants supported the presence of some analgesic and anti-inflammatory flavonoids and alkaloids in the extract (Sutradhar et al., 2006a; Sutradhar et al., 2006b; Sutradhar et al., 2008).

Eighth extensive application of these plants, *S. cordifolia*, *S. rhombifolia* and *S. spinosa* is in the treatment of cardiac diseases. Myocardial infarction (MI) is one of the important cardiac diseases in the developed countries. About one million people have MI each year in the US (NHLBI, 2013). Obesity is one of the major causes of MI disease (Yusuf et al., 2005). Leaf

extracts of these plants would be a promising approach to formulate a drug for obesity induced MI (Kubavat and Asdaq, 2009; Thounaojam et al., 2011a; Thounaojam et al., 2011b; Thounaojam et al., 2011c).

Ninth, traditional application of *S. cordifolia* in India for the treatment of diseases of neurological disorders such as hemiplegia, facial paralysis and Parkinson disease may be a promising approach for utilization of the plant in the preparation of neuroprotective drugs. Neurological disorders are mainly caused by free radical formation and oxidative stress. *S. cordifolia* is rich in phenolic and flavonoid content. These phenolics and flavonoids have strong antioxidant properties (Yoshikawa, 1993; Swathy et al., 2010; Khurana and Gajbhiye, 2013).

Other prospective areas for drug formulations using these plants as an ingredient in the treatment of gonorrhea, urinary and kidney complaints, jaundice, tuberculosis, conjunctivitis, snakebite and HIV.

Pharmacological studies on the extracts of *Sida* plants provided some precautionary measures on the use of these plants in traditional medicines/ ethnopharmacological preparations. For instance, in Ghana rural women use the leaves of *S. veronicaefolia* in a broth or soup near the term of pregnancy on a belief to have painless parturition. The long term use of the leaf extracts by pregnant women in order to get relief from constipation and painful labour could lead to an unnatural acceleration to the onset of labour causing premature childbirth due to strong gastrointestinal smooth muscle relaxation activity of the extract and may induce intense uterotoxicity just like oxytocin and hence could create gynaecological complications (Martzell, 1982; Lutterodt, 1988b). The Northeast Brazilian population frequently uses the leaves of *S. cordifolia* for treatment of stomatit, asthma and nasal congestions. Long term use of this leaf extracts may cause depressant effect on CNS, cardiac ischemia and weight loss by appetite suppression due to the presence of ephedrine (**2**) and its analogues (Schier et al., 2003; Franco et al., 2005; Munhall and Johnson, 2006). Poisoning of Saanen goats fed with green aerial parts of *S. carpinifolia* was caused by the indolizidine alkaloid swainsonine (**23**), an inhibitor of lysozomal enzyme α-mannosidase. An uncharacterized bioactive principle found in the aerial parts, induced the activity of α-mannosidase antagonizing the effect of swainsonine, resulting the storage of mannose containing oligosaccharides in lysozomes of several cells such as neurons, hepatocytes and acinar pancreatic cells and resulted abnormal excretion of oligosaccharides in

urine. Hence, this plant may be used in drug formulation after removal of swainsonine and its antagonizing agent (Dorling et al., 1980; Bedin et al., 2009; Bedin et al., 2010).

Most of the reported pharmacological activities as discussed in this review are the activities of the crude extracts/ isolates of *Sida* plants. None of these pharmacological studies reported the quality and safety assurance of the ethnomedicinal preparations. Recent study on the authenticity of the raw drugs of *Sida cordifolia* in the market samples by DNA bar-coding method indicated that 76% of the market samples belonged to the other species of *Sida*. The predominant one was *Sida acuta* (36%) followed by *S. spinosa* (20%), *S. alnifolia* (12%), *S. scabrida* (4%) and *S. ravii* (4%). The remaining 24% of the samples were from the plants of other genera. This result suggested that the marketed raw plant materials should be authenticated by DNA bar-coding or HPLC and HPTLC finger print assays before their use for the preparation of ethnomedicines (Vassou et al., 2015).

11. Conclusion

As described in this review, the promising pharmacological properties of some *Sida* species namely *S. acuta, S. cordifolia*, *S. rhombifolia*, *S. spinosa* and *S. veronicaefolia* may be utilized fully in the development of nutraceutical and pharmaceutical products after further research on the plant extracts in the direction of safety, quality and efficacy assurance.

Some of the important studies necessary for utilization of these palnts in herbal drugs industry are: (i) the extensive study of different biological activities of the extracts/isolates in their ethnomedicinal preparations, (ii) study of synergistic effects of different extracts/isolates to evaluate their ability to enhance the efficacy of the additive mixture (Williamson, 2001; Wagner, 2011), (iii) the mechanism of drug action of these extracts/isolates, (iv) rigorous quantification and standardization of the bioactive fractions/ extracts/isolates/ethnomedicinal preparations. The pharamacological active extracts and ethnomedicines prepared using these extracts should be standardized on the quantity of alkaloids and other bioactive constituents by extensive HPLC and HPTLC analysis using both multireference standards (MRS) and single reference standard (SRS) so that these preparations are safe with respect to toxicity of bioactive chemicals for their long term use in humans (Jadhav et al., 2007b; Dhalwal et al., 2010; Chatterjee et al., 2013; Gurley et al., 1998; Khatoon et. al., 2005). It may be noted that high concentrations of ephedrine, vasicine, cryptolepine and swainsonine type alkaloids in the ethnomedicinal preparations may create

toxicity in humans. (v) *In vivo* detailed toxicological, pharmacological and pharmacokinetics studies in animal models of the standardized bioactive fractions / ethnomedicinal preparations and (vi) human clinical trial on potential bioactive extracts/isolates/ ethnomedicinal preparations. The plant extracts of promising activities against diarrhea and dysentery causing microbes and malarial parasites as well as activities in nasal congestions and bronchial asthma, childbirth and miscarriage problems, weight loss, rheumatic and other inflammations, cardioprotection and neuroprotection are the most prominent candidates for clinical trials.

In addition to improve the quality of ethnomedicinal preparations using these plant extracts/ isolates, the ethnobotanical knowledge of the local herbal healers/traditional medical practitioners (such as kabiraj, hakim among others) concerning the use of *Sida* plant parts along with other plant parts for the symptoms of different diseases and health disorders is needed very much to select effective ratio of plant parts for preparation of the ethnomedicines. Moreover, some of the validation studies such as conjunctivitis, veneral diseases, eye cataracts, breast cancer, piles, menstrual problems, urinary tract ailments, etc as well as studies on untouched *Sida* species are the areas of further research.

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Table 1

Morphological characteristics of different parts of common *Sida* plants

***Sida* species**	**Leaves**	**Flowers**	**Calyx & Corolla**	**Mericarps**	**Petals**	**Seeds**	**Reference (s)**
S. acuta N. L. Burman f.	Distichous, leaf blade ovate, both surfaces glabrous, stipules often longer than petiole	Usually solitary, sometimes congested at stem apex	Cup-shaped, connate in basal 6mm, mostly glabrous, lobes 5, candate, corolla often yellow	Awns absent, mericarps 5-7, often glabrous	Obovate, 6-7 mm, ciliate, apex rounded, base attenuate	Trigonous, glabrous	Barker (1998); Tang et al. (2007)
S. cordifolia Linnaeus	Ovate, leaf blade 1-5 cm	Initiary solitary but crowded apically with maturity	Cup-shaped, lobes triangular, 5-6 mm, densely stellate with long hairs, corolla yellow	Awns conspicuous, 3-4 mm, 10-11 with vertical grooves, retrorsely barbed	Oblong, 6-8 mm, shorter crowded pedicels	Long ovoid, apex hairy	Barker (1998); Tang et al. (2007)
S. cordata (Burm. f.) Borssum Waalkes	Ovate, both surfaces stellate, puberulen	Usually solitary, axillary, often on leaf	Cup-shaped, 4-6 mm, sparsely pilose with long hairs,	Without distinct awns, 5, ovoid-tetrahedral, 2.5 mm,	Slender pedicels, 1.5-4 cm	—	Tang et al. (2007)

	t		corolla yellow	glabrous			
S. rhombifolia Linnaeus	Serrate apically, entire basally, leaf blade rhombic	Solitary, axillary	Cup-shaped, 4-5 mm, abaxially stellate pubescent, lobes triangular	1 or 2-awned-mericarps 7-10, shallowly grooved to near base, puberulent	Yellow, obovate, 6-8 mm, apex rounded, base attenuate	Reniform, blackish	Barker (1998); Tang et al. (2007)
S. spinosa Linnaeus	Narrowly ovate to elliptic with densely stellate hairs	Spliraty in the leaf axils and crowded at the apices	Yellow with red veined, calyx campanulate lobes 5, triangular	5, apically 2-awned, trigonous, stallate hairy	5, subcordate	—	Lin et al. (2010)

Table 2

Geographical distribution of some common *Sida* species

***Sida* species**	**Asia**	**Africa**	**North America / Europe**	**Central America & Caribbean**	**South America**	**Oceania**	**References**
S. acuta (Burm. f.)	Bhutan, Cambodia*, Chagos Archipelago, China (Fujian, Guangdong, Guangxi, Hainan, Hong	Burundi, Cameroon, Congo, DR Congo, Egypt, Gabon, Ghana*, Kenya*, Madagascar, Mauritius,	Mexico, USA (Alabama, Arizona, Florida, Hawaii*, Louisiana, Mississippi, New Jersey, Pennsylvan	Anguilla*, Antigua & Barbuda*, Barbados*, Bahamas, Costa Rica, Cuba, Dominica*, Grenada*, Guadeloupe*,	Brazil (Bahia, Ceara, Goias, Maranho, Minas Gerais, Para, Pernambuco, Piaui, Tocantins)	Australia* (Northern Territory, New South Wales, Queensland, Western Australia), Cook Islands*, Fiji*,	Holm et al. (1977); Waterhouse and Norris (1987); Parsons and Cuthbertson (1992)

	Kong, Yunan), Christmas Island*, Cocos Islands*, India* (Gujarat, Karnataka, Kerala, Odisha, Tamil Nadu, West Bengal), Indonesia (Java, Nusa), Israel, Japan, Jordan, Laos, Malaysia*, Myanmar, Nepal, Philippines*, Singapore, Sri Lanka*, Taiwan*, Thailand*, Vietnam*	Mozambique, Nigeria*, Rwanda, Somalia, South Africa, Tanzania, Togo, Uganda, Zambia	ia, South Carolina, Texas)	Guatemala, Haiti, Honduras, Jamaica, Martinique*, Montserrat*, Netherlands Antilles*, Panama, Saint Lucia*, Trinidad & Tobago	, Colombia, Ecuador (Galapagos Islands*), Guyana, Peru, Surinam, Venezuela	French Polynesia*, Guam*, Micronesia FS*, New Caledonia*, Niue*, Northern Mariana Islands*, Papua New Guinea*, Samoa*, Solomon Islands*, Tonga*, Vanuatu*	
S. cordifolia L.	Bangladesh*, Bhutan, Cambodia, China (Fujian, Guangdong, Guangxi, Hainan,	Angola, Benin, Botswana, Burkina Faso, Burundi, Cameroon, Central African Republic,	Mexico, USA (Florida, Hawaii, Texas), Europe: Croatia, Italy	British Virgin Islands, Costa Rica, Cuba, Dominica, El Salvador, Guatemala, Haiti,	Argentina, Bolivia, Brazil* (Paraiba, Sao Paulo) Chile, Colombia, Ecuador, French Guinea,	Australia (Northern Territory), Cook Islands, Fiji, French Polynesia, Guam, Nauru,	Perumal (2001); Tang et al. (2007)

	Sichuan, Yunan), India* (Madhya Pradesh, Odisha, Tamil Nadu, West Bengal), Indonesia, Israel, Japan, Jordan, Laos, Malaysia, Myanmar, Nepal, Pakistan*, Philippines, Sri Lanka, Taiwan, Turkey	DR Congo, Egypt, Equatorial Guinea, Ethiopia, Gabon, Ghana, Guinea, Kenya, Madagascar, Mali, Mauritius, Mozambique, Namibia, Nigeria, Rwanda, Senegal, Seychelles, Somalia, South Africa, Sudan, Tanzania, Togo, Uganda, Zaire, Zambia, Zimbabwe		Honduras, Jamaica, Martinique, Netherlands Antilles, Nicaragua, Panama	Guyana, Paraguay, Peru, Uruguay	New Caledonia, Papua New Guinea, Tonga, Vanuatu	
S. rhombifolia L.	Bangladesh*, Bhutan, Cambodia, China (Fujian, Guangdong, Guangxi, Guizhu, Hainan, Hubei, Sichuan, Yunan),	Angola, Botswana, Cameroon, Canary Islands, Cape Verde, Central African Republic, DR Congo, Equatorial Guinea, Eritrea,	Mexico, USA (Alabama, California, Georgia, Hawaii, Oklahoma, South Carolina, Tennessee, Texas) Europe: France, Portugal,	Antigua & Barbuda, Bahamas, Barbados, Costa Rica, Cuba, Dominican Republic, Guadeloupe, Guatemala*, Haiti, Honduras, Jamaica,	Argentina*, Bolivia, Brazil* (Sao Paulo), Colombia, Ecuador, French Guinea, Guyana, Paraguay, Peru*, Surinam, Uruguay,	Australia* (New South Wales, Northern Territory, Queensland*, Victoria, Western Australia), Fiji, Papua New Guinea,	Perumal (2001); Tang et al. (2007); GRIN (2015)

	India* (Assam, Gujarat, Jammu, Kerala, Odisha, Sikkim, Tamil Nadu, Uttar Pradesh, West Bengal), Indonesia, Laos, Malaysia, Nepal, Philippines, Sri Lanka, Sumatra, Taiwan, Thailand, Vietnam, Yemen	Ethiopia, Gabon, Ghana, Guinea, Kenya, Liberia, Madagascar, Malawi, Mauritius, Mozambique, Niger, Nigeria, Rwanda, Senegal, Sierra Leone, South Africa, Sudan, Tanzania, Togo, Uganda, Zaire, Zambia	Spain	Martinique, Netherlands Antilles, Nicaragua, Panama, Puerto Rico, St. Lucia,	Venezuela	New Zealand, Tonga, Vanuatu	

* indicates widespread

Table-3

Ethnomedicinal uses of *Sida* species in different countries

Species	*Plant part used*	*Ethnomedicinal use*	*Country*	*Mode of preparation*	*References*
S. acuta	Leaf	Malarial fever	Nigeria	Decoction of fresh leaves	Gill (1982)

			Mexico	N/S	Frei et al. (1998)
	Leaf	Labour	Nigeria	Infusion of leaf extract	Gill (1982)
	Leaf	Wound	Nigeria	Decoction of leaves	Adetutu et al. (2011)
	Leaf	Dandruff	India	Leaf juice is mixed with coconut oil and applied on head	Silja et al. (2008)
	Leaf	Testicular swellings and elephantiasis	India	Leaf juice is boiled with coconut oil and applied on effected part	Silja et al. (2008)
	Leaf	Anthelmintic	India	Juice of fresh leaves	Akilandeswari et al.(2010a)
	Leaf	Vomiting and gastric disorders	India	Juice of fresh leaves	Ramachandran and Nair (1981)
	Leaf	Cuts	India	Decoction of leaves of *S. acuta* and *Azadirachta indica* are applied externally on cut wounds	Ramachandra Naik et al. (2012)

	Leaf	Hairloss	Mexico	Decoction of leaves	Argueta (1994)
	Leaf	Eczema, kidney stone, headache	Togo	N/S	Anani et al. (2000)
	Leaf	Dermatological	Mexico	N/S	Frei et al. (1998)
	Leaf	Panaris	Burkina Faso	Paste of leaves mixed with salt is applied on skin	Nacoulma (1996)
	Leaf and twig	Kidney disease	Mexico	Concoction	Zamora-Martinez and Pola (1992)
	Root	Cleaning of pimples	Mexico	Concoction	Zamora-Martinez and Pola (1992)
	Root	Boils and abscesses	India	Paste of roots with sparrow's dung and water is applied; Root paste in lemon juice is applied externally over infected parts	Nadkarni (1976); Shivanna and Rajakumar (2010)

	Root	Rheumatism, breathing problems and coughs	India	Decoction of fresh roots	Silja et al. (2008)
	Root	Wounds	India	Juice of roots is applied externally	Anonymous (1972)
				Hot water extract	Argueta (1994)
			Mexico		
	Root	Dysentery	Papua New Guinea	Fresh root is chewed	Holdsworth (1974)
	Root	Hemorrhoids, impotency and eye cataracts	Sri Lanka	N/S	Dash (1991); Pal and Jain (1998)
	WP	Asthma, fever, pains, ulcers, anthelmintic medication, renal inflammation and headache	Nicaragua, Guatemala	Decoction orally	Barrett (1994); Caceres et al. (1987)
	WP	Venereal diseases	Nicaragua	Decoction of dried entire plant orally	Coee and Anderson (1996b)
	WP	Febrifuge and diuretic	India	Hot water extract of entire plant	Nadkarni (1976)

				orally	
	WP	Abortifacient	India	Hot water extract of dried entire plant orally	Kholkute et al. (1978)
	WP	Bronchitis, dysentery, diarrhoea, skin diseases	India	N/S	Ignacimuthu et al. (2006)
	WP	Gastrointestinl problems	Mexico	N/S	Argueta (1994)
	WP	Snake bite	India. Taiwan, Burkina Faso, Western Colombia	Concoction	Anonymous (2003); Kao (1990); Nacoulma (1996); Otero et al. (2000)
	WP	Renal inflammation	Central America	N/S	Caceres et al. (1987)
	WP	Colic pain	Cuba and Jamaica	N/S	Morton (1981)
	WP	Sedative and enema	Haiti	N/S	Morton (1981)
	WP	Conjunctivitis	Venezuela	N/S	Morton (1981)
	WP	"Bundugo"- a supplementary	Kenya	N/S	Parkia (2005)

		strength tonic			
	WP	Malaria, ulcer, breast cancer, gonorrhoea, poisoning, inflammation, wounds	Nigeria, Ivory Coast	N/S	Kayode (2006); Edeoga et al. (2005); Kerharo and Adam (1974)
S. cordifolia	Root	Sciatica and rheumatism	India	Decoction of fresh root bark	Vasudevan Nair (2004)
	Root	Nervous disorders such as hemiplegia and facial paralysis	India	N/S	Divakar et al. (2013)
	Root	Parkinson's disease and fat loss	India	N/S	Khatoon et al. (2005); Nagashayana et al. (2000)
	Root	General weakness; mental exhaustion	India	N/S	Meena et al. (2009)
	Root	Facial paralysis	India	Paste of root bark with sesame oil and milk orally	Kapoor and Lakhera (2013)
	Root	Sunstroke	India	Paste of roots with sugar	Kapoor and Lakhera (2013)

				orally	
	Root	Leucorrhoea	India	Powdered root bark mixed with milk and sugar orally	Kapoor and Lakhera (2013)
	Root	Jaundice	India	Mixture of half cup root juice and half tablespoon sugar candy is given once daily till cured	Sarkar and Das (2010)
	Root	Eye inflammation	Burkina Faso and Tanzania	Maceration or preparation	Brink and Achigan-Dako (2012)
	Root	Abortion	Kenya and Central African Republic	Extract orally	Brink and Achigan-Dako (2012)
	Root	Urinary tract problems and fever	Benin	N/S	Brink and Achigan-Dako (2012)
	Bark	Menstruation	Kenya and Central African Republic	Chewing	Brink and Achigan-Dako (2012)
	Leaf	Hair-loss,	Colombia	Decoction	Ballesteros et al.

	and twig	constipation and fever			(2013)
	Leaf	Cuts	India	Pounded leaves	Kapoor and Lakhera (2013)
	Leaf	Ophthalmic diseases	India	Paste of leaves externally	Ajithabai et al. (2012)
	Leaf	Fever and to prevent miscarriage	Burkina Faso	Decoction	Nacoulma (1996)
	Leaf	Dysentery, sprains, swellings and intestinal worms	Senegal, Burkina Faso, Burundi, Kenya, Papua New Guinea and Philippines	Poultice to sprains and swellings; decoction orally for control of intestinal worms	Brink and Achigan-Dako (2012)
	Leaf	Rheumatism, lung disorder and fever	D.R. Congo	Infusion	Brink and Achigan-Dako (2012)
	Leaf	Pneumonia and syphilis	Rwanda	Extract	Brink and Achigan-Dako (2012)
	Leaf	Cystitis, diuretic and astringent	Mauritius	Decoction	Brink and Achigan-Dako (2012)
	Flowers & Fruits	Painful urination	India	Paste of flowers and unripe fruits	Kapoor and Lakhera (2013)

				with water orally	
	Seed	Bowel complaints and gonorrhoea	India	N/S	Anonymous (1972); Kapoor and Lakhera (2013)
	WP	Toothache and diarrhoea	India	N/S	Rahmatullah et al. (2013)
	WP	Asthma and nasal congestion	Brazil	N/S	Balbach (1978)
	WP	Throat inflammation	Brazil	Infusion	Breitbach et al. (2013)
	WP	Cough, rheumatic and abdominal pains	Burkina Faso	N/S	Nacoulma (2012)
	WP	Cancer and leukaemia	Benin	N/S	Brink and Achigan-Dako (2012)
S. veronicifolia (= *S. cordata*)	WP	Pregnancy and childbirth complaints to shorten and reduce the labour pain	Cameroon, Ghana	Maceration orally for 6 months	Yemele et al. (2015); Lutterodt (1988b)
	Leaf	Diarrhea	India	Juice	Khare (2008)

	Leaf	Cuts and bruises	India	Poultice	Khare (2008)
	Root bark	Leucorrhea and genitourinary infections	India	N/S	Khare (2008)
	Fruits & flowers	Burning sensation in micturition	India	N/S	Khare (2008)
S. cordata	Leaf	Boils	India	Paste of leaves is topically applied	Adhikari et al. (2010)
	Leaf	Diarrhea during pregnancy and cuts & bruises	India	N/S	Krishnan Nambier et al. (1985)
S. rhombifolia	AP	Snake bite and abortifacient	East and Central Africa	Hot aqueous extract orally	Holdsworth (1997)
	Root	Antivenom	India	N/S	Selvanayahgam et al. (1994)
	Root	Boils or abscesses	India	Root paste is topically applied on boils	Adhikari et al. (2010)
	Root	Rheumatism, arthritis and allied complaints as well as to	India	Decoction	Krishnan Nambier et al. (1985)

		facilitate child birth			
	Root	Tuberculosis and malaria	India	Decoction	Aminuddin et al. (1994)
	Root	Abortion	Central Africa and Borneo	Aqueous extract	Holdsworth et al. (1983)
	Root	Habitual abortion	Tanzania	Decoction mixed with *Cissampelos pareira* var. *orbiculata*	Holdworth (1997)
	Root	Abortifacient	Philippines	N/S	Quisumbing (1951)
	Root	Dysentery, diarrhoea and indigestion	Australia, Cameroon, Papua New Guinea	Root infusion orally	Cribb and Cribb (1982); Noumi and Yomi (2001); Holdsworth et al. (1983)
	Root	Tuberculosis	Europe	N/S	Mills (1994)
	Leaf & Root	Asthma, bronchitis, dyspnoea and pneumonia	Senegal, Central African Republic and Madagascar	N/S	Perumal (2001); Burkill (1997)

	WP	Rheumatic pain	India	Decoction mixed with equal proportion of cow's milk and taken orally in the morning	Bhandary et al. (1995)
	WP	Heart disease, burning sensation, urinary disorder and all kinds of inflammations	India	N/S	Ramachandra Rao et al. (2006)
	WP	Gout	Indonesia	N/S	Dharma (1985)
	WP	Pulmonary tuberculosis	Malaysia	N/S	Perumal (2001); Burkill (1997)
	WP	Irregular menses	Malaysia	Hot aqueous extract orally	Burkill (1966)
	WP	Severe fever, liver disease and body pain	Thailand	Decoction orally	Maneenoon et al. (2015)
	WP	Dermatological problems	Mexico	N/S	Heinrich et al. (1998)
	WP	Kidney inflammation, diarrhea and	Bolivia	N/S	Boom (1989)

		fever			
	WP	Dandruff, skin ailments, wound healing	Panama Mexico	N/S	Martinez Crovetto (1981); Argueta (1994)
	WP	Bile, dysentery	Mexico	N/S	Argueta (1994)
	WP	Gonorrhea	Guatemala	Infusion orally	Ceceres et al. (1995)
			Mexico	N/S	Argueta (1994)
	WP	Cough	Mozambique	Hot aqueous extract	Lentz (1993)
	Leaf	Wounds	India, Ethiopia	Crushed leaves are applied on wounds	Singh and Maheswari (1994); Megersa (2011)
	Leaf	Menstrual pain	Argentina	Mashed leaves cooked in a little water are poulticed very hot over ovaries	Morton (1981)
	Leaf	Euphoric effect	Australia	N/S	Mediherb (1995)
	Leaf	Fever, heart diseases, piles	India	N/S	Kirtikar and Basu (1987)

		and rheumatism			
	Leaf	Antihypertensive, sedative, antidiarrheal, veneral diseases	Cameroon and DR Congo	Water maceration orally	Perumal (2001); Burkill (1997)
	Leaf	Abscesses, ulcers and wounds	Equatorial Guinea, Gabon, DR Congo, Tanzania and Madagascar	Sap	Perumal (2001); Burkill (1997)
	Leaf	Scurf and itch	Philippines and Indonesia	Leaf paste mixed with coconut oil	Perumal (2001); Burkill (1997)
	Leaf	Strained muscle, labour pain and migraine	Fiji and Papua New Guinea	N/S	Perumal (2001); Burkill (1997)
	Leaf	Abortifacient	Gabon, DR Congo	Decoction	Perumal (2001); Burkill (1997)
	Leaf	Chest pain, diabetes	Central Africa	Infusion of dried leaf	Muanza et al. (1994)
	Leaf	Swelling	India	Pounded	Parrotta (2001)
	Leaf	Abscesses, conjunctivitis, dermatitis,	Guatemala	Hot aqueous extract	Caceres et al. (1987a); Coee and

		inflammation, eruptions		externally	Anderson (1996b)
	Leaf	Pain, veneral diseases, respiratory problems	Nicaragua	Decoction	Mishra and Chaturvedi (1978)
	Leaf	Gonorrhoea, tuberculosis, tumors, snake bite, diuretic and skin ulcers	Peru	N/S	Caceres et al. (1987b)
	Leaf	To stop menstrual flow	Mexico	Concoction	Zamora-Martinez and Pola (1992)
	Leaf	Skin disease, rabies and skin bleeding	Ethiopia	N/S	Megersa (2011)
	Leaf and stem	Urinary inflammation	Guatemala Mexico	Decoction Decoction	Giron et al. (1991) Argueta (1994)
	Leaf and stem	Scabies, hair loss and dandruff	Mexico	Decoction	Argueta (1994)
	Stem	Tooth brush	Gabon	Small sticks named as ‘karaba’	Perumal (2001); Burkill (1997)
	Flower	Wasp stings	Senegal, Madagascar	N/S	Perumal (2001); Burkill (1997)

	Flower and leaf	Dysentery and cleaning of open sores	Madeira, Porto Santo	Decoction for cleaning of open sores and infusion mixed with *Bidens pilosa* used for baths to relieve dysentery	Rivera and Obon (1995)
	Fruits	Headache	India	N/S	Parrotta (2001)
S. alnifolia	Root	Abortion		N/S	Perry (1980)
S. glutinosa (= *S. mysorensis*)	WP	Tuberculosis and rheumatism	India	N/S	Chopra et al. (1992)
S. spinosa	Leaf	Skin disease and snakebite	Egypt	N/S	Iwu (1993)
	Leaf	Gonorrhoea and scalding urine	India	N/S	Khare et al. (2002)
	Leaf & root	Diarrhoea and dysentery	Cameroon	N/S	Noumi and Yomi (2001)
	Root	Fever and urinary infection	India	N/S	Khare et al. (2002)
	WP	Asthma and other chest ailments	India	N/S	Prakash et al. (1981)

S. cuneifolia	WP	Fracture and sprains	Uganda	N/S	Nalubega et al. (2013)
S. corymbosa	WP	Childbirth	Nigeria	Pounded leaf extract in water orally	Attah et al. (2012)

Table 4

Chemical constituents and their evaluated biological activity from different species of *Sida* L.

Chemical constituents	**Species**	**Biological activity**	**Reference(s)**
Alkaloids			
β – Phenethylamine (**1**)	*S. cordifolia*		Ghosal et al. (1975)
	S. rhombifolia		Prakash et al. (1981)
Ephedrine (**2**)	*S. cordifolia*		Ghosh and Dutta (1930); Ghosal et al. (1975)
	S. acuta		Gunatilaka et al. (1980)
	S. rhombifolia		Prakash et al. (1981)
Ψ-(Pseudo) -Ephedrine (**3**)	*S. cordifolia*		Ghosh and Dutta (1930)

	S. rhombifolia		Prakash et al. (1981)
N-Methyl- *β*-phenethylamine (**4**)	*S. rhombifolia*		Prakash et al. (1981)
N-Methyl ephedrine (**5**)	*S. cordata*		Prakash et al. (1981)
N-Methyl *Ψ*-ephedrine (**6**)	*S. cordata*		Prakash et al. (1981)
S-(+)-N_b-Methyltryptophan methyl ester (**7**)	*S. cordifolia*		Ghosal et al. (1975)
	S. rhombifolia		Prakash et al. (1981)
Hypaphorine (**8**)	*S. cordifolia*		Ghosal et al. (1975)
Hypaphorine methyl ester (**9**)	*S. rhombifolia*		Prakash et al. (1981)
	S. spinosa		Prakash et al. (1981)
Vasicinone (**10**)	*S. cordifolia*		Ghosal et al. (1975)
Vasicine (**11**)	*S. cordifolia*		Ghosal et al. (1975)
	S. rhombifolia		Prakash et al. (1981)
Vasicinol (**12**)	*S. cordifolia*		Ghosal et al. (1975)
1,2,3,9-Tetrahydro-pyrrolo[2,1-*b*]-quinazolin-3-yl-amine (**13**)	*S. cordifolia*		Sutradhar et al. (2007a)
	S. glutinosa		Das et al. (2011)
5′-Hydroxymethyl-1′-(1,2,3,9-tetrahydro-pyrrolo[2,1-*b*]-quinazolin-1-yl)-haptan-1-one (**14**)	*S. cordifolia*	Analgesic and anti-inflammatory	Sutradhar et al. (2007a); Sutradhar et al. (2006b)
2-(1′-Aminobutyl)-indol-3-one (**15**)	*S. cordifolia*		Sutradhar et al. (2007a)
2′-(3H-Indol-3yl *methyl*)-butan-1′-ol (**16**)	*S. cordifolia*		Sutradhar et al. (2007a)
Cryptolepine (**17**)	*S. acuta*	Antimalarial ;	Banzouzi et al. (2004);

		antimicrobial and cytotoxic	Rao et al. (1984); Gunatilaka et al. (1980);Ahmed et al.(2011) Karou et al. (2005)
Quindolinone (**18**)	*S. acuta*	Cytotoxic	Jang et al. (2003)
Cryptolepinone (**19**)	*S. acuta*	Cytotoxic	Jang et al. (2003)
	S. rhombifolia	Vasorelaxant	Chaves et al. (2013)
11-Methoxyquindoline (**20**)	*S. acuta*	Cytotoxic	Jang et al. (2003)
Quindoline (**21**)	*S. acuta*	Antimicrobial	Gunatilaka et al. (1980); Karou et al. (2005)
Salt of Cryptolepine (**22**)	*S. rhombifolia*		Chaves et al. (2013)
Swainsonine (**23**)	*S. carpinifolia*	Toxicological	Colodel et al. (2002);Bedin et al., (2009)
Flavonoids			
Chrysin (**24**)	*S. glutinosa*	Antioxidant	Das et al. (2012)
5,7-Dihydroxy-4′-methoxy flavone (= Acacetin) (**25**)	*S. rhombifolia*		Chaves et al. (2013)
5,7-Dihydroxy-3-isoprenyl flavone (**26**)	*S. cordifolia*	Analgesic and anti-inflammatory	Sutradhar et al. (2008)
5-Hydroxy-3-isoprenyl flavone (**27**)	*S. cordifolia*	Analgesic and anti-inflammatory	Sutradhar et al. (2008)
Apigenin (**28**)	*S. galheirensis*		Silva et al. (2006)
Luteolin (**29**)	*S. galheirensis*		Silva et al. (2006)
Luteolin-7-*O*-*β*-D-glucopyranoside (**30**)	*S. galheirensis*		Silva et al. (2006)

Glutinoside (**31**)	*S. glutinosa*	Antioxidant	Das et al. (2011)
Kaempferol-3-*O*-*α*-L-rhamnopyranosyl-*β*-D-glucopyranoside (**32**)	*S. acuta*		Ahmed et al. (2011)
Kaempferol-3-*O*-*β*-D-glucopyranoside (**33**)	*S. acuta*		Ahmed et al. (2011)
3′-(3″,7″-Dimethyl-2″,6″-octadiene)-8-C-*β*-D-glucosyl-keampferol 3-*O*-*β*-D-glucoside (**34**)	*S. cordifolia*	Analgesic and anti-inflammatory	Sutradhar et al. (2007b); Sutradhar et al. (2006)
3′-(3″,7″-Dimethyl-2″,6″-octadiene)-8-C-*β*-D-glucosyl-keampferol-3-*O*-*β*-D-glucosyl [1→4]-*α*-D-glucoside (**35**)	*S. cordifolia*		Sutradhar et al. (2007b)
6-(Isoprenyl)-3′-methoxy-8-C-*β*-D-glucosyl-keampferol 3-*O*-*β*-D-glucosyl [1→4]-*α*-D-glucoside (**36**)	*S. cordifolia*		Sutradhar et al. (2007b)
5,4' -Dihydroxy-3,7,3' -trimethoxy flavone (**37**)	*S. galheirensis*		Silva et al. (2006)
Kaempferol-3-*O*-*β*-D (6' ' -*E*-p-coumaroyl) Glucopyranoside (**38**)	*S. galheirensis*		Silva et al. (2006)
Rutin (**39**)	*S. hermaphrodita*		Ligai and Bandyukova (1990)
Quercetin-3-*O*-glucoside (= isoquercitrin) (**40**)	*S. hermaphrodita*		Ligai and Bandyukova (1990)
Quercetin-7-*O*-glucoside (= quercimeritrin) (**41**)	*S. hermaphrodita*		Ligai and Bandyukova (1990)
Herbacetin (**42**)	*S. hermaphrodita*		Ligai and Bandyukova (1990)

Ecdysteroids			
Ecdysone (**43**)	*S. rhombifolia*		Jadhav et al. (2007a)
	S. szechuensis		Yao and Xu (2000)
	S. filicaulis		Dinan et al. (2001)
20-Hydroxyecdysone (**44**)	*S. rhombifolia*		Jadhav et al. (2007a); Jadhav et al. (2007b)
	S. spinosa		Darwish and Reinecke (2003)
	S. acuta		Dinan et al. (2001)
2-Deoxy-20-hydroxyecdysone-3-*O*-*β*-D-Glucopyranoside (**45**)	*S. rhombifolia*		Jadhav et al. (2007a)
20-Hydroxyecdysone-3-*O*-*β*-D-Glucopyranoside (**46**)	*S. rhombifolia*		Jadhav et al. (2007a)
25-Acetoxy-20-hydroxyecdysone-3-*O*-*β*-D-glucopyranoside (**47**)	*S. rhombifolia*		Jadhav et al. (2007a)
Pterosterone-3-*O*-*β*-D-glucopyranoside (**48**)	*S. rhombifolia*		Jadhav et al. (2007a)
Ecdysone-3-*O*-*β*-D-glucopyranoside (**49**)	*S. rhombifolia*		Jadhav et al. (2007a)
24(28)-Dehydromakisterone A (**50**)	*S. glutinosa*	Antioxidant	Das et al. (2012)
Sidasterone A (**51**)	*S. cordifolia*		Ghosal (1976)
	S. rhombifolia		Prakash and Ghosal (1979)
	S. spinosa		Prakash and Ghosal (1979)
Sidasterone B (**52**)	*S. cordifolia*		Ghosal (1976)
	S. rhombifolia		Prakash and Ghosal

			(1979)
20-Hydroxy-24-hydroxymethyl ecdysone (**53**)	*S. spinosa*		Darwish and Reinecke (2003)
Turkesterone (**54**)	*S. spinosa*		Darwish and Reinecke (2003)
Makisterone C (**55**)	*S. spinosa*		Darwish and Reinecke (2003)
20-Hydroxyecdysone-20,22-monoacetonide (**56**)	*S. spinosa*		Darwish and Reinecke (2003)
Ecdysterone (**57**)	*S. carpinifolia*		Pandit et al. (1976)
Polypodine B (**58**)	*S. szechuensis*		Yao and Xu (2000)
Monoterpenoids			
Vomifoliol (**59**)	*S. acuta*	Cytotoxic	Jang et al. (2003)
Loliolide (**60**)	*S. acuta*	Cytotoxic	Jang et al. (2003)
Triterpenoids			
Taraxast-1,20(30)-dien-3-one (**61**)	*S. acuta*		Chen et al. (2007)
Taraxasterone (**62**)	*S. acuta*		Chen et al. (2007)
α-Amyrin (**63**)	*S. acuta*		Rao et al. (1984)
Tocopherols			
α-Tocopherol (**64**)	*S. acuta*	Antioxidant	Chen et al. (2007)
7-Methoxymethyl-α-tocopherol (6**5**)	*S. acuta*	Antioxidant	Chen et al. (2007)
β-Tocopherol (**66**)	*S. acuta*	Antioxidant	Chen et al. (2007)
α-Tocospiro B (**67**)	*S. acuta*	Antioxidant	Chen et al. (2007)
Lignans			
4-Ketopinoresinol (**68**)	*S. acuta*		Jang et al. (2003)

(±) Syringaresinol (**69**)	*S. acuta*		Jang et al. (2003)
Acanthoside B (**70**) [= (±) Syringaresinol-*β*-D-glucoside]	*S. acuta*		Cao and Qi (1993)
Coumarins			
Scopoletin (**71**)	*S. acuta*		Jang et al. (2003)
	S. hermaphrodita		Ligai and Bandyukova (1990)
Scopoletin 7-*O*-*β*-D-glucoside (**72**)	*S. hermaphrodita*		Ligai and Bandyukova (1990)
6,7-Dimethoxy coumarin (**73**)	*S. galheirensis*		Silva et al. (2006)
Heraclenol (**74**)	*S. acuta*		Cao and Qi (1993)
Steroids			
Cholesterol (**75**)	*S. acuta*		Goyal and Rani (1988a)
	S. rhombifolia		Goyal and Rani (1988b)
	S. veronicaefolia		Goyal and Rani (1988b)
Campesterol (7**6**)	*S. acuta*		Goyal and Rani (1988a)
	S. rhombifolia		Goyal and Rani (1988b)
	S. veronicaefolia		Goyal and Rani (1988b)
	S. glutinosa		Das et al. (2011)
β-Sitosterol (**77**)	*S. acuta*		Goyal and Rani (1988a)
	S. cordifolia		Sutradhar et al. (2007a)
	S. rhombifolia	Antibacterial	Goyal and Rani (1988b); Woldeyes et al., (2013)
	S. veronicaefolia		Goyal and Rani (1988b)
	S. glutinosa		Das et al. (2011)

Stigmasterol (**78**)	*S. acuta*		Goyal and Rani (1988a)
	S. cordifolia		Sutradhar et al. (2007a)
	S. rhombifolia	Antibacterial	Goyal and Rani (1988b); Woldeyes et al., (2013)
	S. veronicaefolia		Goyal and Rani (1988b)
	S. glutinosa		Das et al. (2011)
Stigmast-7-enol (= 22-dihydrospinasterol) (**79**)	*S. acuta*		Goyal and Rani (1988a)
	S. rhombifolia		Goyal and Rani (1988b)
22-Dehydrocampesterol (**80**)	*S. rhombifolia*		Goyal and Rani (1988b)
	S. veronicaefolia		Goyal and Rani (1988b)
Spinasterol (**81**)	*S. rhombifolia*		Goyal and Rani (1988b)
24-Methylene cholesterol (**82**)	*S. rhombifolia*		Goyal and Rani (1988b)
$\Delta^{8(14)}$-Stigmastenol (**83**)	*S. rhombifolia*		Goyal and Rani (1988b)
	S. veronicaefolia		Goyal and Rani (1988b)
β-Sitosterol-3-*O*-*β*-D-glucopyranoside (**84**)	*S. rhombifolia*		Chaves et al. (2013)
	S. spinosa		Darwish and Reinecke (2003)
	S. galheirensis		Silva et al. (2006)
Stigmasterol-3-*O*-*β*-D-glucopyranoside (**85**)	*S. rhombifolia*		Chaves et al. (2013)
	S. galheirensis		Silva et al. (2006)
3*β*,6*α*,23*ε*-Trihydroxy-cholest-9(11)-ene (**86**)	*S. spinosa*		Darwish and Reinecke (2003)
Phenolics			
β-Hydroxyphenethyl *trans*-	*S. spinosa*		Darwish and Reinecke

ferulate (**87**)			(2003)
N-trans-Feruloyltyramine (**88**)	*S. acuta*	Cytotoxic	Jang et al. (2003)
Evofolin-A (**89**)	*S. acuta*	Cytotoxic	Jang et al. (2003)
Evofolin-B (**90**)	*S. acuta*	Cytotoxic	Jang et al. (2003)
Ferulic acid (**91**)	*S. acuta*	Hepatoprotective	Jang et al. (2003); Sreedevi et al., (2009)
Sinapic acid (**92**)	*S. acuta*		Jang et al. (2003)
Syringic acid (**93**)	*S. acuta*		Jang et al. (2003)
Vanillic acid (**94**)	*S. acuta*		Jang et al. (2003)
Salicylic acid (**95**)	*S. galheirensis*		Silva et al. (2006)
Chlorogenic acid (**96**)	*S. hermaphrodita*		Ligai and Bandyukova (1990)
Aliphatics			
Triacontane (**97**)	*S. spinosa*		Darwish and Reinecke (2003)
1-Eicosene (**98**)	*S. spinosa*		Darwish and Reinecke (2003)
Glyceryl-1-eicosanoate (**99**)	*S. spinosa*		Darwish and Reinecke (2003)
9-Hydroxy-*cis*-11-octadecenoic acid (**100**)	*S. spinosa*		Darwish and Reinecke (2003)
1-Triacontanol (**101**)	*S. glutinosa*		Das et al. (2011)
Docosanoic acid (**102**)	*S. glutinosa*		Das et al. (2011)
Hentriacontane (**103**)	*S. acuta*		Goyal and Rani (1988a)
Nonacosane (**104**)	*S. acuta*		Goyal and Rani (1988a)
Pristane (**105**)	*S. acuta*		Goyal and Rani (1988a)
Phytane (**106**)	*S. acuta*		Goyal and Rani (1988a)

1-*O*-Linoloyl-3-*O*-*β*-D-galactopyranosyl-*syn*-glycerol (**107**)	*S. spinosa*		Darwish and Reinecke (2003)
1-*O*-*β*-D-Glucopyranosyl-(2*S*,3*S*,4*R*,8*Z*)-2-[(2′*R*)-2′-hydroxypalmito-ylamino]-8-octadecene-3,4-diol (**108**)	*S. spinosa*		Darwish and Reinecke (2003)
(10*E*, 12*Z*)-9-Hydroxyoctadeca-10,12-dienoic acid (**109**)	*S. cordifolia*		Tamura et al. (2010)
n-Hexacos-11-enoic acid (**110**)	*S. rhombifoia*	Antimicrobial	Biftu et al. (2014)
Sterculic acid (**111**)	*S. rhombifoia*		Ahmad et al. (1976)
	S. cordifolia		Rastogi and Mehrotra (1995)
	S. acuta		Ahmad et al. (1976)
Malvalic acid (**112**)	*S. rhombifoia*		Ahmad et al. (1976)
	S. cordifolia		Rastogi and Mehrotra (1995)
	S. acuta		Ahmad et al. (1976)
(+)-Coronaric acid (**113**)	*S. cordifolia*		Rastogi and Mehrotra (1995)
Myristic acid (**114**)	*S. acuta*		Rao et al. (1973)
	S. rhombifolia		Bhatt et al. (1983)
Palmitic acid (**115**)	*S. acuta*		Rao et al. (1973)
	S. rhombifolia		Bhatt et al. (1983)
Stearic acid (**116**)	*S. acuta*		Rao et al. (1973)
	S. rhombifolia		Bhatt et al. (1983)
Oleic acid (**117**)	*S. acuta*		Rao et al. (1973)
	S. rhombifolia		Bhatt et al. (1983)

Linoleic acid (**118**)	*S. acuta*		Rao et al. (1973)
	S. rhombifolia		Bhatt et al. (1983)
Phaeophytins			
Phaeophytin A (**119**)	*S. rhombifolia*		Chaves et al. (2013)
17^3-Ethoxy Pheophorbide A (**120**)	*S. rhombifolia*		Chaves et al. (2013)
	S. galheirensis		Silva et al. (2006)
13^2-Hydroxy phaeophytin B (**121**)	*S. rhombifolia*		Chaves et al. (2013)
17^3-Ethoxy Pheophorbide B (**122**)	*S. rhombifolia*		Chaves et al. (2013)
Amino acids			
Glycine (**123**)	*S. rhombifolia*		Bhatt et al. (1983)
Alanine (**124**)	*S. rhombifolia*		Bhatt et al. (1983)
Valine (**125**)	*S. rhombifolia*		Bhatt et al. (1983)
Leucine (**126**)	*S. rhombifolia*		Bhatt et al. (1983)
Phenylalanine (**127**)	*S. rhombifolia*		Bhatt et al. (1983)
Asparagine (**128**)	*S. rhombifolia*		Bhatt et al. (1983)
Serine (**129**)	*S. rhombifolia*		Bhatt et al. (1983)
	S. hermaphrodita		Ligai and Bandyukova (1990)
Threonine (**130**)	*S. rhombifolia*		Bhatt et al. (1983)
Tyrosine (**131**)	*S. rhombifolia*		Bhatt et al. (1983)
Glutamine (**132**)	*S. rhombifolia*		Bhatt et al. (1983)
Lysine (**133**)	*S. rhombifolia*		Bhatt et al. (1983)
Histidine (**134**)	*S. rhombifolia*		Bhatt et al. (1983)
Arginine (**135**)	*S. rhombifolia*		Bhatt et al. (1983)

Aspartic acid (**136**)	*S. rhombifolia*		Bhatt et al. (1983)
	S. hermaphrodita		Ligai and Bandyukova (1990)
Glutamic acid (**137**)	*S. rhombifolia*		Bhatt et al. (1983)
	S. hermaphrodita		Ligai and Bandyukova (1990)
Proline (**138**)	*S. hermaphrodita*		Ligai and Bandyukova (1990)
Other compounds			
Choline (**139**)	*S. cordifolia*		Ghosal et al. (1975)
	S. rhombifolia		Prakash et al. (1981)
	S. acuta		Prakash et al. (1981)
Betaine (**140**)	*S. cordifolia*		Ghosal et al. (1975)
	S. rhombifolia		Prakash et al. (1981)
	S. acuta		Prakash et al. (1981)
Di- (2-ethylhexyl) phthalate (**141**)	*S. cordifolia*	Anti-inflammatory	Preethidan et al. (2013)
	S. alnifolia		Preethidan et al. (2013)
	S. acuta		Preethidan et al. (2013)
	S. mysorensis		Preethidan et al. (2013)
Phenylethyl-*β*-D-glucopyranoside (**142**)	*S. rhombifolia*	Larvicidal	Ekramul Islam et al. (2003a)

Table 5

Summary of pharmacological activities of the extracts / pure isolated compounds from different parts of *Sida* species

Activity tested	***Sida* species**	**Extract/ Isolate**	**Plant part**	***In vitro* / *In vivo***	**Model**	**Effect / Controls used**	**Dosage / duration**	**Reference(s)**
Antimicrobial	*S. acuta*	MeOH	Leaf	*In vitro*	Disc Diffusion and UV A exposure	Significant antibacterial activity at the tested concentration against *Staphylococcus aureus*, *Escherichia coli*, *Bacillus subtilis* and *Mycobacterium phlei*	2 mg/disc / 24, 48 h, 2 h for UV A	Anani et al. (2000)
	S. acuta	EtOH	AP	*In vitro*	Disc Diffusion	Significant antibacterial activity against *Staphylococcus aureus*, *Bacillus subtilis* and *Streptococcus faecalis* with MIC of 5-10 mg/mL Ciprofloxacin and amoxycilin (PCs)	200 μL disc of 25 mg/mL	Oboh et al. (2007)
	S. acuta	EtOH and H_2O	Leaf	*In vit*	Disc Diffusion	EtOH extract showed	100 μL/disc	Iroha et al. (2009)

				ro		better activity against *Staphylococcus aureus* isolated from HIV/AID patients with MIC value 0.9625 – 1.8125 μg/mL Linomycin (PC)	from 25 mg/mL (EtOH ext.) and 250 mg/mL (H_2O ext.) / 24 h	
	S. acuta	Cryptolepine and quindoline mixture	AP	*In vitro*	Disc Diffusion	Significant antibacterial activity against *E. coli*, *Shigella dysenteriae*, *Sh. boydii*, *Sh. flexneri*, *Staphylococcus aureus*, *Enterococcus faecalis* Penicillin, sulfadiazine and spectinomycin (PCs)	100 μg/disc	Karou et al. (2005); Karou et al. (2006)
	S. acuta	Alkaloid fr.	Root, stem, leaf and	*In vitro*	Disc Diffusion	Significant activity against *Staphylococcus aureus* and *Proteus mirabilis*	1 mg/disc	Jindal and Kumar (2012b)

			bud			Streptomycin (PC)		
	S. acuta	Flavonoid	Root, stem, leaf and bud	*In vitro*	Disc Diffusion	Significant antifungal activity against *Candida albicans* Terbinafine (PC)	1 mg/disc	Jindal *et al.* (2012a)
	S. acuta	EtOH, H_2O	WP	*In vitro*	Disc Diffusion	Significant activity against *E. coli* and *Streptococcus faecalis* and moderate activity against *Staphylococcus aureus* and *Pseudomonas aeruginosa*		Ibrahim et al. (2012)
	S. acuta	EtOH, $CHCl_3$,	Leaf	*In vitro*	Disc Diffusion	Both these extracts exhibited antimicrobial activity against *E. coli*, *Streptococcus aureus*, *Pseudomonas aeruginosa*, *Bacillus subtilis* and *Candida*	100 mg/disc / 24 h	Akilandeswari et al. (2010a)

						albicans Gentamicin (PC; 10mcg) / nystatin (PC; 100 units)		
	S. acuta	EtOH, H_2O	Leaf	*In vitro*	Disc Diffusion	EtOH extract showed better antimicrobial activity against *Bacillus subtilis*, *E. coli*, *Staphylococcus aureus* and weak activity against *Pseudomonas aeruginosa*, *Scopulaiopsis candida*, *Aspergillus niger* and *A. fumigates* Gentamicin and griseofulvin (PCs)	125, 250, 500, 1000 mg/mL	Ekpo and Etim (2009)
	S. acuta	Polyphenol extract	WP	*In vitro*	Disc Diffusion	Showed significant activity against *Salmonella parathyphi* B, *Klebsiella pneumoniae*, *Shigella dysenteriae*	50 μL of 5000 μg/mL extract	Karou et al. (2005)

						and *Staphylococcus aureus*		
	S. cordifolia	MeOH	Leaf and root	*In vitro*	Disc Diffusion	Both the leaf and root extracts showed moderate antibacterial activity against five bacteria, *Staphylococcus aureus*, *Escherichia coli*, *Bacillus subtilis*, *Pseudomonas fluorescense*, *Xanthonomonas axonopoelies* and mild antifungal activity against fungi, *Aspergillus flavus*, *Dreschlera turcica* and *Fusarium verticilloides*. Leaf extract had better activity MeOH (NC), Streptomycin sulphate (PC; 10μg/disc) and nystatin	100 μg/mL / 72 h	Mahesh and Satish (2008)

						(PC; 10μg/disc)		
	S. cordifolia	H_2O, MeOH	Leaf	*In vitro*	Disc Diffusion	Aqueous extract (1-2 mg/disc) showed moderate antibacterial activity against *Staphylococcus aureus*, *Enterococcus faecalis*, *Proteus mirabilis*, *Pseudomonas aeruginosa* and strong antifungal activity against *Candida albicans* and *Cryptococcus neoformans*. MeOH extract was moderately active against the bacteria Ciprofloxacin (PC; 5μg/disc) and fluconazole (PC; 25μg/disc)	175 μg-2 mg/ disc / 24 h for MHA plates, 48 h for SDA plates	Reddy *et al.* (2012)
	S. cordifoli	Alkaloid	AP	*In vit*	Disc	Exhibited significant	800 – 0.78	Ouedraogo et al.

	a	fr.		*ro*	Diffusion	antifungal activity against *Candida albicans* (2 strains), *C. krasei*, *C. parapsilosis* and *C. tropicalis* with MIC value in the range 8.33 – 12.50 μg/mL Nystatin / Clotrimazole (PC)	μg/mL / 24 h	(2012)
	S. cordifolia	PE, $CHCl_3$	Seed	*In vitro*	Disc Diffusion	Both the extracts were moderately active against *E. coli* and *Aspergillus niger* Norfloxacin (PC; 50μg/disc) and griseofulvin (PC; 50μg/disc)	100 and 300 μg/disc	Ternikar et al. (2010)
	S. cordifolia	$CHCl_3$, MeOH	Leaf, Root	*In vitro*	Disc Diffusion	Both the extracts exhibited significant activity against *Bacillus subtilis*,	100 μg/disc	Prabhakar et al. (2007a)

						Staphylococcus aureus, *B. cerius* and *Candida albicans* and moderate activity against *P. vulgaris*, *Aspergillus niger* and *A. fumigants*. Co-trimoxazol (PC)		
	S. rhombifolia	PE, $CHCl_3$, EtOAc and H_2O	Leaf	*In vitro*	Disc Diffusion	EtOAc extract showed better activity against *Bacillus subtilis*, *B. megaterium*, *Staphylococcus aureus*, *Sarchina lutea*, *E. coli*, *Shigella shiga*, *S. dysenteriae*, *S. soneii*, *S. boydu*, *Pseudomonas aeruginosa* and *Klebsiella* species Kanamycin (PC; 30μg/disc)	200 μg/disc / 24 h	Ekramul Islam et al. (2003b)

	S. rhombifolia	MeOH	Leaf	*In vitro*	Disc Diffusion	Strong antibacterial activity against *E. coli*, *Pseudomonas aeruginosa*, *Staphylococcus aureus*	30 µL/disc	Caceres et al. (1987)
	S. rhombifolia	50% EtOH	Leaf	*In vitro*	Disc Diffusion	Moderate activity against Gram negative bacteria, *Neisseria gonorrhoeae*	50 µL/disc (= 50 mg dry plant material) / 24h	Caceres et al. (1995)
	S. rhombifolia	*n*-Hexacos-11-enoic acid	Fruit, root	*In vitro*	Disc Diffusion	Moderate activity against *P. aeruginosa*, *Staphylococcus aureus*, *E. coli* and *Salmonella thyphimurium* Gentamicin (PC)	50 µg/mL / 24 h	Woldeyes et al. (2013); Biftu et al. (2014)
	S. rhombifolia	MeOH, MeOH-H_2O (4:1, 1:1, 2:3) fr.	WP	*In vitro*	Disc Diffusion	All these extracts showed significant activity against *Proteus vulgaris*, *Salmonella typhii*,	100 - 500 µg/disc / 24 h	Assam et al. (2010)

						Shigella dysenteriae and *Klebsiella pneumonia*. MeOH-H_2O (4:1) extract was most active against *S. dysenteriae*. Gentamicin with MIC of 49.40 μg/mL (PC; 133μg/disc)		
	S. rhombifolia	MeOH, EtOAc, H_2O frs.	WP	*In vitro*	Disc Diffusion	Both EtOAc and H_2O showed marked activity against *Staphylococcus aureus*, *Streptococcus mutano*, *Aspergillus niger*, *Microsporum gypseum*, *Klebsiella pneumonia*, *C. albicans*	125 - 250 mg/mL	Maunza et al. (1994)
	S. rhombifolia	Alkaloid fr.	AP	*In vitro*	Disc Diffusion	Strong activity against *Bacillus antracis*, *B. subtilis*, *E. coli*,	1 mg/mL	Mishra and Chaturvedi (1978)

						Pseudomonas aeruginosa, *Staphylococcus aureus* and *Cryptococcus neoformans*		
	S. rhombifolia	Stigmasterol, β-Sitosterol	Root	*In vitro*	Disc Diffusion	Exhibited moderate activity against *E. coli*, *Pseudomonas aeruginosa*, *Staphylococcus aureus* and *Salmonella typhimurium* Ciprofloxacin (PC)	50 µL from 100 mg/mL	Woldeyes et al. (2012)
	S. rhombifolia	PE, $CHCl_3$, MeOH	Fruit	*In vitro*	Disc Diffusion	MeOH extract showed better antibacterial activity against *Bacillus licheniformis*, *E. coli*, *Proteus vulgaris*, *Pseudomonas aeruginosa*, *Shigella flexneri*, *Bacillus subtilis*, *Staphylococcus aureus* and	100 - 300 µg/mL / 24 h	Sarangi et al. (2010)

						S. epidermis Ciprofloxacin (PC)		
	S. spinosa	EtOH	WP	*In vitro*	Disc Diffusion	Significant activity against *Bacillus subtilis*, *E. coli*, *Pseudomonas aeruginosa*, *Staphylococcus aureus* and *Candida albicans* Ciprofloxacin (PC; 5μg/disc)	50 – 500 μg/disc	Selvadurai et al. (2011)
	S. spinosa	EtOH	Leaf	*In vitro*	Disc Diffusion	Significant activity against *Bacillus subtilis*, *E. coli*, *Pseudomonas aeruginosa*, *Staphylococcus aureus*, *Candida albicans* and *Aspergillus niger* Ciprofloxacin (PC; 30μg/disc) and amphotericin B (PC; 30μg/disc)	50 – 500 μg/disc	Navaneetha-Krishnan et al. (2011)

	S. alba	Polyphenol extract	WP	*In vitro*	Disc Diffusion	Showed significant antibacterial activity against 10 bacterial strains *Shigella dysenteriae*, *Sh. boydii*, *Sh. flexneri*, *Salmonella typhii*, *Klebsiella pneumoniae*, *K. arogenes*, *E. coli*, *Enterococcus faecalis*, *Enterobacter aeruginosa* and *Proteus mirabilis* (Gram positive and Gram negative) with MIC values 12.5 – 50 μg/mL. The extract showed better activity against *E. faecalis* by killing all the microorganisms after 5h of exposition	10 μl from 100 μg/mL / 24 h	Konate et al. (2012b)

Antiplasmodial	*S. acuta*	EtOH, PE, $CHCl_3$ and H_2O, alkaloid fr.	WP	*In vitro*	Giemsa stained	EtOH extract and its $CHCl_3$ and H_2O sub-fractions showed significant activity against *Plasmodium falciparam* with IC_{50} of 4.37, 0.87 and 0.92 μg/mL, respectively. The alkaloid fraction showed strong activity against *P. falciparam* with IC_{50} of 0.05 μg/mL Chloroquine (PC)	100 – 0.19 μg/mL for extracts 1 – 0.03 μg/mL for alkaloid fr. / 24 and 72 h	Karou et al. (2003)
	S. acuta	EtOH, $CHCl_3$ and MeOH fr.	AP	*In vitro*	Radioactive micromethod using ^{3}H-hypoxanthine	MeOH fr. showed significant activity against *Plasmodium falciparam* strains, Nigerian and FeM29-Cameroon with IC_{50} of 0.5 ± 0.1 and 0.8 ± 0.01	100 – 0.01 μg/mL / 24 and 72 h	Banzouzi et al. (2004)

						μg/mL, resp. after 72 h of treatment		
	S. acuta	Cryptolepine	AP	*In vitro*	Radioactive micromethod	Showed significant activity against *Plasmodium falciparam* strains, Nigerian and FeM29-Cameroon with IC_{50} of 0.17 ± 0.04 and 0.17 ± 0.02 μg/mL, resp. after 72 h of treatment	100 – 0.01 μg/mL / 24 and 72 h	Banzouzi et al. (2004)
	S. rhombifolia	80% MeOH	Leaf	*In vivo*	Antimalarial assay against *Plasmodium berghei* infected mice	All the tested doses exhibited significant antiplasmodial activity with 50.1 – 53.9 % inhibition Chloroquine (PC)	200, 400 and 600 mg/kg / 4 d	Baye Akele et al. (2012)
Larvicidal and repellent	*S. acuta*	MeOH	Leaf	*In vivo*	WHO specification	Significant larvicidal activity against *Culex quinquefasciatus*, *Aedes aegypti* and	15-90 mg/L / 24 h	Govindarajan (2010)

						Anopheles stephensi mosquitoes with LC_{50} of 38-48 mg/L Acetone (control)		
	S. acuta	MeOH	Leaf	*In vivo*	Cage model	Strong repellent activity with 100% protection against *Anopheles stephensi* for 180 min. followed by *Aedes aegypti* (150 min.) and *Culex quinquefasciatus* (120 min.) Ethanol (control)	1.0, 2.5 and 5.0 mg/cm^2 / 10 h	Govindarajan (2010)
	S. rhombifolia	Phenyl ethyl-β-D-glucopyranoside	Stem bark	*In vitro*	Filaria vector *Culex quinquefasciatus* larvae	Significant larvicidal activity with age dependent LC_{50} , 82.52 ppm after treatment of 48 h to larvae 4th instar	10, 20, 40 and 80 ppm / 24 and 48 h	Ekramul Islam et al. (2003a)
Antiulcer	*S. acuta*	EtOH	WP	*In viv*	APPLIU, HCEIU and	Significant activity	300 mg/kg	Malairajan et al.

				o	WISIU ulcer models in rats	against aspirin plus pyrolus ligated, HCl-ethanol and water immersion stress induced ulcers with 53.69, 55.14 and 24.4 % inhibition of ulcer, respectively Rantidine, sucralfate and omeprazole (PCs)	orally / 4 h	(2006)
	S. acuta	EtOH	Leaf	*In vivo*	APPLIU, AIU, EIU ulcer models in rats	Higher dose (200 mg/kg) showed significant reduction in ulcer index in all these models, which were comparable to that of reference drug famotidine (20 mg/kg,)	100 and 200 mg/kg / 4 h	Akilandeswari et al. (2010b)
	S. cordifolia	MeOH	AP	*In vivo*	Aspirin plus ethanol induced ulcer model	Significant activity by decreasing the ulcer	500 mg/kg / 10 d	Philip et al. (2008)

					in rats	index Rantidine (PC)		
Cytotoxic	*S. rhombifolia*	EtOH	AP	*In vivo*	Brine shrimp lethality bioassay	Exhibited significant lethality against brine shrimp nauplii with LC_{50} of 40 µg/mL and LC_{90} of 80 µg/mL Gallic acid (PC)	10 – 100 µg/mL / 24 h	Rahman et al. (2011)
	S. rhombifolia	PE, $CHCl_3$, EtOAc and H_2O	Leaf	*In vivo*	Brine shrimp lethality bioassay	EtOAc and $CHCl_3$ extracts showed significant lethality with LC_{50} of 5.41 and 13.87 µg/mL respectively Gallic acid (PC)	10, 100 and 1000 µg/mL / 24 h	Ekrammul Islam et al. (2003b)
	S. acuta, S. rhombifolia	MeOH	WP	*In vitro*	HepG2	Showed highly anti-proliferative activity with CC_{50} of 461.53 and 475.33µg/mL, resp. after 24 h.	50 – 1000 µg/mL 24, 48, 72 h	Pieme et al. (2011)

	S. acuta	Quindolinone, cryptolepinone, 11-methoxy quindoline	WP	*In vitro*	QR induction assay in Hepa1c1c7 cells	Compounds showed potent QR activity with CD values in the range 0.01 – 0.12 μg/mL Sulforaphane (PC)	10 μg/mL	Jang et al. (2003)
	S. acuta	Cryptolepinone (**19**) and N-*trans*-feruloyl-tyramine (**88**)	WP	*In vitro*	DMBA induced preneoplastic lesions in MMOC	Compounds showed 83.3% and 75.0% respectively, inhibition of DMBA induced preneoplastic lesions Sulforaphane (PC)	10 μg/mL	Jang et al. (2003)
	S. acuta	Cryptolepine (**17**)	WP	*In vitro*	TRAIL resistance AGS cells	Sensitized AGS cells and induced apoptosis through caspase-3/7 activation Luteolin (PC)	1.25, 2.5 and 5 μM / 24 h	Ahmed et al. (2011)
	S. cordifolia	MeOH	Leaf	*In vitro*	HeLa cells in Trypan blue assay	Exhibited significant cytotoxicity with 30.6% of cell viability	150 μg/mL	Joseph et al. (2011)
	S.	MeOH	Lea	*In viv*	Brine shrimps	Showed moderate	400 – 6.25	Islam et al.

	cordata		f	*o*	lethality assay	cytotoxicity with LC_{50} of 263.02 μg/mL Gallic acid (PC)	μg/mL	(2014)
Hepatoprotective	*S. acuta*	MeOH	Root	*In vivo*	Paracetamol induced hepatotoxicity in rats	Significant dose-dependent hepatoprotective activity by decreasing serum SGPT, SGOT, ALP and bilirubin levels. 100 mg/kg dose showed better activity Silymarin (PC; 100mg/kg)	50, 100 and 200 mg/kg p.o / 4 d	Sreedevi et al. (2009)
	S. cordifolia	H_2O	Leaf	*In vivo*	Partial hepatectomy in rats	Lower doses of the extract (100 and 200 mg/kg) showed higher liver regeneration indices than control group	100, 200 and 400 mg/kg orally / 24 h	Silva et al. (2006)
	S. cordifolia	50% EtOH	Root	*In vivo*	Alcohol induced toxicated rats	Significantly normalized the elevated levels of toxicity marker enzymes by	50mg / 100g bw/d / 90 d	Rejitha et al. (2012); Rejitha et al. (2015)

						reducing oxidative stress and upregulating glutathione metabolism		
	S. rhomboidea (= *S. rhombifolia*)	H_2O	Leaf	*In vitro*	Oleic acid treated HepG2 cells induced NASH assay	Significantly resisted NASH by preventing lipid accumulation and LDH release	20 – 200 µg/mL / 24 h	Thounaojam et al. (2012a)
	S. rhomboidea	H_2O	Leaf	*In vivo*	High fat diet induced NASH in mice	Exhibited significant hepatoprotective effect by decreasing elevated levels of plasma marker enzymes, AST and ALT, plasma and hepatic lipids, TG and FFA, mitochondrial oxidative stress and compromising antioxidant status	HFD containing 1% extract / 16 weeks	Thounaojam et al. (2012b)
	S. rhombifolia	Powder, MeOH, H_2O	Root, AP	*In vivo*	CCl_4, paracetamol, rifampicin induced hepatotoxic	Powdered root showed maximum and significant	100 and 500 mg/kg / 24 h for CCl_4;	Rao and Mishra (1997)

					rats	hepatoprotective activity against CCl_4 toxicated rats followed by MeOH and aqueous extracts. Aqueous extract of AP showed maximum hepatoprotective activity against paracetamol and rifampicin induced toxicated rats	3 days for paracetamol; 36 h for rifampicin	
	S. cordata (= *S. veronicaefolia*)	EtOH	Leaf	*In vivo*	CCl_4 induced hepatotoxic rats	Significantly and dose dependently exhibited hepatoprotective activity by reducing elevated levels of liver marker enzymes and lipid peroxidation and normalizing defence antioxidant enzymes, GSH, SOD and CAT	100, 200 and 400 mg/kg orally / 5 d	Mistry et al. (2013)

						Silymarin (PC; 100mg/kg)		
	S. veronica efolia	EtOH, H_2O	Leaf	*In vivo*	EtOH induced hepatotoxicity in rats	Both the extracts exhibited significant hepatoprotective effect by decreasing the elevated levels of SGPT, SGOT, ALP and total bilirubin and increasing the levels of total proteins. The effects were comparable to that of silymarin (PC; 25 mg/kg)	500 mL/kg orally /21 d	Sharma et al. (2012a)
Analgesic and anti-inflammatory	*S. cordifolia*	EtOAc, MeOH	Root and AP	*In vivo*	Acetic acid induced writhing test in mice	Higher dose (600 mg/kg) of EtOAc extract of both root and aerial parts exhibited good analgesic effect by inhibiting 58 and 68 % of writhing resp. This effect was better than that of aspirin (PC;	150, 300 and 600 mg/kg orally / 20 min	RaviKanth and Diwan (1999)

						100 mg/kg)		
	S. cordifolia	EtOAc and MeOH	Root and AP	*In vivo*	Hot plate model in mice	Higher dose (600 mg/kg) of EtOAc extract of both root and aerial parts possessed less analgesic potency than that of morphine (PC; 4 mg/kg)	150, 300 and 600 mg/kg orally / 30, 60, 120 min	RaviKanth and Diwan (1999)
	S. cordifolia	EtOAc and MeOH	Root and AP	*In vivo*	Carrageenan induced paw oedema in rats	Higher dose (600 mg/kg) of EtOAc extract of root exhibited comparable anti-inflammatory activity with indomethacin (PC; 6 mg/kg) by inhibition of paw oedema (50.8 and 47 % respectively)	150, 300 and 600 mg/kg orally / 3 h	RaviKanth and Diwan (1999)
	S. cordifolia	H_2O	Leaf	*In vivo*	Carrageenan induced paw oedema in rats	Extract at the dose of 400 mg/kg exhibited significant anti-inflammatory activity (38.3%	200, 400 and 800 mg/kg orally / 1, 2, 3, 4 h	Franzotti et al. (2000)

						inhibition of oedema)		
	S. cordifolia	H_2O	Leaf	*In vivo*	Acetic acid induced writhing test in mice	Extract at higher dose (400 mg/kg) exhibited higher analgesic activity than indomethacin (PC; 5mg/kg) with writhing inhibition of 99.7% and 60.39% resp. Morphine (PC; 1mg/kg) and aspirin (PC; 10mg/kg) were also used	100, 200 and 400 mg/kg *Ip* / 30 min	Franzotti et al. (2000)
	S. cordifolia	H_2O	Leaf	*In vivo*	Arachidonic acid induced rat oedema model	Extract was ineffective to inhibit the oedema	200 mg/kg / 15, 30, 45, 60, 75, 90, 105, 120 min	Franzotti et al. (2000)
	S. cordifolia	3'-(3",7"-Dimethyl-2",6"-octadiene)- 8-C-β-D-glucosyl-kaempferol-3-O-β-D	AP	*In vivo*	Acetic acid induced writhing response in mice	Showed significant analgesic effect comparable to that of aminopyrine (PC) with writhing	25 and 50 mg/kg / 10 min	Sutradhar et al. (2006a)

		glucoside (**34**)				inhibition of 52.30 and 67.69 % respectively		
	S. cordifolia	C ompound (**34**)	AP	*In vivo*	Radiant heat tail-flick response in mice	Exhibited significant analgesic activity by increasing the stress tolerance capacity of mice (5.65 ± 0.34 sec after 120 min) Morphine (PC)	25 and 50 mg/kg bw / 30, 60, 120 min	Sutradhar et al. (2006a)
	S. cordifolia	Compoun d (**34**)	AP	*In vivo*	Carrageenan induced paw oedema in rats	Exhibited significant anti-inflammatory activity by inhibiting paw oedema volume (28.52% after 3h). It was comparable to that of phenylbutazone (PC; 80 mg/kg, 32.98% inhibition after 3h)	25 and 50 mg/kg bw / 1, 2, 3, 4, 24 h	Sutradhar et al. (2006a)
	S. cordifolia	Alkaloid **14**	AP	*In vivo*	Acetic acid induced writhing response in	Significant analgesic effect at higher dose	25 and 50 mg/kg	Sutradhar et al. (2006b)

					mice	by 47.04% inhibition of writing response compared to 67.69 % inhibition by aminopyrine (PC; 50mg/kg)		
	S. cordifolia	Alkaloid **14**	AP	*In vivo*	Carrageenan induced paw oedema in rats	Exhibited significant anti-inflammatory activity at higher dose with 22.44% inhibition of oedema after 4h compared to that(28.90% inh.) of phenylbutazone (PC; 80 mg/kg)	25 and 50 mg/kg bw / 1, 2, 3, 4, 24 h	Sutradhar et al. (2006b)
	S. cordifolia	EtOH	Root	*In vivo*	Quinolinic acid induced neurotoxicity in rat brain	Exhibited significant anti-inflammatory effect by decreasing the elevated levels of cyclooxygenase and lipoxygenase. It was comparable to that of	50 mg/ 100g bw (o.t) / 21 d	Swathy et al. (2010)

						reference drug deprenyl (PC; 100μg/100g bw)		
	S. cordifolia	5,7-Dihydroxy-3-isoprenyl flavone (**26**) and 5-hydroxy-3-isoprenyl flavone (**27**)	AP	*In vivo*	Acetic acid induced writhing test in mice	Compounds **26** and **27** showed significant analgesic effect at higher dose (50 mg/kg) by inhibiting the writhing responses of 56.92% and 54.35 % respectively.	25 and 50 mg/kg	Sutradhar et al. (2008)
	S. cordifolia	5,7-Dihydroxy-3-isoprenyl flavones (**26**) and 5-hydroxy-3-isoprenyl flavone (**27**)	AP	*In vivo*	Carrageenan induced rat oedema test	Compounds **26** and **27** showed significant acute anti-inflammatory effect at higher dose (50 mg/kg) by inhibiting paw oedema volume by 37.11% and 30.58 % resp which was comparable with phenylbutazone (PC; 80mg/kg, 31.94%	25 and 50 mg/kg / 1, 2, 3, 4, 24 h	Sutradhar et al. (2008)

						inhibition) at 3rd hour of carrageenam administration		
	S. cordifolia	EtOH	Root	*In vivo*	Acetic acid induced writhing test in mice	Exhibited significant analgesic activity by producing 44.30% inhibition of writhing Diclofenac sodium (PC)	500 mg/kg / 15 min	Momin et al. (2014)
	S. cordifolia	PE, $CHCl_3$	Seed	*In vivo*	Carrageenan induced paw oedema in rats	PE extract showed significant anti-inflammatory activity Diclofenac sodium (PC)	400 mg/kg / 0, 30, 60, 180, 300 min	Ternikar et al. (2010)
	S. cordifolia	EtOH and its $CHCl_3$ and MeOH fr.	Leaf	*In vivo*	Glutamate and formalin induced orofacial nociception in mice	In formalin test, all these extracts significantly reduced orofacial nociception. In glutamate test only $CHCl_3$ and MeOH fractions significantly and dose dependently	100, 200 and 400 mg/kg	Bonjardim et al. (2011)

						reduced orofacial nociception. All these extracts did not change motor activity		
	S. cordifolia and other *S.* species	Di-(2-ethylhexyl) phthalate (**141**)	WP	*In vitro*	LOX inhibitory assay	Significant LOX inhibitory activity with IC_{50} value of 0.217 μM Nordihydroguaiaretic acid (PC)	0.2 mM / 0-5 min	Preethidan et al. (2013)
	S. acuta and *S. cordifolia*	Aqueous Me_2CO	WP	*In vivo*	Acetic acid induced writhing test in mice	Both the plant extracts showed analgesic effect by producing significant inhibition of writhing response in dose dependent manner Paracetamol (PC)	200, 400 and 600 mg/kg / 5-20 min	Konate et al. (2012a)
	S. acuta and *S. cordifolia*	Aqueous Me_2CO	WP	*In vivo*	Formalin induced nociception	Both the plant extracts significantly inhibited the formalin induced	200, 400 and 600 mg/kg / 0-5,	Konate et al. (2012a)

						inflammation in dose dependent manner. Extract of *S. cordifolia* produced higher inhibition. Paracetamol (PC)	15-30 min	
	S. acuta	EtOAc	WP	*In vitro*	LOX inhibitory assay	About 85% LOX inhibitory activity. Ibuprofen (PC)	50 µg/mL	Konate et al. (2010)
	S. rhomboidea (= *S. rhombifolia*)	Hexane, $CHCl_3$, EtOAc, BuOH and MeOH	Leaf	*In vivo*	Acetic acid induced writhing test in mice	EtOAc extract showed significant analgesic activity with 39.2% inhibition of writhing. Aspirin (PC; 100 mg/kg)	200 mg/kg orally / 30 min	Venkatesh et al. (1999)
	S. rhomboidea	Hexane, $CHCl_3$, EtOAc, BuOH and MeOH	Leaf	*In vivo*	Carrageenan induced paw oedema in rats	BuOH extract showed comparable anti-inflammatory activity with phenylbutazone (PC; 100 mg/kg) by inhibition of paw oedema (33.05 and	200 mg/kg orally / 3 h	Venkatesh et al. (1999)

						35.83 % respectively)		
	S. rhombifolia	MeOH	AP	*In vivo*	Acetic acid induced writhing test in mice	Both the tested doses showed significant analgesic activity by producing writhing inhibition, comparable to that of reference drug diclofenac sodium (PC; 25 mg/kg)	250 and 500 mg/kg / 15 min	Rahman et al. (2011)
	S. rhombifolia	H_2O and EtOH	Root	*In vivo*	Carrageenan induced paw oedema in rats	EtOH extract (400 mg/kg) and aqueous extract (600 mg/kg) showed significant anti-inflammatory activity comparable to that of indomethacin (PC; 5 mg/kg) having inhibition of oedema 65.28%, 63.89% and 69.50% resp. after 5 h	200, 400 and 600 mg/kg / 1, 2, 3, 4 & 5 h	Logeswari et al. (2013)

	S. rhombifolia	Powder, MeOH and H_2O	Root and AP	*In vivo*	Carrageenan induced rat oedema test	MeOH extract of AP showed maximum oedema suppressant activity similar to that of indomethacin (PC). The aqueous extract followed by powder and MeOH extract of roots showed oedema suppressant effect in decreasing order	100 mg/kg for ext.; 500 mg/kg for powder / 1, 2, 3, 4, 5 h	Rao and Mishra (1997)
Antipyretic	*S. cordifolia*	MeOH	AP	*In vivo*	TAB vaccine-induced pyrexia in rats	Significant antipyretic effect comparable to that of reference drug nimesulide (PC)	500 mg/kg orally / 6 h	Philip et al. (2008)
	S. acuta	PE, Me_2CO, EtOH, H_2O	Leaf	*In vivo*	Brewers's yeast induced pyrexia in rats	EtOH extract showed better activity than the other extracts by lowering the rectal	500 mg/kg	Sharma et al. (2012b)

						temperature with time		
Antituberc ular	*S. rhombifo lia*	EtOAc, EtOH	Lea f, Ro ot	*In vit ro*	Luciferase reporter phage assay	EtOAc extracts of leaf and root at concentratio ns of 100 and 500 μg/mL showed strong antitubercula r activity against *Mycobacteriu m tuberculosis* strains (standard and clinical)	100 and 500 μg/mL	Papitha et al. (2013)
Antigout	*S. rhombifo lia*	Flavonoid fr	AP	*In vit ro*	Xanthine oxidase (XO) inhibitory assay	Inhibited XO up to 55% and lowered uric acid content	100 – 1000 mg/L	Iswantini and Darusman (2003)
	S. rhombifo lia	Flavonoid fr	AP	*In vit ro*	Kinetics of inhibition assay on XO	Exhibited competent inhibition with inhibition affinity (α) of 2.32 and had better inhibitory effect (48-71 %) than allopurinol (PC)	100 – 800 mg/L	Iswantini et al. (2009)

	S. acuta	DCM & EtOAc	WP	*In vitro*	XO-inhibitory assay	Exhibited 58% inhibition. Allopurinol (PC)	50 μg/mL	Konate et al. (2010)
Antiviral	*S. cordifolia*	(10E, 12Z)-9-Hydroxy octadeca-10,12-dienoic acid (**109**)	WP	*In vitro*	Viral inhibitory protein, Rev export inhibitory assay	Exhibited significant Rev-export inhibitory activity at 30μM concn with IC_{50} of 7.2 μM and could be potential anti-HIV drug	1 – 100 μM	Tamura et al. (2010)
	S. acuta	MeOH	Leaf		Virus induced cytopathic assay	Exhibited antiviral activity against *Herpes simplex* virus	0.1 mL from 500 pg/mL / 1 h – 4 d	Anani et al. (2000)
Vasorelaxant	*S. rhombifolia*	Cryptolepinone (**19**)	AP	*In vivo*	Mesenteric artery rings of rats	Showed significant vasorelaxation effect in rings with functional endothelium (E_{max} = 91.6 ± 4.0 %, n = 6), and this effect was changed after removal of endothelium	10^{-12} – 10^{-3} M / 3-5 min	Chaves et al. (2013)
	S. cordifoli	H_2O fr. of	Lea	*In viv*	Superior mesenteric	Produced vaso	3 – 1000	Santos et

	a	EtOH	f	*o*	artery of rats	relaxation of phenylephedrine induced contraction of artery. This effect was attenuated after removal of endothelium and after addition of atropine, L-NAME, indomethacin, high K^+ content (20 mM) and tetraethylammonium. It suggested endothelium derived factors (NO, PGI2) and K^+ channels are possibly involved in the vaso relaxation	μg/mL	al. (2006)
Anti-arthritic	*S. rhombifolia*	PE, $CHCl_3$, EtOAc, EtOH, H_2O	AP	*In vivo*	Adjuvant induced arthritis in rats; motor performance induced arthritis in rats and mean distance travelled by	Aqueous and EtOH extracts (100 mg/kg) showed significant activity by reducing paw oedema volume. Both these extracts	30 and 100 mg/kg / 4, 8, 12, 16 & 20 d	Gupta et al. (2009)

					rats	exhibited significant activity in motor performance and mean distance travelled models Diclofenac sodium (PC)		
	S. rhombifolia	EtOH	Root Stem	*In vivo*	Adjuvant induced arthritis in rats	Significant anti-arthritic effect by increasing the levels of thiobarbituric acid reactive substances, catalase and glutathione peroxidase and reducing the levels of reduced glutathione and SOD	200 mg/kg / 30 d	Narendhirakannan and Limmy (2012)
	S. rhombifolia	EtOH	Root	*In vivo*	Adjuvant induced arthritis in rats	Significant anti-inflammatory activity by increasing antioxidant potential and decreasing lipid peroxide content. Antioxidant potential was	100 mg/kg / 42 d	Gangu et al. (2011)

						enhanced by increasing the levels of SOD, GP_X, ASA Diclofenac sodium (PC; 0.5 mg/kg)		
	S. cordifolia	Powder	WP	*In vivo*	Collagenase type-II induced osteoarthritis (CIOA) in rats	Showed significant antiosteoarthritis activity by reducing rat paw volume, preventing body weight loss and knee swelling. Indomethacin (3 mg/kg) was usedas PC	270 mg/kg bw. 20 d	Nirmal et al. (2013)
Cardiovascular and cardioprotective	*S. cordifolia*	70% EtOH	Leaf	*In vivo*	Blood pressure and ECG records in non-anaesthetized, anaesthetized and vagotomised rats	Significantly reduced hypotension and bradycardia, mainly due to direct stimulation of endothelial vascular muscarinic receptor and indirect cardiac muscarinic activation,	5, 10, 20, 30 and 40 mg/kg *i.v.* / 15-30 min	Medeiros et al. (2006)

						respectively. Atropine was used as antagonist of muscarinic receptor and hexametoniu m as ganglionic blockade		
	S. cordifoli a	MeOH	Lea f	*In viv o*	Isoprotereno l (ISO) and ischemia reperfusion injury (IRI) induced myocardial injury in rats	Exhibited significant protective effect against ISO and IRI induced myocardial damage in rats by increasing endogenous antioxidants, SOD and catalase in heart tissue homogenate	100 and 500 mg/kg / 30 d	Kubavat and Asdaq (2009)
	S. acuta	MeOH	WP	*In viv o*	Heartbeat rate (HBR) and blood flow in zebrafish embryos	Significantly decreased the HBR and blood flow in cardiac cycle, which were greater than that caused by nebivolol used as positive control	-	Kannan and Vincent (2012)
	S.	EtOH	Lea	*In*	Isoprotereno	Exhibited	200,	Thounaoja

	rhombifolia		f	*vivo*	l induced myocardial necrosis in rats	significant cardioprotective effect at the dose of 400 mg/kg by decreasing heart weight, plasma lipid profile, plasma marker enzymes of cardiac damage and improving the status of enzymatic and nonenzymatic antioxidants	400 and 600 mg/kg/d, *p.o*. for 30 d	m et al. (2011a)
CNS depressive and antidepressive	*S. cordifolia*	70% EtOH	Leaf	*In vivo*	Behavioural screening, spontaneous locomotion, open field, rotarod tests,and pentobarbital induced sleep time test in mice	Exhibited depressive activity on CNS by significant reduction of spontaneous activity and decreasing ambulation and rearing in open-field test and no alternation in latency and sleep time in pentobarbital induced sleep test	1000 mg/kg *i.p.*, *p.o.* / 30, 60 & 120 min	Franco et al. (2005)

	S. tiagii	Hexane, EtOAc and residual EtOH	Fruit	*In vivo*	Forced swim test (FST) and tail suspension test (TST) in mice	Residual EtOH extract exhibited antidepressant effect in both FST and TST by reducing immobility times of mice Imipramine (PC; 15mg/kg) & fluoxetine (PC; 20mg/kg)	100, 200 and 500 mg/kg / 20 d, *p.o*	Datusalia et al. (2009)
Antidiabetic and antiobesity	*S. cordifolia*	EtOAc and MeOH	Root and AP	*In vivo*	Hypoglycaemic activity in rats	MeOH extract of the root possessed significant hypoglycaemic activity by decreasing blood sugar level (31 % reduction) after 2 h and recovered after 6 h	600 mg/kg / 0, 2, 4, 6 h	RaviKanth and Diwan (1999)
	S. cordifolia	EtOH	AP	*In vivo*	Streptozotocin induced diabetic rats	Higher dose (400 mg/kg) showed significant antidiabetic effect by decreasing TC, TG, low density lipids,	200 and 400 mg/kg / 28 d	Ahmad et al. (2014)

						plasma-creatinine, plasma-urea nitrogen and lipid peroxidation and increasing high density lipid level Glibenclamide (PC; 5 mg/kg)		
	S. cordifolia	MeOH, H_2O	AP	*In vivo*	STZ induced diabetic rats	Aqueous extract showed maximum reduction of serum glucose level at a dose of 1000 mg/kg. Metformin was PC	500, 750 and 1000 mg/kg/ 7, 14 and 21 d	Kaur et al. (2011)
	S. rhomboidea (= *S. rhombifolia*)	H_2O	Leaf	*In vitro*	3T3L1 pre-adipocyte differentiation and leptin release assays	Significantly prevented adipocyte differentiation (30 – 75% inhibition) lipid accumulation and leptin release and promoted lipolysis	10 - 200 μg/mL / 12 d	Thounaojam et al. (2011b)
	S. rhomboi	H_2O	Leaf	*In viv*	High fat diet (HFD) induced	Exhibited significant antiobsity	1% ext. with	Thounaojam et al.

	dea			*o*	obesity in mice	effect by reducing food intake, downregulating PPARγ2, SREBP1c, FAS and LEP expressions and upregulating CPT-1 in epididymal adipose tissue compared to obese mice	HFD / 20 weeks	(2011b)
	S. rhomboidea	H_2O	Leaf	*In vivo*	HFD induced insulin resistance in mice	Significant antidiabetic effect by reducing body weight, food intake and feed efficiency ratio and lowering of elevated plasma and hepatic TC, TG and FFA. It also lowered the levels of blood glucose, plasma insulin and FIRI	1 and 3% ext. of HFD	Thounaojam et al. (2010b)
	S. rhomboi	H_2O	Leaf	*In viv*	Triton and oral lipid emulsion	Exhibited significant anti-	200 and 400	Thounaojam et al.

	dea			*o*	induced hypertriglyceridemia in rats	hyperglyceridemic effect by decreasing plasma TC and TG levels and increasing HDL level compared to triton treated rats	mg/kg	(2009b)
	S. rhomboidea	H_2O	Leaf	*In vivo*	HFD-hyperlipidemic rats	Higher doses; 400 and 800 mg/kg significantly lowered the levels of plasma and tissue lipid profiles of LDL, TC, TG and TL and elevating plasma HDL level by augmenting catabolism of lipids and cholesterol. The results were comparable to reference hypolipidemic drug lovastatin (PC; 5 mg/kg)	200, 400 and 800 mg/kg / 42 d	Thounaojam et al. (2009a)
	S. tiagii	Hexane, EtOAc RES	Fruit	*In viv*	Neonatal streptozotocin induced	Residual EtOH extract (RES) showed	200 and 500	Datusalia et al.

				o	diabetic rats	significant antiglycemic activity by improving antioxidant status and lowering blood glucose and cholesterol levels. Tolbutamide (PC; 100 mg/kg) & Glibenclamide (PC; 600 µg/kg)	mg/kg / 19 d	(2012)
	S. acuta	EtOH, MeOH	Leaf	*In vivo*	Alloxan induced diabetic rats	Both the extracts significantly reduced plasma TC and TG and increased GSH and uric acid. Their hypoglycaemic and hypolipidaemic effects were comparable to that of glibenclamide (PC; 200 mg/kg)	200 and 400 mg/kg / 3 d	Ekor et al. (2010)
	S. rhombifolia	MeOH	AP	*In vivo*	Streptozotocin induced diabetic rats	Exhibited significant antihyperglyc	200 mg/kg / 2, 4, 8	Ghosh et al. (2011)

						emic effect by decreasing glycemia and blood glucose level. It showed antioxidant activity in DPPH assay with IC_{50} of 40 μg/mL. This antioxidant potency contributed to its antihyperglycemic effect	h	
	S. spinosa	EtOH	AP	*In vivo*	Alloxan induced diabetic rats	Extract exhibited antidiabetic effect by reduction of TG, TC and glucose levels in dose dependent manner. The effect of higher dose was comparable to that of reference, glibenclamide (PC; 10 mg/kg)	200 and 400 mg/kg / 10 d	Selvadurai et al. (2012)
Neurological and	*S. acuta*	EtOH	Leaf		Histology of cerebral cortex of	Exhibited hyperplasia of cells in	200, 400 and 600	Eluwa et al. (2013)

neuroprotective				rats	cortical, intermediate and sub-ventricular layers of cerebral cortex with doses of 200 and 600 mg/kg, while the extract with dose of 400 mg/kg showed hypertrophy of cells in intermediate and sub-ventricular layers	mg/kg / 14 d, o.t.	
	S. cordifolia	H_2O and its hexane, $CHCl_3$, H_2O frs.	WP	Rotenone induced oxidative stress model of PD in rats	Aqueous extract and its aqueous fraction at the dose 100 mg/kg showed neuroprotective effect by significantly attenuating the depletion of dopamine and norepinephrine levels in the mid brain regions of rotenone treated rats. The effect	50, 100, 200 mg/kg *p.o.* / 35 d	Khurana and Gajbhiye (2013)

					was comparable to that of L-deprenyl (PC; 10 mg/kg) treated group of rats. Rotenone (NC; 2mg/kg)		
Antioxidant	*S. cordifolia*	EtOH and H_2O	WP	ABTS radical scavenging assay	EtOH extract showed strong antioxidant activity with IC_{50} of 16.07 μg/mL, while H_2O extract showed mild antioxidant effect (IC_{50} of 342.82 μg/mL) Trolox (PC)	10 – 100 μg/mL for EtOH extract, 50 – 400 μg/mL for H_2O extract	Auddy et al. (2003)
	S. glutinosa	Glutinoside (**31**), chrysin (**24**) and 24 (28)-dehydro-makisterone A (**50**)	AP	DPPH assay	Compounds **31**, **24** and **50** exhibited significant antioxidant activity with IC_{50} of 28.90, 35.72 and 22.50 μg/mL, respectively, comparable to BHT (PC; IC_{50}, 16.17 μg/mL)	100 μg/mL	Das et al. (2012)

	S. rhomboidea (= *S. rhombifolia*)	MeOH	Leaf	DPPH, superoxide, H_2O_2, nitric oxide and hydroxyl radical assays	Exhibited significant antioxidant activity with IC_{50} values of 63.23 ± 1.59, 142.36 ± 2.59, 125.96 ± 3.00, 85.36 ± 2.01 and 90.45 ± 1.88 μg/mL in DPPH, superoxide radical, H_2O_2, NO^- - and hydroxyl radical assay, respectively ASA (PC)	50 – 800 μg/mL	Thounaojam et al. (2010c)
	S. cordifolia	Alkaloid fr.	AP	*In vitro*	DPPH, ABTS and FRAP assays	Moderate antioxidant activity in DPPH assay (6.63 mM of ascorbic acid / g fr.) Quercetin / Trolox (PC)	1 mg/mL / 5-15 min	Ouedraogo et al. (2012)
	S. alba and *S. acuta*	Aqueous-Me_2CO and its Hexane, CH_2Cl_2, EtOAc, *n*-BuOH frs	WP	*In vitro*	DPPH, ABTS, FRAP, lipoxygenase and xanthine oxidase inhibitory assays	EtOAc and CH_2Cl_2 fractions showed highest antioxidant and enzymatic inhibitory	1 – 10 mg/mL	Konate et al. (2010)

						activities Quercetin (PC)		
	S. cordifolia	EtOH, H_2O	WP	*In vitro*	DPPH, reducing power, NO and H_2O_2 scavenging assays	EtOH extract exhibited better and significant antioxidant activity against DPPH, reducing power, NO and H_2O_2 scavenging assays with IC_{50} values of 15, 16, 112 and 183 μg/mL, respectively and were comparable to ascorbic acid (PC)	5 – 180 μg/mL	Pawar et al. (2011)
	S. rhombifolia ssp. *retusa*	EtOH	Root, Stem, Leaf, WP	*In vitro*	DPPH, reducing power, superoxide, NO and lipid peroxidation assays	Root extract exhibited highest antioxidant activity. In DPPH assay, their scavenging activity was in the order root > leaf > WP > stem. BHT / α-tocopherol acetate (PC)	5 – 100 μg/mL	Dhalwal et al. (2007)

	S. veronicaefolia	Hexane, $CHCl_3$, 50% EtOH, H_2O	WP	*In vitro*	DPPH, H_2O_2 and reducing power assays	50% EtOH extract showed significant antioxidant activity in all these assays	2 -21.4 mg/mL	Pandey et al. (2009)
	S. cordata	MeOH		*In vitro*	DPPH assay	Significant free radical scavenging activity with IC_{50} of 190 μg/mL Ascorbic acid (PC)	500 – 10 μg/mL	Islam et al. (2014)
	S. galheirensis	EtOH and its hexane, $CHCl_3$, EtOAc, BuOH frs.	WP	*In vitro*	DPPH assay	EtOH extract showed better antioxidant activity among the tested extracts with CE_{50} of 30.8 μg/mL which was comparable to that of BHT (CE_{50} of 20.26 μg/mL). The activity of other extracts was of the order EtOAc > BuOH > EtOH > $CHCl_3$ >	24 – 143 μg/mL	Silva et al. (2006)

						hexane		
	S. acuta	7-Methoxy methyl-α-tocopherol, β-tocopherol and α-tocopherol	WP	*In vitro*	DPPH assay	Compounds exhibited strong antioxidant activity with EC_{50} of 86.9, 68.2 and 70.9 μM, respectively. Their activity was comparable to that of BHT (EC_{50} of 64.5 μM) used as positive control	6.25 – 200 μM	Chen et al. (2007)
	S. acuta	Polyphenol extract	WP	*In vitro*	ABTS and PM assay	Showed moderate activity in both assays	50 μL of 5000 μg/mL	Karou et al. (2005b)
Abortifacient and contraceptive	*S. veronicaefolia*	H_2O fr. of EtOH	Leaf and Shoot	*In vivo*	Abortifacient effects in pregnant rats	Oral dose of 32 mL/kg or intravenous dose of 6 mL/kg of extract on administration to rats from 15-17th day of pregnancy produced abortifacient effect by reducing the litters to 40%	16, 32 and 62 mL/kg orally or 3 and 6 mL/kg i.v / 15, 16, 17 d	Lutterodt (1988a)

	S. acuta	PE, $CHCl_3$, EtOH	Leaf	*In vivo*	Anti-implantation activity in female rats	EtOH extract showed significant anti-implantation activity at the dose 100 mg/kg bw/ 7d (d1 –d7 of pregnancy) compared to other extracts. EtOH extract also showed estrogenic activity in immature ovariectomized female rats Ethinyl estradiol (1 μg/rat) + EtOH (PC)	50 and 100 mg/kg	Londonkar et al. (2009)
	S. rhombifolia	EtOH, H_2O	WP	*In vivo*	Anti-plantation activity in female rats	Exhibited anti-plantation activity	1 – 2 g/kg / 5 d	Satthawongsakul (1980)
Spasmogenic	*S. veronicaefolia*	H_2O fr. of EtOH	Leaf and Shoot	*In vivo*	Effect on isolated guinea pig and isolated rabbit duodenum	Exhibited spasmogenic response in presence of antagonists, atropine and mepyramine suggesting its muscarinic site of action	0.1×10^{-3}, 5×10^{-3}, 25×10^{-3} μg/mL / 30 s	Lutterodt (1988b)

	S. corymbosa	Aqueous	WP	*In vitro*	Uterine contractility assay in human uterine myometrial muscle cells	Showed dose-dependent increase in uterine contractility. Oxytocin (100 nM) was PC	200 and 400 µg.mL 2.5 – 3.5 h	Attah et al. (2012)
Antivenom	*S. acuta*	EtOH	WP	*In vitro*	Neutralization of *Bothrops atrox* venom	Exhibited moderate neutralization (34 ± 3 %) of *B. atrox* venom (PC)	7.8 – 4000 µg/ mouse / 2 h	Otero et al. (2000)
Nephroprotective	*S. rhomboidea*	EtOH	Leaf	*In vivo*	Gentamicin induced nephrotoxicity and renal dysfunction in rats	Exhibited significant nephroprotective effect by decreasing the elevated levels of plasma and urine, urea and creatinine, renal lipid peroxidation and increasing the status of renal enzymatic and non-enzymatic antioxidants Gentamicin (100 mg/kg/d; *i.p.*)	200 and 400 mg/kg *p.o.* / 8 d	Thounaojam et al. (2010a)

	S. cordifolia	H_2O	Root	*In vivo*	Gentamicin and cisplatin induced nephrotoxicity in rats	Higher dose (400 mg/kg) of extract showed significant nephroprotective effect in both gentamicin (100 mg/kg/d) and cisplatin (7 mg/kg/alt.d) induced nephrotoxicity in rats by normalizing the increased levels of renal markers, serum creatinine and urea, urine creatinine and BUN.	200 and 400 mg/kg / 8 d, 10 d, resp.	Makwana et al. (2012)
	S. cordifolia	EtOH, H_2O	Leaf	*In vivo*	Gentamicin induced nephrotoxicity in rats	Both the extracts produced significant nephroprotective effect by decreasing the elevated levels of serum creatinine and urea, urine creatinine and BUN.	200 and 400 mg/kg / 8 d	Lovkesh et al. (2012)

						Higher dose of EtOH extract had better activity Gentamicin (100 mg/kg/d;		
Toxicological	*S. carpinifolia*	-	WP		Blood enzyme and urine oligosaccharide assay of Saanen goats fed with *S. carpinifolia*	Saanen goats faced toxicological effect due to induction of α-mannosidase activity in leukocytes by 3-4 fold and abnormal excretion of mannose-rich oligosaccharides in urine on consumption of this plant for 28 – 60 days. Phytochemicals of this plant responsible for this activity could be used in human α-mannosidosis	500 g / goat / day; 5, 15, 20, 28, 40, 60, 94 d	Bedin et al. (2010);Bedin et al.(2009)
Immuno-stimulatin	*S. cordifoli*	Alkaloid fr.	AP	*In viv*	Cyclosporin (25 mg/kg)	Exhibited low immuno-	50, 100 and 200	Ouedraogo et al.

g	*a*			*o*	induced immune system in rats	stimulating effect by decreasing haematological (TWBC and lymphocytes) and serological (CD8 and CD4) parameters compared to control groups	mg/kg / 28 d	(2012)
Wound healing	*S. acuta*	MeOH	WP	*In vivo*	Excision and incision wound models in rats	In excision model, the extract showed faster epithelialisation and higher rate of wound contraction at the higher dose compared to control. In incision model, the extract facilitated the healing process by increasing the tensile strength of the wound. The results were comparable	5 and 10%	Akilandeswari et al. (2010c)

						to standard drug nitrofurazone (PC)		
	S. cordifolia	EtOH	WP	*In vivo*	Excision, incision and burn wound models in rats	In excision model, the extract showed faster re-epithelialization and decrease in wound area compared to control. In incision and burn models, the extract increased the healing process by increasing the tensile strength of the wounds. Extract and standard treated groups showed better healing process within 14 and 10 days, respectively. Silver sulfadiazine was used as standard	10%	Pawar et al. (2013)

						drug (PC).		
Antidiarrheal	*S. rhombifolia*	MeOH	Root	*In vivo*	Castor oil induced diarrhoea in rats and mice	Extract (400 mg/kg) produced significant antidiarrheal activity by reducing the total number and total weight of faeces with 67.41 and 72.91% inhibition, respectively. It also reduced the intestinal transit of charcoal meal in rats (61.84% inhibition) Diphenoxylate (PC; 50 mg/kg)	200 and 400 mg/kg / 2 d	Sarangi et al. (2011)
Antistress and adaptogenic	*S. cordifolia*	EtOH	Root	*In vivo*	Cold restraint stress and swim endurance in mice	Extract exhibited cold restraint stress activity by decreasing the elevated level of total WBC count, blood glucose and plasma cortisone and adaptogenic	100 mg/kg	Sumanth and Mustafa (2009)

						activity by significant increase in swimming time		
Anthelmintic	*S. cordifolia*	EtOH, H_2O	WP	*In vitro*	Paralysis time of earthworm	Aqueous extract at the tested doses exhibited significant anthelmintic activity against earthworm (*Pheretima posthuma*), comparable to reference drug albendazole (PC; 10-40 mg/mL)	10, 20, 30 and 40 mg/mL	Pawar et al. (2011)
Diuretic	*S. cordifolia*	PE, $CHCl_3$, EtOAc, MeOH	Root	*In vivo*	Diuretic potency in rats	$CHCl_3$, EtOAc and MeOH extracts exhibited dose dependent diuretic activity by increasing the Na^+, K^+, Cl^- levels	250 and 500 mg/kg	Prabhakar et al. (2007b)
	S. spinosa	H_2O, EtOH	Leaf	*In vivo*	Diuretic potency in rats	Both the extracts showed diuretic activity by increasing	100 mg/kg	Narendra Naik et al. (2011)

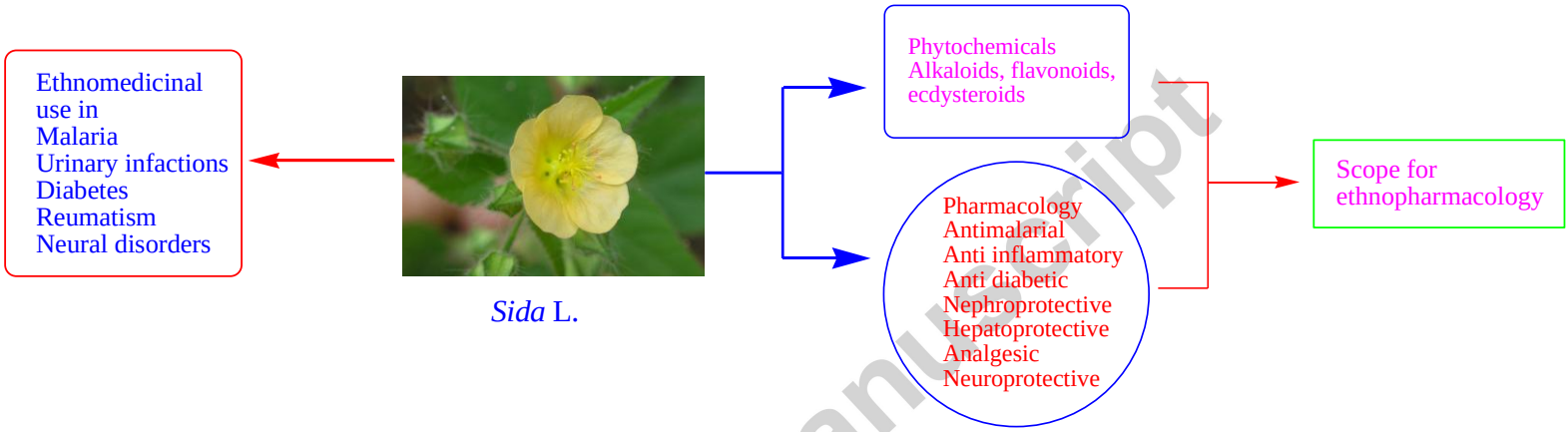
						excretion of urine volume, Na^+, K^+, Cl^- ions. Furosemide was used as reference diuretic		
Anti-atherosclerotic	*S. rhomboidea*	H_2O	Leaf	*In vitro*	Oxidized LDL-induced macrophage apoptosis	Extract significantly resisted copper and cell mediated LDL oxidation, mitochondrial dysfunction, nuclear condensation and apoptosis in oxidized LDL exposed human monocyte derived macrophages		Thounaojam et al. (2011c)
Anti-anxiety	*S. rhombifolia*	PE, EtOH	WP	*In vivo*	Elevated Plus Maze model in mice	EtOH extract produced significant anti-anxiety effect, comparable to that of positive control diazepam (2 mg/kg)	300 mg/kg orally / 45 min prior to study	Sundaraganapathy et al. (2013)

Fig. 1. Chemical structures of compounds form different *Sida* species.

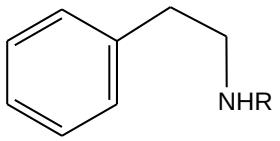
Graphical Abstract

The genus *Sida* L. a traditional medicine: Its ethnopharmacological, phytochemical and pharmacological data for commercial exploitation in herbal drugs industry

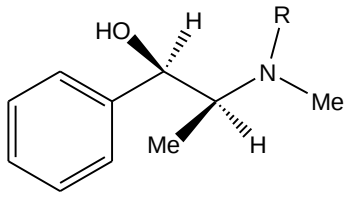
Biswanath Dinda*, Niranjan Das, Subhajit Dinda, Manikarna Dinda, Indrajit SilSharma



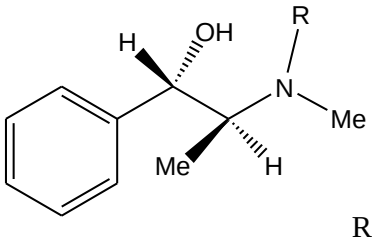
a. Alkaloids



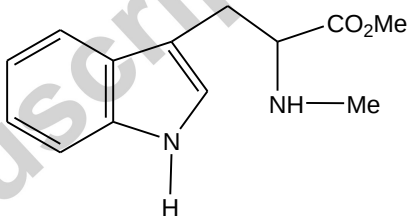
	R
β-Phenethylamine **(1)**	H
N-Methyl-β-phenethylamine **(4)**	Me



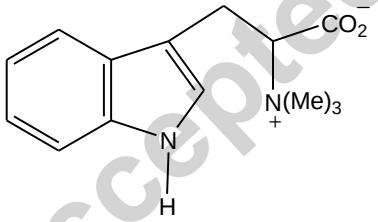
	R
Ephedrine **(2)**	H
N-Methyl ephedrine **(5)**	Me



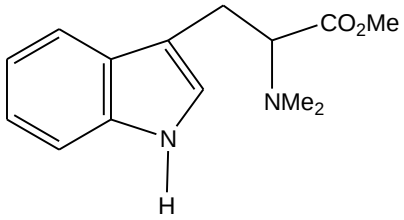
	R
Ψ-Ephedrine **(3)**	H
N-Methyl Ψ-ephedrine **(6)**	Me



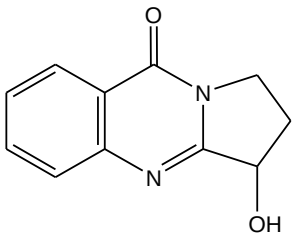
S-(+)-N_b-Methyltryptophan methyl ester **(7)**



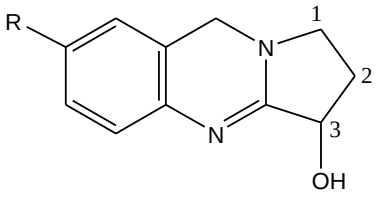
Hypaphorine (**8**)



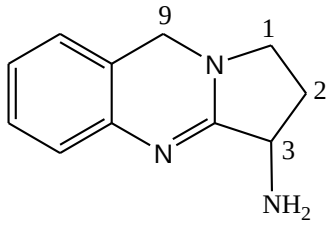
Hypaphorine methyl ester (**9**)



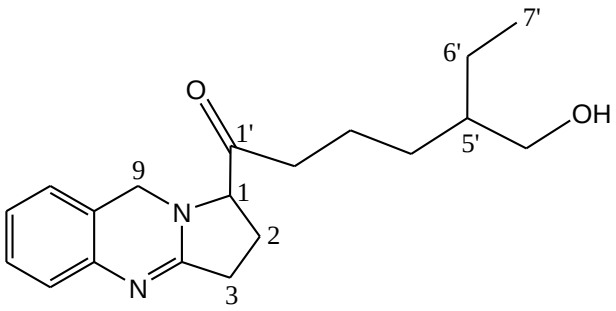
Vasicinone (**10**)



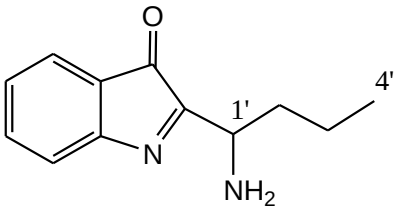
	R
Vasicine (**11**)	H
Vasicinol (**12**)	OH



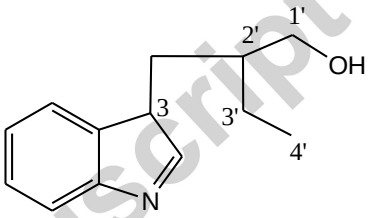
1,2,3,9-Tetrahydro-pyrrolo[2,1-*b*]-quinazolin-3-yl-amine (**13**)



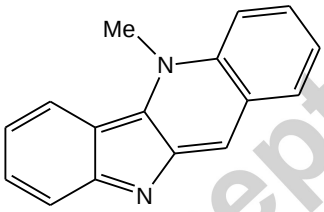
5'-Hydroxymethyl-1'-(1,2,3,9-tetrahydro-pyrrolo[2,1-*b*]-quinazolin-1-yl)-haptan-1-one (**14**)



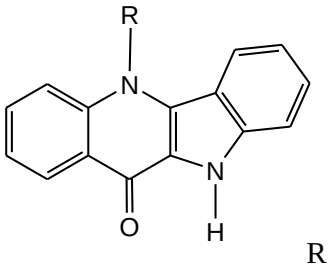
2-(1'-Aminobutyl)-indol-3-one (**15**)



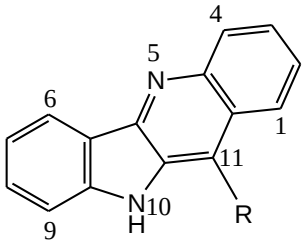
2'-(3H-Indol-3yl methyl)-butan-1'-ol (**16**)



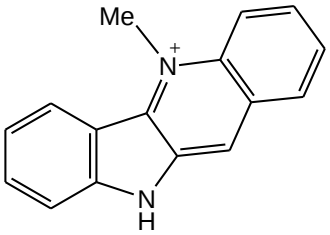
Cryptolepine (**17**)



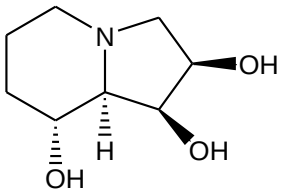
	R
Quindolinone (**18**)	H
Cryptolepinone (**19**)	Me



	R
11-Methoxyquindoline (**20**)	OMe
Quindoline (**21**)	H

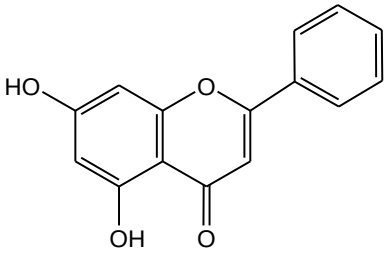


Salt of Cryptolepine (**22**)

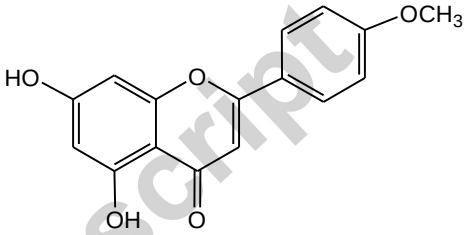


Swainsonine (**23**)

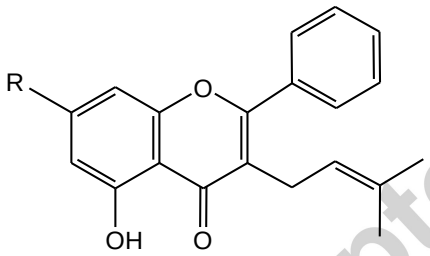
b. Flavonoids



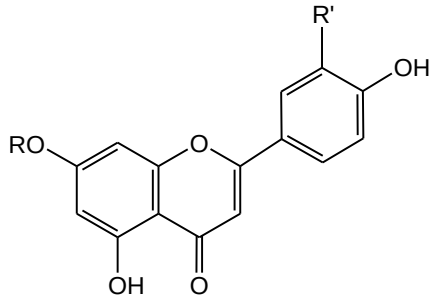
Chrysin (**24**)



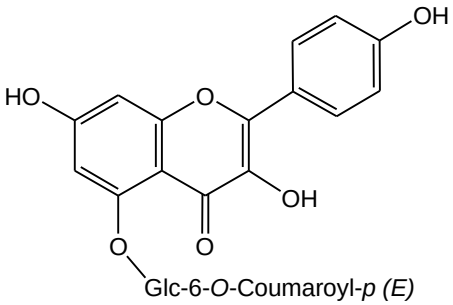
5,7-Dihydroxy-4'-methoxy flavone (= Acacetin) (**25**)



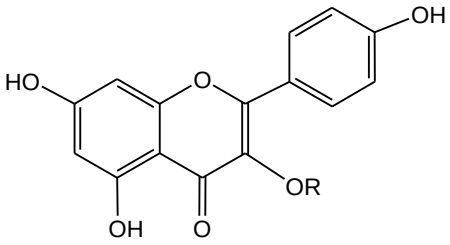
	R
5,7-Dihydroxy-3-isoprenyl flavone (**26**)	OH
5-Hydroxy-3-isoprenyl flavone (**27**)	H



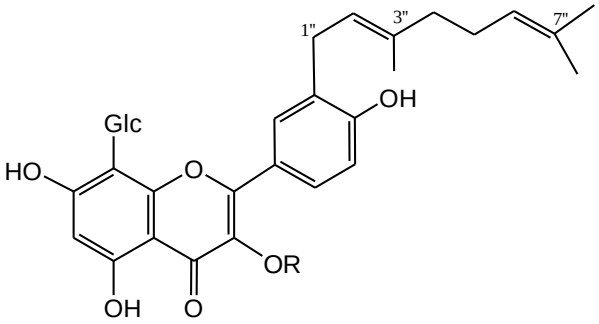
	R	R'
Apigenin (**28**)	H	H
Luteolin (**29**)	H	OH
Luteolin-7-O-β-D-glucopyranoside (**30**)	Glc	OH



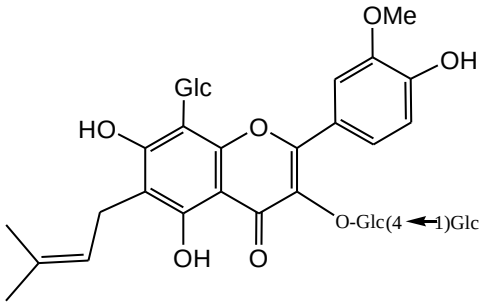
Glutinoside (**31**)



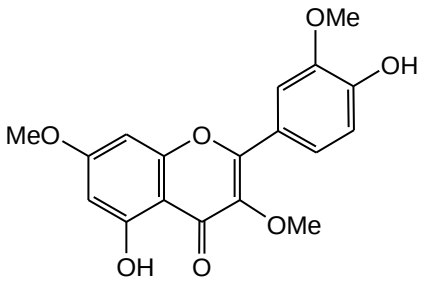
	R
Kaempferol-3-O-α-L-rhamnopyranosyl-β-D-glucopyranoside (**32**)	-Glc(6 ← 1)Rha
Kaempferol-3-O-β-D-glucopyranoside (**33**)	-Glc



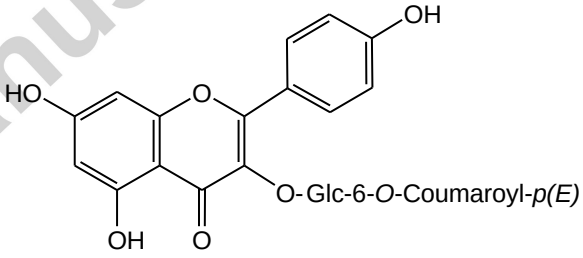
	R
3'-(3",7"-Dimethyl-2",6"-octadiene)-8-*C*-β-D-glucosyl-keampferol 3-*O*-β-D-glucoside (**34**)	-Glc
3'-(3",7"-Dimethyl-2",6"-octadiene)-8-*C*-β-D-glucosyl-keampferol-3-*O*-β-D-glucosyl [1→4]-α-D-glucoside (**35**)	-Glc(4←1)Glc



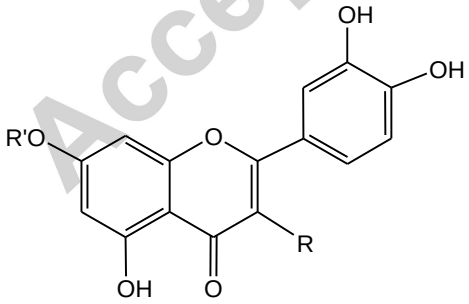
6-(Isoprenyl)-3'-methoxy-8-*C*-β-D-glucosyl-keampferol 3-*O*-β-D-glucosyl [1→4]-α-D-glucoside (**36**)



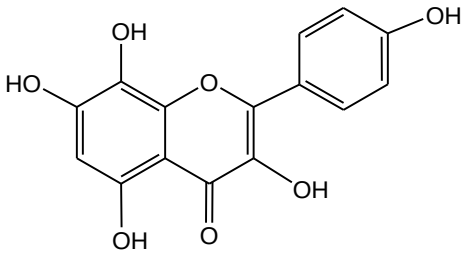
5,4'-Dihydroxy-3,7,3'-trimethoxy flavone (**37**)



Kaempferol-3-*O*-β-D (6"-*E*-*p*-coumaroyl) Glucopyranoside (**38**)

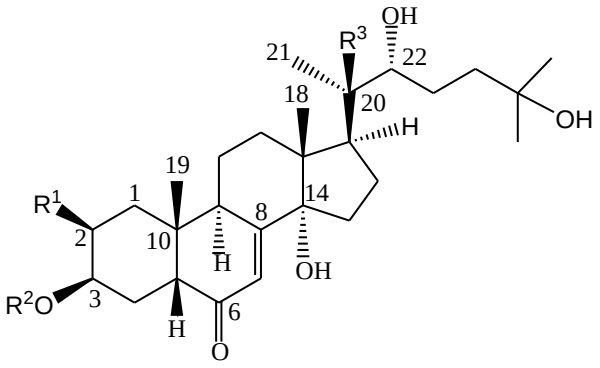


	R	R'
Rutin (**39**)	Glc(6←1)Rha	H
Quercetin-3-*O*-glucoside (= isoquercitrin) (**40**)	Glc	H
Quercetin-7-*O*-glucoside (= quercimeritrin) (**41**)	H	Glc

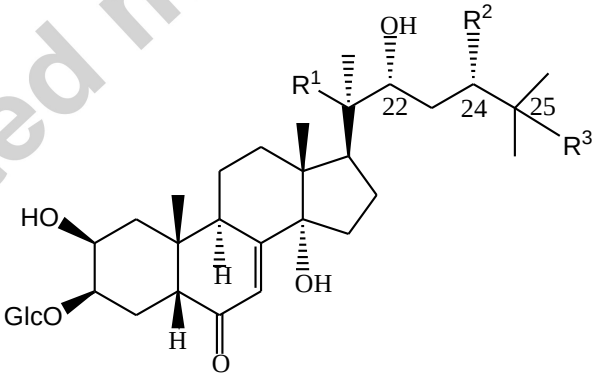


Herbacetin (**42**)

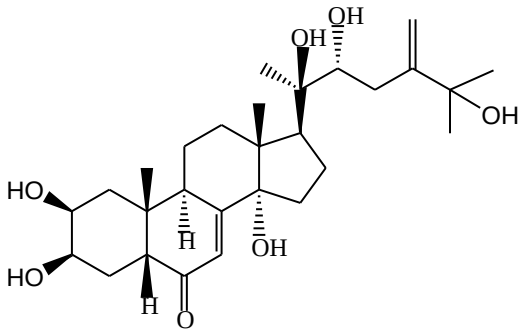
c. Ecdysteroids



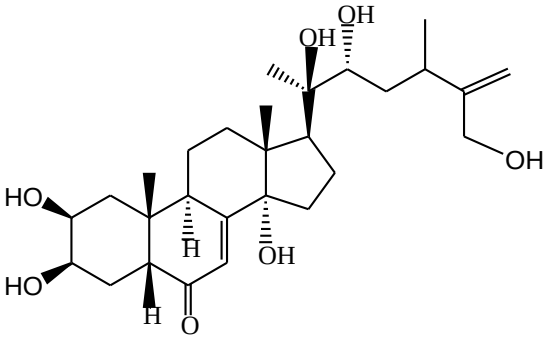
	R^1	R^2	R^3
Ecdysone (**43**)	OH	H	H
20-Hydroxyecdysone (**44**)	OH	H	OH
2-Deoxy-20-hydroxyecdysone-3-*O*-β-D-Glucopyranoside (**45**)	H	Glc	OH
20-Hydroxyecdysone-3-*O*-β-D-Glucopyranoside (**46**)	OH	Glc	OH



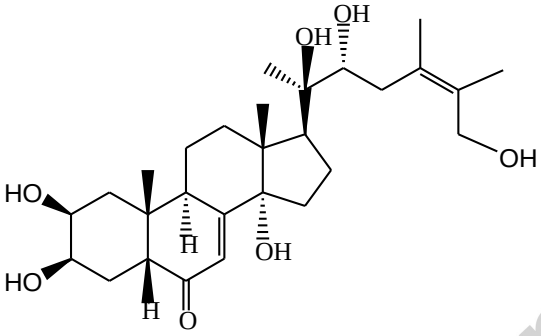
	R^1	R^2	R^3
25-Acetoxy-20-hydroxyecdysone-3-*O*-β-D-glucopyranoside (**47**)	OH	H	OAc
Pterosterone-3-*O*-β-D-glucopyranoside (**48**)	OH	OH	H
Ecdysone-3-*O*-β-D-glucopyranoside (**49**)	H	H	OH



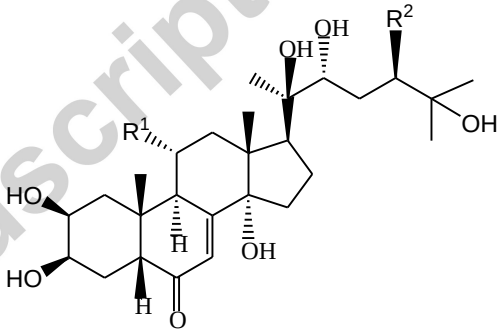
24(28)-Dehydromakisterone A (**50**)



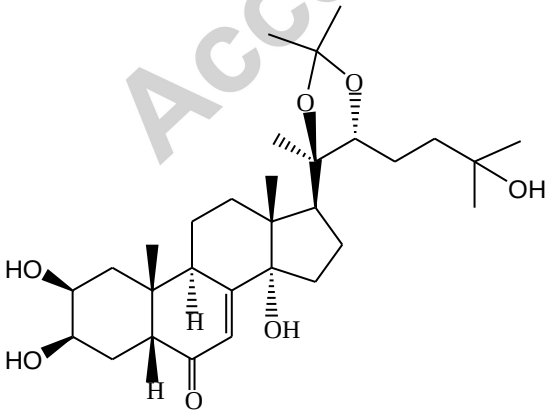
Sidasterone A (**51**)



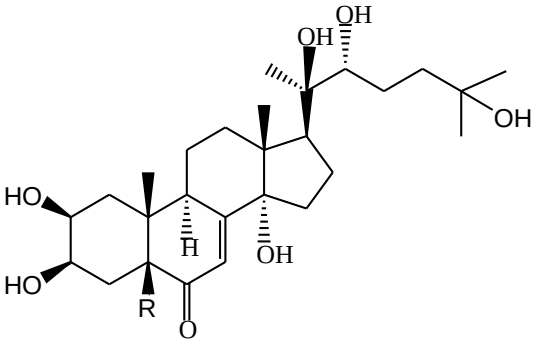
Sidasterone B (**52**)



	R^1	R^2
20-Hydroxy-24-hydroxymethyl ecdysone (**53**)	H	CH_2OH
Turkesterone (**54**)	OH	H
Makisterone C (**55**)	H	CH_2CH_3

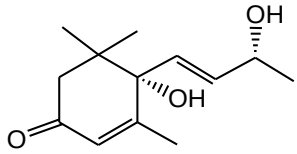


20-Hydroxyecdysone-20,22-monoacetonide (**56**)

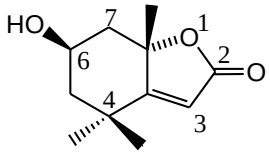


	R
Ecdysterone (**57**)	H
Polypodine B (**58**)	OH

d. Monoterpenoids

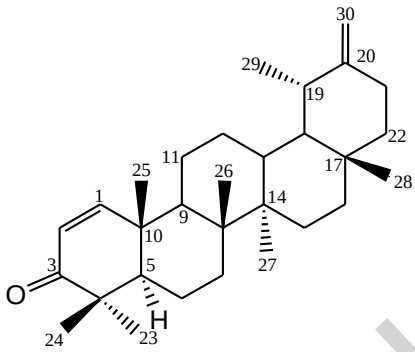


Vomifoliol (**59**)

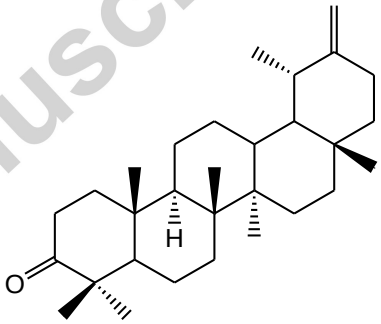


Loliolide (**60**)

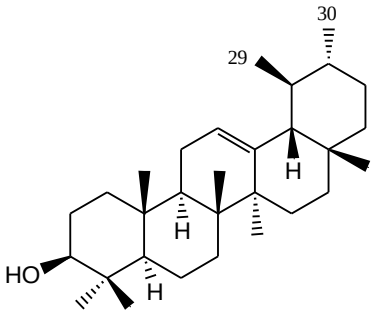
e. Triterpenoids



Taraxast-1,20(30)-dien-3-one (**61**)

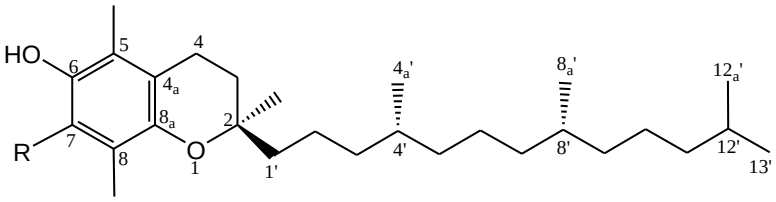


Taraxasterone (**62**)



α-Amyrin (**63**)

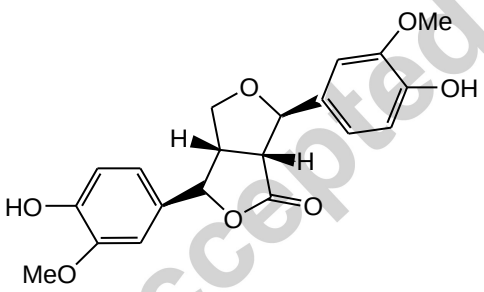
f. Tocopherols



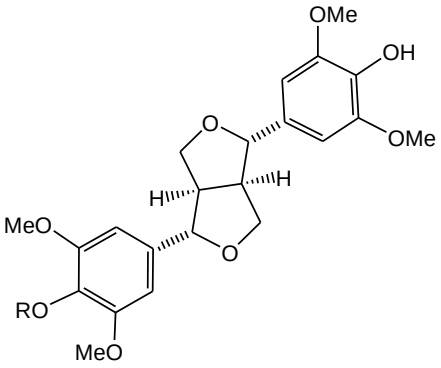
	R
α-Tocopherol (**64**)	Me
7-Methylmethoxy-α-tocopherol (**65**)	CH_2OMe
β-Tocopherol (**66**)	H

α-Tocospiro B (**67**)

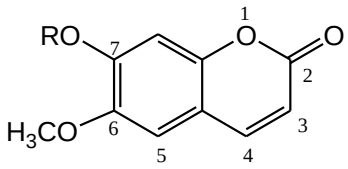
g. Lignans



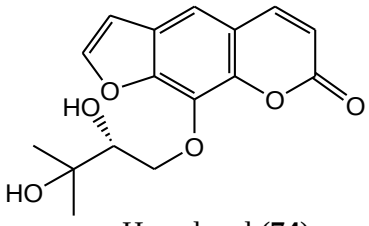
4-Ketopinoresinol (**68**)



	R
(±) Syringaresinol (**69**)	H
Acanthoside B (**70**)	Glc

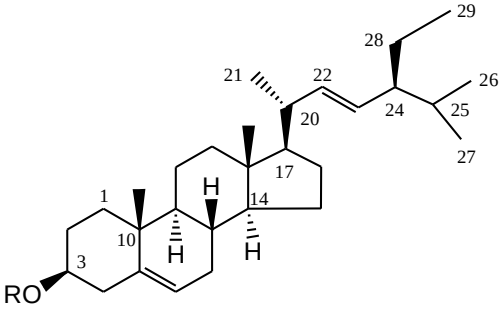


	R
Scopoletin (**71**)	H
Scopoletin 7-*O*-β-D-glucoside (**72**)	Glc
6,7-Dimethoxy coumarin (**73**)	Me

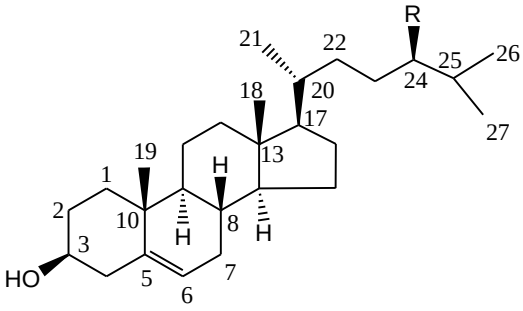


Heraclenol (**74**)

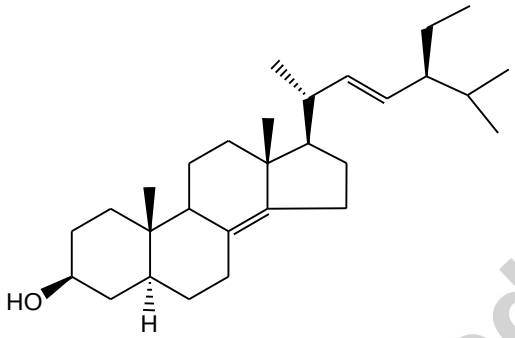
h. Steroids



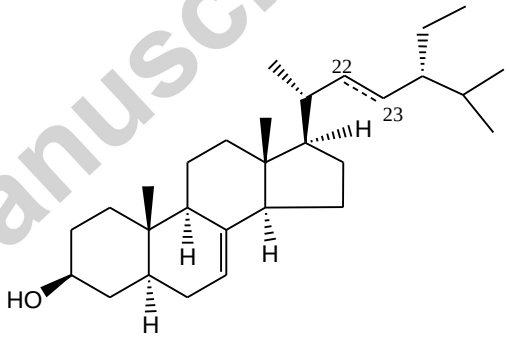
	R
Stigmasterol (**78**)	H
Stigmasterol-3-*O*-β-D-glucopyranoside (**85**)	Glc



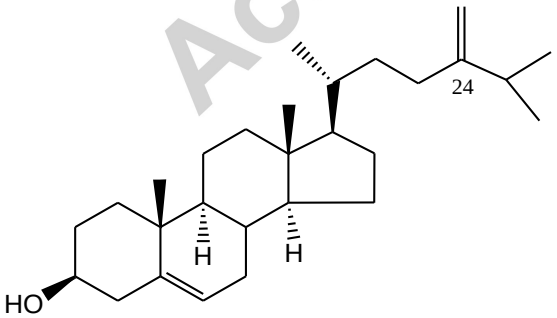
	R
Cholesterol (**75**)	H
Campesterol (**76**)	Me
β-Sitosterol (**77**)	Et
22-Dehydrocampesterol (**80**)	Me, $\triangle^{22}$



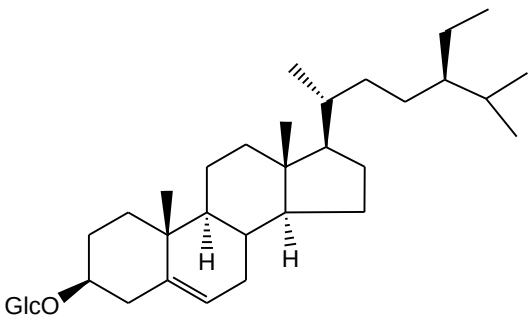
$\triangle^{8(14)}$-Stigmastenol (**83**)



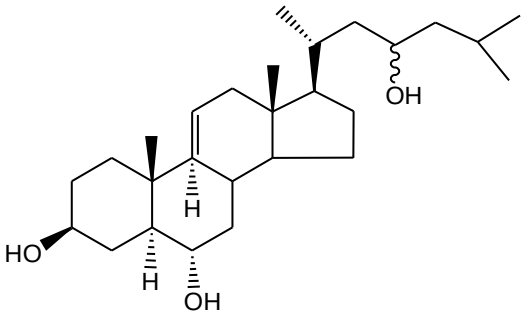
Stigmast-7-enol (= 22-dihydrospinasterol) (**79**)	22,23-dihydro
Spinasterol (**81**)	22,23-dehydro



24-Methylene cholesterol (**82**)

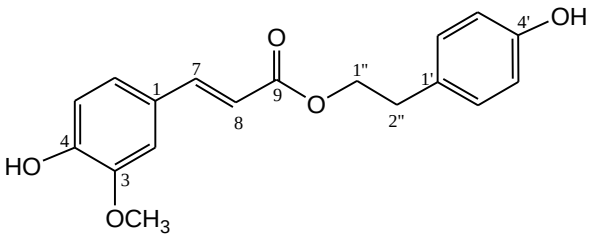


β-Sitosterol-3-*O*-β-D-glucopyranoside (**84**)

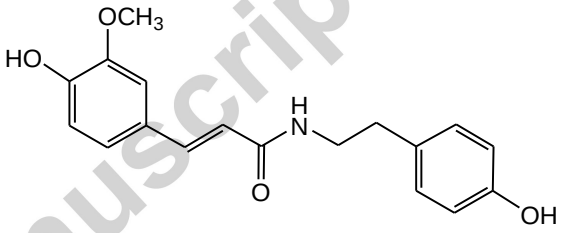


3β,6α,23e-Trihydroxy-cholest-9(11)-ene (**86**)

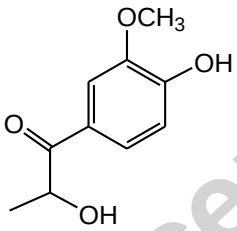
i. Phenolics



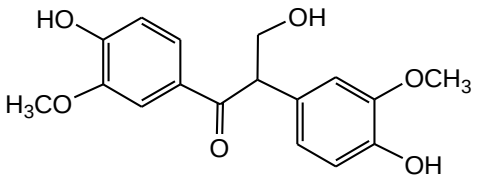
β-Hydroxyphenethyl *trans*-ferulate (**87**)



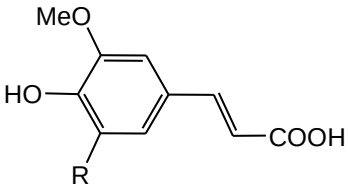
N-trans-feruloyltyramine (**88**)



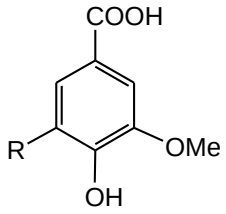
Evofolin-A (**89**)



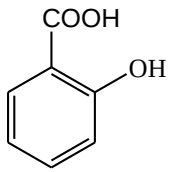
Evofolin-B (**90**)



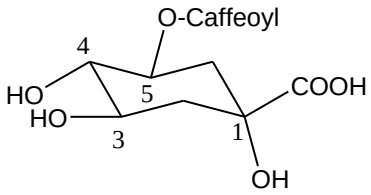
	R
Ferulic acid (**91**)	H
Sinapic acid (**92**)	OMe



	R
Syringic acid (**93**)	OMe
Vanillic acid (**94**)	H

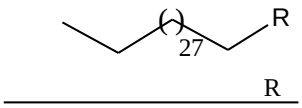


Salicylic acid (**95**)

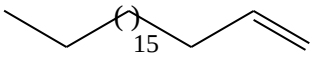


Chlorogenic acid (**96**)

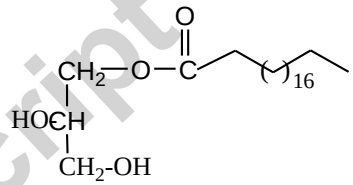
j. Aliphatics



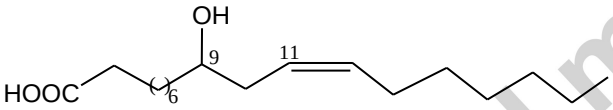
	R
Triacontane (**97**)	H
1-Triacontanol (**101**)	OH
Hentriacontane (**103**)	Me



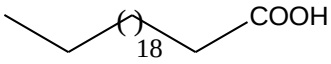
1-Eicosene (**98**)



Glyceryl-1-eicosanoate (**99**)

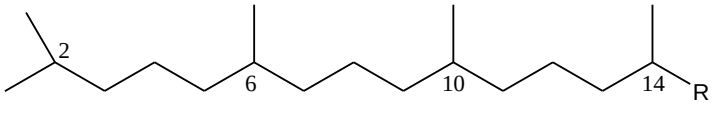


9-Hydroxy-*cis*-11-octadecenoic acid (**100**)

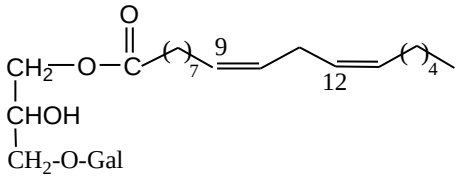


Docosanoic acid (**102**)

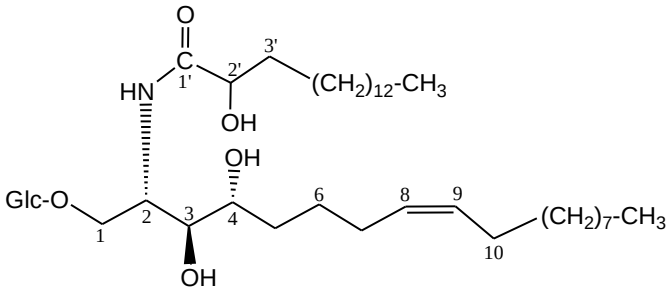
Nonacosane (**104**)



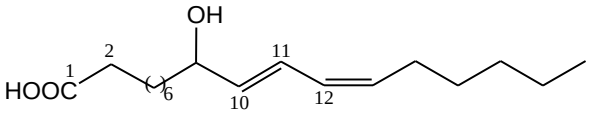
	R
Pristane (**105**)	Me
Phytane (**106**)	Et



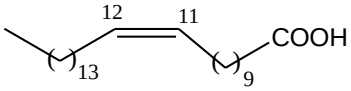
1-*O*-Linoloyl-3-*O*-β-D-galactopyranosyl-*syn*-glycerol (**107**)



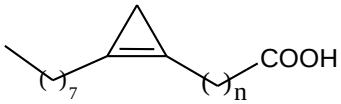
1-*O*-β-D-Glucopyranosyl-(2*S*,3*S*,4*R*,8*Z*)-2-[(2'*R*)-2'-hydroxypalmito-ylamino]-8-octadecene-3,4-diol (**108**)



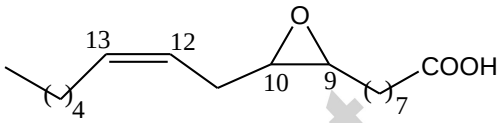
(10*E*, 12*Z*)-9-hydroxyoctadeca-10,12-dienoic acid (**109**)



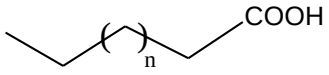
n-Hexacos-11-enoic acid (**110**)



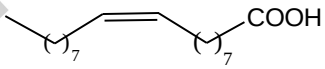
	n
Sterculic acid (**111**)	7
Malvalic acid (**112**)	6



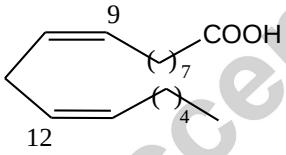
(+)-Coronaric acid (**113**)



	n
Myristic acid (**114**)	10
Palmitic acid (**115**)	12
Stearic acid (**116**)	14

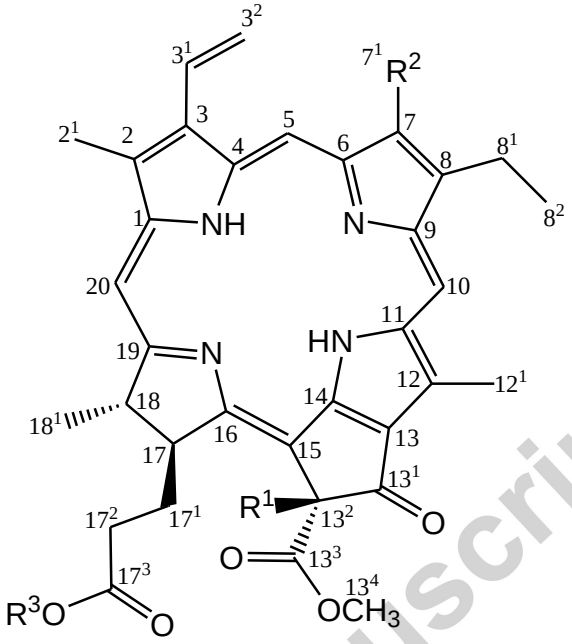


Oleic acid (**117**)



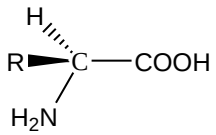
Linoleic acid (**118**)

k. Phaeophytins

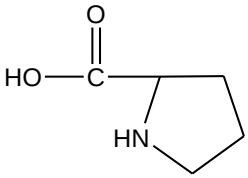


	R^1	R^2	R^3
Phaeophytin A (**119**)	H	Me	Phytyl
17^3-Ethoxy Pheophorbide A (**120**)	H	Me	CH_2-Me
13^2-Hydroxy phaeophytin B (**121**)	OH	CHO	Phytyl
17^3-Ethoxy Pheophorbide B (**122**)	H	CHO	CH_2-Me

l. Amino acids

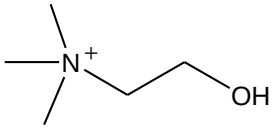


	R
Glycine (**123**)	-H
Alanine (**124**)	-Me
Valine (**125**)	-$CHMe_2$
Leucine (**126**)	-CH_2CHMe_2
Phenylalanine (**127**)	-CH_2-Ph
Asparagine (**128**)	-CH_2CONH_2
Serine (**129**)	-CH_2OH
Threonine (**130**)	-CHOH (Me)
Tyrosine (**131**)	-CH_2-C$_6$H$_4$-OH
Glutamine (**132**)	-$CH_2CH_2CONH_2$
Lysine (**133**)	-CH_2-$(CH_2)_3$-NH_2
Histidine (**134**)	-CH_2-imidazole
Arginine (**135**)	-CH_2-$(CH_2)_2$-NH-C(=NH)-NH_2
Aspartic acid (**136**)	-CH_2-COOH
Glutamic acid (**137**)	-CH_2-CH_2-COOH

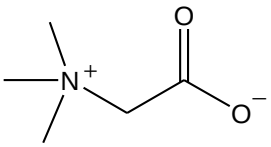


Proline (**138**)

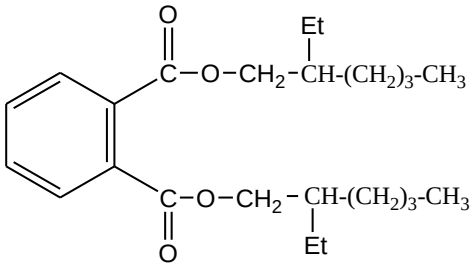
m. Other compounds



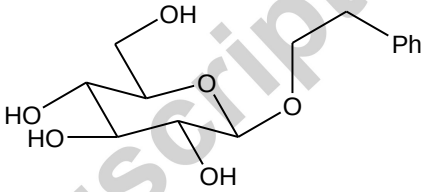
Choline (**139**)



Betaine (**140**)



Di- (2-ethylhexyl) phthalate (**141**)



Phenylethyl-β-D-glucopyranoside (**142**)

Fig. 1. Chemical structures of compounds form different *Sida* species.