Traditional Medicinal Plants

Volume - 6

Chief Editor

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Message

Prof. LB Laxmikanth Rathod
Vice Chancellor

I am immensely happy to know that, Dr. P Shivakumar Singh, Department of Botany, Palamuru University has authored the Book entitled "Traditional Medicinal Plants Vol. 6". I congratulate him for his academic dedication. I hope this book will be useful for the faculty, students of plant science and interdisciplinary studies of life sciences.

I am sure the volumes books have all the content and wisdom in the related areas and will prove highly useful in enriching the knowledge and skill of readers.

I convey my best wishes and hope the author will come out with many more such works in the days to come.

I also appreciate AkiNik Publishers for their effort in volumes of books.

Vice Chancellor

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Chapter - 3

Sesbania grandiflora: A Potential Source of Phytopharmaceuticals

P.N. Ansil, S. Soumya and S. Shafna

Abstract

Sesbania grandiflora (Linn.) is a well-known Fabaceae family medicinal plant, also known as Agati or the vegetable hummingbird. This plant is widely used in Ayurvedic medicine for the treatment of various diseases as well as the preparation of various formulations in 'Rasashastra'. *S. grandiflora*'s medicinal value has been mentioned in ancient ayurvedic texts including 'Dravyaguna'. This plant's roots, bark, leaves, flowers, and fruits all have different pharmacological properties and are used as medicine in South East Asia and India. Leprosy, rheumatism, tumours, liver disorders, colic disorders, poisoning conditions, smallpox, eruptive fever, epilepsy, nasal catarrh, headache, constipation, gout, ozaena, bronchitis, pain and other ailments have long been treated with the plant in traditional medicine. *S. grandiflora* has antioxidant, antiviral, antiulcer, antiurolithiatic, anticonvulsive, antiarthritic, anti-inflammatory, anthelmintic, anticancer, apoptotic, cardioprotective, hepatoprotective, antibacterial and anxiolytic activity, among other properties, according to pharmacological studies. Flavonoids, terpenoids, triterpenes, anthocyanin, saponins, phenolics, alkaloids, tannins, delphinidin glucosides, cyanidin, leucocyanidin, kaemferol-3-rutinoside, isovestitol, medicarpin, sativan, betulinic acid and various amino acids and vitamins are among the bioactive compounds found in *S. grandiflora*. The plant's diverse pharmacological properties may be attributed to the presence of these active phytoconstituents, lending credence to the traditional claim of medicinal properties for a variety of ailments.

Keywords: *Sesbania grandiflora*, fabaceae, agati, vegetable hummingbird, phytochemicals, pharmacological activities

Introduction

For thousands of years, humans have relied on natural products as a source of drugs. Plant-based drugs have long been the foundation of traditional

medicine systems in many countries, including India. Plant-based drugs continue to play an important role in health care today. The World Health Organization (WHO) estimates that 70-80 percent of the world's population relies primarily on herbal remedies for primary health care [1]. *Sesbania grandiflora* (Linn.), often known as Agati or the vegetable hummingbird, is a prominent traditional medicinal plant from the Fabaceae family [2]. The plant has long been used in traditional medicine to treat a variety of ailments, including leprosy, rheumatism, gout, tumours, and liver disorders [3]. It is widely used in Ayurveda for the treatment of various diseases as well as the preparation of various formulations in 'Rasashastra'. The medicinal value of *S. grandiflora* has been mentioned in ancient ayurvedic texts such as 'Dravyaguna'. In South East Asia and India, all parts of this plant, including preparations made from the plant parts, are used as medicine. The roots, bark, leaves, flower and fruit of *S. grandiflora* have different pharmacological properties [4, 5].

In various parts of South Asia, the tender leaves, green fruit, and flowers are eaten as a vegetable or mixed into curries or salads due to their high nutrient profile. The plant is known as 'Agathi Keerai' in South India and is one of the most popular green vegetables. It's a small, erect, fast-growing, perennial, deciduous or evergreen legume tree with few branches. *S. grandiflora* has a lifespan of about 20 years. Its roots are densely nodulated, and some floating roots may form in wet conditions [6]. Since it grows quickly, it combines well with agriculture (agroforestry) in areas at which trees are not normally grown and it becomes an important fuel wood source. In addition, the tender parts are used as cattle feed [7]. *S. grandiflora* is native to many Asian countries, including India, Malaysia, Indonesia, and the Philippines, and grows from sea level to 800 m. It is commonly found on dikes between rice paddies, along sides of the roads, and in backyard vegetable gardens. It thrives in humid tropical climates. Throughout general, they can be found in Australia, Africa and Asia. It can be found in the many parts of India, including Assam, Karnataka, Gujarat, Punjab, Delhi, West Bengal, Tamil Nadu and Kerala [8].

Taxonomic classification [9]

Kingdom	Plantae
Subkingdom	Tracheobionta
Phylum	Spermatophyta
Subphylum	Angiospermae
Class	Dicotyledonae

Subclass	Rosidae
Order	Fabales
Family	Fabaceae
Genus	Sesbania
Species	*Sesbania grandiflora* (Linn)

Synonyms: *Sesban coccinea*, *Coronilla grandiflora*, *Aeschynomene grandiflora* (L.), *Agati grandiflora* (L.) Desv., *Robinia grandiflora* L., *Sesban grandiflorus* Poir. [10].

Fig 1: *Sesbania grandiflora*

Vernacular names [9, 10]

English	Vegetable humming bird, West Indian pea, Swamp pea, Sesban
Hindi	Agast, Agasti, Hadga, Hathya, Basna
Malayalam	Agatti, Athi
Sanskrit	Varnari, Munipriya, Agasti, Drigapalaka
Tamil	Peragathi, Attikkirai, Sevvagatti
Kannada	Agase, Vakrapushpi, Chinnadaare
Telugu	Avisa, Avasinara, Ettagise, Sukanasamu
Oriya	Agastee
Gujarati	Agathiyo
Bengali	Bak, Agathi, Agusta, Bagphol, Bake

Botanical description

The plant stands 6-9 metres tall and has a girth of 0.6 metres. Sesbania is a short-lived, fast-growing plant. The plant's wood is soft and white in colour. Steam contains both inner and outer bark. The bark is light grey in colour and has a corky, deeply furrowed texture. The *S. grandiflora*'s leaves range in

length from 15-30 cm. The leaf structure is abruptly pinnate, with about 20-50 linear-oblong leaflets measuring 12-44 x 5-15mm. A single leaflet is 2-4cm long and 10-15mm wide. The flower of *S. grandiflora* appears at the base of the leaf. The plant's flowers are fleshy and have white, pink, or red petals. Flowers range in size from 6-10cm and arranged like a pea flower with five petals, with the standard petal upright and the other wing petal spread out on the other sides of the flower. The pods, also known as the plant's fruit, are 30cm or more long, 5-8mm wide, pendulous and slightly curved, flat and four-cornered, septate with swollen margins and contain 15-50 seeds. The seeds are cylindrical or elliptical in shape and are olive green or red-brown in colour [9, 11].

Traditional uses

The majority of the parts of the *S. grandiflora* plant are being used in traditional medicine. In Southeastern Asia and India, all portions of *S. grandiflora* are being used in medicine, including preparations made from the roots, bark, gum, leaves, flowers and fruits.

Leaves: *S. grandiflora* leaves have traditionally been used to treat bronchitis, coughing, vomiting, nasal catarrah, wounds, nyctalopia, cephalagia, diarrhoea, and dysentery. According to Ayurveda, these leaves are a rich nutritional way to promote bone health and immunity. Furthermore, the leaves have anthelmintic, diuretic and laxative properties. Chewing the leaves also aids in the cleaning of the mouth and throat [12, 13]. The leaves of *S. grandiflora* are also used in Ayurvedic medicine to treat epileptic seizures [14].

Flowers: The flowers are high in calcium and iron. They are also a good source of Vitamin B. The juice of the leaves and flowers is a popular remedy for nasal catarrh, headache, head congestion and stuffy nose. Flowers are used to treat biliousness, bronchitis, gout, nyctalopia, aphrodisiacs, pain, thirst, ozaena, and quartan fever. Additionally, the crushed leaves are applied to sprains and bruises and the juices derived from its flowers have a special ability to improve vision [10, 15, 16]. It's also been reported that the flower of *S. grandiflora* has been used in Indian and Nepalese folk medicine to treat diabetes mellitus [17].

Fruits: The fruits of *S. grandiflora* have traditionally been used to treat colic disorders, jaundice, anemia, bronchitis, fever, tumors and poisoning. The fruits, according to Ayurvedic practitioners, have alexiteric, laxative and intellectually stimulating properties. It is often used to treat pain, gastralgia, and nyctalopia [10, 11].

Bark: *S. grandiflora* bark is very astringent, and it is used to treat smallpox and other eruptive fevers. The bitter bark is a tonic, febrifuge and anthelmintic. It is also used to treat mouth and alimentary canal ulcers, as well as thrush, diarrhoea, and infantile stomach disorders. Scabies is treated with pounded bark. A decoction of the bark is used to treat hemoptysis. The bark juice is also beneficial for dyspepsia and gastralgia. Furthermore, the bark is used to treat dysentery and sprue in small doses, laxative in large doses, and emetic in even larger doses [10, 11, 13].

Root: The root is used as a poultice to treat inflammation and fever. Powdered roots of *S. grandiflora* are mixed with water and applied externally to rheumatic swelling as a poultice or rub. In catarrh, the root juice is taken with honey as an expectorant [13].

Nutritional facts

S. grandiflora flowers and leaves are high in nutrients such as protein, minerals, and vitamins. Vitamin A, folate, thiamin, niacin and vitamin C are all found in *S. grandiflora*. The leaf contains 73.1g H_2O, 1.4g fat, 2.2g fibre, 3.1g ash, 1,130mg calcium, 80mg phosphorous, 3.9mg iron, 9,000 IU vitamin A, 0.21mg thiamine, 0.09mg riboflavin, 1.2mg niacin and 169mg ascorbic acid per 100g. Besides this, 100g of *S. grandiflora* leaves contain 8g of protein and all eight essential amino acids, as well as 321 calories. The amino acids identified in the leaves of *S. grandiflora* include Alanine, Arginine, Aspartic acid, Glutamic acid, Cystine, Histidine, Isoleucine, Leucine, Lysine, Methionine, Proline, Serine, Threonine, Tryptophan, Tyrosine and Valine. Histidine and Arginine were the most abundant amino acids in the leaves, with 18.87 ± 0.02 and 11.0 ± 0.01g/kg dry matter, respectively. Fresh *S. grandiflora* leaves also contained the following fatty acids: Capric acid, Caproic acid, Caprylic acid, Lauric acid, Linoleic (alpha) acid, Linolenic acid, Myristic acid, Oleic acid, Palmitic acid, Palmitoleic acid and Stearic acid. C20:0 Arachidic acid, C18:2 Linoleic (alpha) acid and C16:0 Palmitic acid were the most abundant fatty acids found in the leaves, accounting for 31.60 ± 0.31 percent, 21.30 ± 0.18 percent, and 20.20 ± 0.19 percent, respectively. Flowers are also high in magnesium, phosphorus, potassium, and selenium. 100g of the flower contains 14.5g of protein, 3.6g of fat, 77.3g of carbohydrate, 10.9g of fibre, 4.5g of ash, 145mg calcium, 290mg phosphorus, 5.4mg iron, 291mg sodium, 1,400mg potassium, 636mg β-carotene equivalent, 0.91mg thiamine, 0.72mg riboflavin, 14.54mg niacin, and 473mg ascorbic acid. In addition, 100g of flower can provide 345 calories of energy [18, 19].

Pharmacological activities

In Indian traditional medicine, the plant *S. grandiflora* is commonly used to treat a wide range of ailments. In drug discovery, ethnobotanical knowledge combined with rationale-driven scientific research is critical [16]. Thus, *S. grandiflora's* pharmacological studies are reviewed here to learn about its various potentials as a therapeutic candidate in the drug development process. It has been identified as a promising medicinal plant with the following potentials.

1. Antimicrobial activity

Sesbania grandiflora, which is used in traditional pharmacopoeias in Burkina Faso, was tested for antibacterial activity. The plant's leaves, stems, granules, pods of fruit, and roots were extracted using aqueous, methanol and hydro-acetone. The extracts demonstrated strong antibacterial activity [20]. It has also been reported that an acetone extract of *S. grandiflora* flower has antimicrobial activity against *P. aeruginosa, S. aureus and E. coli* [21]. *S. grandiflora*'s anti-biofilm and anti-bacterial activity against *Staphylococcus aureus* was also investigated. The aqueous extract of *S. grandiflora* leaf demonstrated anti-biofilm and antibacterial efficacy and it plays an important role in the control of biofilm creating pathogens [12]. Another study used *S. grandiflora* leaf extract to synthesize silver nanoparticles (AgNPs), and their antibacterial activity against selected human pathogens was tested *in vitro*. Green-synthesized AgNPs demonstrated excellent antibacterial activity against clinically isolated multidrug resistant human pathogens. The clear zone of inhibition against *Salmonella enterica* and *Staphylococcus aureus* demonstrated the antibacterial activity of AgNPs [2]. AgNPs made from *S. grandiflora* leaf extract were tested for antimicrobial activity against a variety of bacterial and fungal pathogens in another study. AgNPs had the most potent antibacterial activity against *Pseudomonas* spp. and the best antifungal activity against *Penicillium* spp. [3].

2. Antiproliferative and apoptotic activity

In human cancer cell models, researchers investigated the antiproliferative effects of *S. grandiflora* leaves. On cancer cell lines such as MCF-7, HepG2, Hep-2, HCT-15 and A549, five different solvent fractions from *S. grandiflora* leaves were tested. The methanolic fraction of *S. grandiflora* was discovered to have potent antiproliferative effects, particularly in the human lung cancer cell line A549 [22]. A fraction (F2) isolated from *S. grandiflora* flowers was also studied in cancer cells for its anti-proliferative effects. F2 preferentially kills leukemic cells (especially

histiocyte lymphoma cells) by inducing programmed cell death. In leukemic cells, fraction F2 induces pro-oxidant activity and mediates its cytotoxicity via apoptosis and autophagy [16].

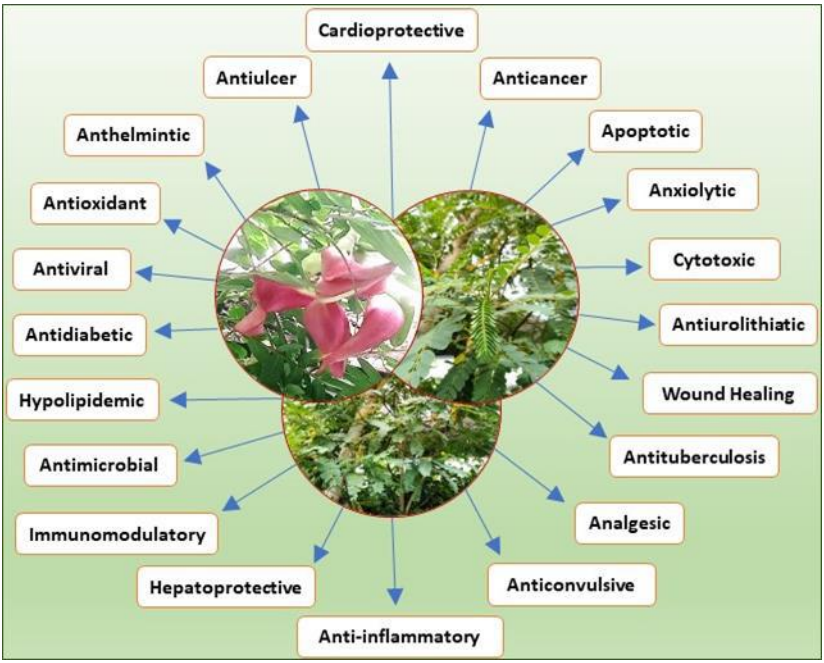

Fig 2: Important Pharmacological Properties of *Sesbania grandiflora*

3. Anticancer activity

In swiss albino mice, ethanol extracts of *S. grandiflora* leaves and flowers showed anticancer activity against Ehrlich Ascites Carcinoma cell line at doses of 100 and 200mg/kg body weight intraperitoneally. According to the findings of this study, an ethanolic extract of *S. grandiflora* was effective in inhibiting tumour growth in ascetic models and was comparable to 5-fluorouracil [23]. In another study, SF2 (Sesbania fraction 2), a potent protein fraction isolated from the flower of *S. grandiflora*, was tested for anticancer activity in two murine ascites tumour cell lines and two human cancer cell lines of different origin. In Dalton's lymphoma ascites (DLA) and colon cancer cells, SF2 inhibited cell proliferation and induced apoptosis (SW-480). SF2 potentiated apoptosis, reduced tumour cell viability, and interfered with proliferative signals that would otherwise be conducive to tumour growth, all without causing any unwanted side effects [24].

4. Antioxidant activity

It has been reported that Agathi Leaf Protein (ALP), a protein isolated from the water extract of *S. grandiflora* (agathi) leaves, can effectively scavenge various Reactive Oxygen Species *in vitro* at low doses. On the RBC ghost and linolenic acid micelle systems, ALP inhibited lipid peroxidation strongly. Furthermore, ALP inhibited deoxyribose oxidation and DNA damage in a concentration-dependent manner. ALP is not only an intriguing antioxidant source, but it is also a potential antimicrobial agent that is nontoxic in nature [25]. A study was also carried out to investigate the antioxidant and antibacterial activities, as well as the total content of phenolics and flavonoids in *S. grandiflora* leaves. Agar diffusion assays were used to determine antibacterial activities against *Escherichia coli, Burkholderia* sp., *Haemopilus somnus, Haemopilus parasuis* and *Clostridium perfringens*. Butanol extract of *S. grandiflora* leaves had the highest anti-*Burkholderia* sp. activity, with a MIC of 135µg/mL. Total phenolics in *S. grandiflora* methanolic extract were 41.7µg/mL and flavonoid content was 22.5µg/mL. The antibacterial and antioxidant properties of *S. grandiflora* leaves were also confirmed in this study [26].

5. Antioxidant activity against oxidative damage caused by cigarette smoke

A study was carried out to assess the protective mechanism of *S. grandiflora* leaves against cigarette smoke-induced oxidative damage in rat liver and kidney. Adult male Wistar-Kyoto rats were exposed to cigarette smoke for 90 days before being treated for 3 weeks with *S. grandiflora* aqueous suspension (SGAS, 1000mg/kg body weight per day by oral gavage). In cigarette smoke-exposed rats, SGAS significantly reduced elevated hepatic, renal, and lipid peroxidation markers, improved antioxidant levels and restored hepatic and renal architecture. This study concludes that *S. grandiflora* leaves reduce cigarette smoke-induced oxidative damage in rats' liver and kidney [27].

6. Cardioprotective activity

The cardioprotective effects of *S. grandiflora* against cigarette smoke–induced oxidative damage in rats were investigated. Adult male Wistar-Kyoto rats were exposed to cigarette smoke for 90 days before being treated for 3 weeks with *S. grandiflora* aqueous suspension (SGAS, 1000mg/kg body weight per day orally). Lactate dehydrogenase activity in serum and cardiac lipid peroxidation product levels were significantly increased in rats exposed to cigarette smoke. While the activities of cardiac superoxide dismutase,

catalase, glutathione peroxidase, glutathione-S-transferase, glutathione reductase and glucose-6-phosphate dehydrogenase were significantly reduced in rats exposed to cigarette smoke, the levels of reduced glutathione, vitamin C, and vitamin E were significantly decreased. Furthermore, copper levels were elevated in the heart of rats exposed to cigarette smoke, whereas zinc, manganese, and selenium levels were significantly decreased. SGAS treatment restored antioxidant status while maintaining micronutrient levels. These findings suggest that chronic cigarette smoke exposure raises oxidative stress, which agitates the cardiac defense mechanism, and that *S. grandiflora* protects the heart from oxidative damage by virtue of its antioxidant potential [28].

7. Hepatoprotective activity

In experimental rats, an ethanolic extract of *S. grandiflora* leaves (200mg/kg/day) produced significant hepatoprotection against erythromycin estolate-induced hepatotoxicity (800mg/kg/day). Serum enzymes (AST, ALT, ALP), bilirubin, cholesterol, triglycerides, phospholipids, free fatty acids, plasma thiobarbituric acid reactive substances, and hydroperoxides were significantly reduced in rats treated concurrently with sesbania extract and erythromycin estolate. The sesbania extract also restored the antioxidant levels to near normal. The findings suggest that *S. grandiflora* leaves may have a considerable protective effect against erythromycin estolate-induced hepatotoxicity. Sesbania's effect was compared to that of silymarin, a reference hepatoprotective drug [29]. In another study, ethanolic and aqueous extracts of *S. grandiflora* flower were tested for hepatoprotective activity in CCl_4-induced liver damage in Swiss albino rats. The biochemical parameters were significantly ($p<0.001$) reduced by *S. grandiflora* flower extracts (SGOT, SGPT, ALP, TP and TB). Silymarin (25mg/kg), a well-known hepatoprotective drug used as a control, demonstrated significant activity ($p<0.001$). The study's findings suggested that an ethanolic and aqueous extract of *S. grandiflora* flower was effective in improving hepatocyte function. The ethanolic extract at doses of 250 and 500mg/kg, p.o., as well as the aqueous extract at dose of 500mg/kg, p.o., had a significant effect on the liver of the CCl_4 induced hepatotoxicity animal model. Histological examinations confirmed the extract's healing properties [30].

8. Hypolipidemic activity

The most important risk factor for coronary heart disease is hyperlipidemia. According to the literature, flavonoids can help reduce hyperlipidemia. The anti-hyperlipidemic activity of an aqueous extract of the

leaves of *S. grandiflora* against triton-induced hyperlipidemia in rats was investigated based on its high flavonoid content. The plant extract was given to the triton induced hyperlipidemic rats at a dose of 200g/kg (p.o). *S. grandiflora* significantly reduces serum cholesterol, phospholipid, triglyceride, LDL and VLDL levels while increasing serum HDL levels. The aqueous extract reduced total cholesterol and LDL levels in the blood while increasing HDL levels [31].

9. Antidiabetic activity

An investigation into the anti-diabetic activity of an alcoholic extract of *S. grandiflora* flower in alloxan-induced diabetes rats was carried out. In comparison to diabetic control, the alcoholic extract of *S. grandiflora* flower at doses of 250 and 500mg/kg showed significant ($p<0.01$) antidiabetic activity. Furthermore, when compared to diabetic controls, the extract of both doses showed a significant ($p<0.01$) reduction in serum total cholesterol, triglyceride, SGOT, SGPT, and BUN. According to the findings, a 70% alcoholic extract of *S. grandiflora* flower has anti-diabetic activity in diabetic rats in a dose-dependent manner [17]. Researchers also investigated the anti-hyperglycemic efficacy of *S. grandiflora* flower (SGF) extract in diabetic rats by measuring the concentrations of C-peptide, insulin, glucose, glycosylated haemoglobin (HbA1C), haemoglobin (Hb), glycogen, and carbohydrate metabolic enzymes. The research revealed that SGF (250mg/kg body weight for 45 days) reduced glucose and HbA1C levels while improving C-peptide, insulin, Hb, glycogen, and carbohydrate metabolic enzymes activities. The current study's findings were compared to diabetic rats given glibenclamide (600mg/kg body weight). The findings show that *S. grandiflora* flower extract modulated carbohydrate metabolic enzyme activities by improving insulin secretion and decreasing glucose concentration in Streptozotocin-induced diabetic rats via bioactive compounds [32].

Another study looked at the anti-diabetic and antioxidant properties of *S. grandiflora* leaves. A single intraperitoneal injection of streptozotocin (45mg/Kg b.wt) was used to induce diabetes. The levels of blood glucose, glycosylated hemoglobin, blood urea, serum uric acid, serum creatinine, and diminished activities of pathophysiological enzymes such as aspartate transaminase (AST), alanine transaminase (ALT) and alkaline phosphatase (ALP) were all significantly lower ($p<0.05$) after diabetic rats were given *S. grandiflora* leaves extract (300mg/kg b.w/day) orally for 30 days. In diabetic rats treated with leaves extract, glycogen content and glycogen metabolizing enzyme activity were normalized. The elevated oxidative stress marker and decreased antioxidant status were normalized, indicating that the leaves

extract has antioxidant potential. This study's findings suggest that the leaves extract has anti-diabetic and antioxidant properties, which could be attributed to the presence of pharmacologically active ingredients in the leaves such as vitamins, flavonoids, saponins, tannins, diterpenes, triterpenoids, glycosides, and phenols [33]. Panigrahi *et al*., [34] also investigated the anti-diabetic properties of a methanolic extract of *Sesbania grandiflora* leaves (MESG) in type 2 diabetic rats induced by low dose streptozotocine and a high-fat diet. MESG (200 and 400mg/kg, p.o.) reduced elevated blood glucose levels in diabetic rats and restored other parameters to normal levels (< 0.05). As a result, it is concluded that MESG has potential antihyperglycemic and antihyperlipemic properties, as well as the ability to alleviate insulin resistance conditions. Based on the findings of these studies, it is concluded that *S. grandiflora* has potential anti-diabetic properties, which scientifically supports its use in folklore remedies.

10. Antiviral activity

The methanolic extract of *S. grandiflora* flower was tested for antiviral and cytotoxic activity against viruses such as herpes simplex-1 and 2, vaccinia, vesicular stomatitis, cox sackie, respiratory syncytical, feline corona, feline herpes, para influenza, reo-1, sindbis and punta toro in different cell lines such as Hel, HeLa, CRFK and Vero cell cultures. Among the viruses tested, the extract had the highest antiviral activity against herpes simplex 1 and 2, respiratory syncytical, para influenza, reo, sindbis, cox sickie and punta toro viruses (EC_{50} = 20µg/mL and 45µg/mL, respectively) and moderate activity against the remaining viruses (EC_{50} = 100µg/mL). The antiviral activities measured by the selectivity index may be due to the presence of flavonoids in the extracts, which inhibit virus cell fusion during the early and late stages of replication. The cytotoxicity effect was assessed using the MTT assay, and the results revealed that the extracts were cytotoxic at concentrations ranging from 20 to 100µg/mL. This study confirmed that *S. grandiflora* can be used as an antimicrobial agent in the future [4].

11. Antituberculosis activity

The isoflavanoids isovestitol, medicarpin and sativan, as well as another compound betulinic acid isolated from the root of *S. grandiflora*, seemed to have activity against *Mycobacterium tuberculosis* H37Rv. The methanol extract demonstrated moderate activity, whereas the isoflavanoid compounds demonstrated promising antitubercular activity, with MIC values of 50µg/mL for compounds isovestitol, medicarpin and sativan and 100µg/mL for betulinic acid, whereas the methanolic extract displayed MIC values of 625µg/mL [35].

12. Anti-inflammatory activity

The effects of administration of *S. grandiflora* bark extracts (300mg/kg bw p.o) on the development of carrageenan-induced paw edoema and adjuvant-induced arthiritis were studied. Inflammation was measured by paw swelling, and arthritis was measured by primary and secondary paw swelling, as well as changes in the thymus, spleen, and body weight. Exposure to *S. grandiflora* extracts during the inflammation process was claimed to modulate the inflammation process due to the presence of triterpenoidal compounds [36]. Gunathilake *et al.*, [37] also reported that methanolic extracts of *S. grandiflora*'s leaves had anti-inflammatory properties. In another study, the crude methanolic extract of *S. grandiflora* aerial parts was tested for anti-inflammatory activity in mice using an acetic acid-induced writhing model. At 250 and 500mg/kg body weight, the extract significantly ($p<0.001$) reduced the number of acetic acid-induced abdominal constriction (writhing) in mice. The outcome was comparable to the standard drug, Diclofenac sodium [38].

13. Antiulcer activity

In rats, an ethanolic extract of *S. grandiflora* leaf was given orally at a dose of 400mg/kg to prevent gastric ulcers induced by aspirin, ethanol, and indomethacin. The extract significantly reduced basal gastric acid secretion and inhibited gastric mucosal damage. The study's findings suggest that the protective effect of ethanolic extract of *S. grandiflora* leaves may have been mediated by both anti-secretory and cytoprotective mechanisms [39]. In another study, an ethanolic extract of *S. grandiflora* bark prevented acute gastric injury in rats. The extract significantly reduced stress and nonsteroidal anti-inflammatory drug-induced lesions. The extract had no effect on the volume, pH, or hydrochloric acid content of gastric secretion at a dose of 36.75mg/kg (ED_{50}, p. o.). The animals showed no signs of pharmacotoxicity at the doses used, indicating that the extract lacks centrally acting antiulcer components. The findings indicate that *S. grandiflora* may have antiulcer properties [40].

14. Wound healing activity

Using an excision wound model in Wistar albino rats, the wound healing activity of the methanolic extract of *S. grandiflora* bark was investigated. Treatment was continued in the excision model until the wound healed completely. Using 2% sodium alginate, 2.5 percent w/w, 5% w/w and 10% w/w ointments of methanol bark extract were prepared for topical application. The percentage of wound contraction and period of epithelialization were used to assess wound healing activity. When compared to standard 1 percent Framycetin sulphate, methanol extract demonstrated

significant wound healing activity at a 10 percent w/w dose. The findings confirmed that a methanol extract of *S. grandiflora* bark had significant wound healing activity [41].

15. Antiurolithiatic activity

A study was carried out to look into the potential of *S. grandiflora* for the treatment of renal calculi. *S. grandiflora* leaf juice was tested for median lethal dose, gross behavioural changes, antiurolithiatic and antioxidant activity. A calculi-producing diet model was used to assess antiurolithiatic activity, with gentamicin (subcutaneously) and 5% ammonium oxalate in rat feed to induce calcium oxalate-type stones. The parameters monitored in this study are calcium and oxalate deposition in the kidney, kidney weights, and urinary calcium and oxalate excretion. Antioxidant parameters such as lipid peroxidation, glutathione reductase and catalase were measured *in vivo*. The plant juice was also tested for its ability to scavenge nitric oxide and 2-diphenyl-2-picryl hydrazyl free radicals. Except for an increase in urination, *S. grandiflora* leaf juice was safe to consume orally. *S. grandiflora* leaf juice exhibited significant antiurolithiatic activity against calcium oxalate-type stones as well as antioxidant properties. The findings of this study support the efficacy of *S. grandiflora* leaf juice as an antiurolithiatic agent [42].

16. Anxiolytic and anticonvulsant activity

Animal models of convulsions were used to test the anticonvulsive activity of *S. grandiflora* leaves. The fraction with anticonvulsant activity was also identified using bioassay guided separation. The benzene: ethyl acetate fraction (BE) of the acetone soluble part of a petroleum ether extract significantly delayed the onset of convulsions in mice induced by pentylenetetrazol (PTZ) and strychnine (STR) and reduced the duration of tonic hindleg extension in mice induced by maximum electroconvulsive shock (MES). A triterpene was a major component of the BE. Furthermore, the BE inhibited electrically induced kindled seizures in mice as well as lithium-pilocarpine-induced status epilepticus in rats. It increased the duration of sleep induced by pentobarbital and decreased the effect of D-amphetamine. BE-treated mice preferred the open arm of the elevated plus maze, indicating anxiolytic activity. The BE increased the levels of gamma-aminobutyric acid and serotonin in the brain. According to the findings, the triterpene-containing fraction of *S. grandiflora* exhibits a broad spectrum of anticonvulsant and anxiolytic activity [14].

17. Immunomodulatory activity

S. grandiflora's immunomodulatory activity on cellular and humoral immunity was investigated. In mice, oral administration of a methanolic

extract (200 and 400mg/kg) of *S. grandiflora* flowers significantly increased the production of circulating antibody titre in response to sheep red blood cells (SRBC). It significantly increased the delayed-type hypersensitivity response induced by SRBC. A positive response to phagocytosis was also observed in the carbon clearance assay, which prevented myelosuppression in the cyclophosphamide drug. The immunomodulatory activity of aqueous extract at 250mg/kg dose level was not observed, but 500mg/kg of aqueous extract potentiated the activity, albeit less significantly than both doses of methanolic extract. The findings of this study suggest that a methanolic extract (400mg/kg) of *S. grandiflora* has potential immunomodulatory activity [43].

18. Anthelmintic activity

The anthelmintic activity of *S. grandiflora* seed oil against *Pheretima posthuma* was investigated. The bioassay used three concentrations of oil (10, 50, and 100mg/ml) to determine the time of paralysis and death of the worm. In both parameters, *S. grandiflora* seed oil demonstrated highly significant anthelmintic activity (paralysis and death) [44] Another research was carried out to test the anthelmintic activity of *S. grandiflora* leaf extracts in ethanol, methanol and ethyl acetate on Indian adult earthworms (*Pheretima posthuma*). At concentrations ranging from 10-100mg/ml, all of the extracts demonstrated concentration-dependent activity. *S. grandiflora* ethanolic extract was more active than methanol and ethyl acetate extracts. The findings were compared to those of the standard drug piperazine citrate (10mg/ml). According to this study, an ethanolic extract of *S. grandiflora* has promising anthelmintic activity [5].

19. Analgesic activity

The antipyretic activity of *S. grandiflora* flowers was evaluated using three different extracts with petroleum ether, ethyl acetate, and ethanol as solvents, which were then tested for analgesic activity on Albino rats using Tail Flick methods. When compared to petroleum ether and ethanol extracts, ethyl acetate extract demonstrated superior analgesic and antipyretic activities [45]. The leaf extract of *S. grandiflora* also has analgesic and CNS depressant properties, according to Sutradhar and Choudhury [46].

Phytochemicals of *S. grandiflora*

Plants produce a variety of organic chemicals with varying structural types. Many of these phytochemicals are necessary for plant growth and development, and they are widely consumed for their health benefits by humans. Phytochemicals help to reduce the risk of a variety of diseases by acting alone or in combination. The presence of the phytochemicals listed

below may explain the reported pharmacological properties of *S. grandiflora*'s various parts.

Leaf: According to preliminary phytochemical analysis, *S. grandiflora* leaves contain alkaloids, saponins, phenols, and proteins [7]. The leaves also have essential amino acids, minerals, vitamins (vitamin A, vitamin E, vitamin C, thiamine, riboflavin, and nicotinic acid) and other active compounds like pectin, triterpenoid, tannin, glycosides and grandiflorol (-5-methyl-5-pentacosanol), as well as a saponin that when hydrolyzed yields an acid sapogenin oleanoic acid, galactose, rhamnose and glucuronic acid [27]. The bitter leaves are high in calcium, sterols, quercetin, myricetin, and kaempferol. A protein known as Agathi Leaf Protein (ALP) was also isolated from the leaves of *S. grandiflora* [25].

Flower: Flavonoids, terpenoids, triterpenes, anthocyanin, saponins, phenolics, alkaloids, and tannins were the major phytochemical classes found in the flower of *S. grandiflora* [32]. The flower also contains oleolic acid and its methyl ester, as well as kaemferol-3-rutinoside [30]. In addition, delphinidin glucosides, cyanidin and various amino acids and vitamins were isolated from the flower of *S. grandiflora* [11]. Two distinct proteins (SGF60 and SGF90) from agathi flower extract with-glucosidase inhibiting properties were also identified [47]. Laladhas *et al*. [24] isolated an anticancer protein fraction (Sesbania fraction 2) from the flowers of *S. grandiflora*.

Seed: Saponins, as well as leucocyanidin and cyanidin, are isolated from the seeds of *S. grandiflora* [30].

Bark: The bark of *S. grandiflora* contains tannins and gum [30]. The stem bark contains two phenolic compounds called sesbagrandiflorains A and B. 2-arylbenzofuran, sesbagrandiflorain C, 2-(3,4-dihydroxy-2-methoxyphenyl)-4-hydroxy-6-methoxybenzofuran-3-carbaldehyde and 2-(4-hydroxy-2-methoxyphenyl)-5,6-dimethoxybenzofuran-3 carboxaldehyde has also been reported in the stem bark of S. grandiflora [48].

Root: Isoflavanoids like isovestitol, medicarpin and sativan, as well as betulinic acid, were isolated from the root of *S. grandiflora* [35].

Conclusion

Extensive research on different plant species with reference to their therapeutic principles is currently reevaluating traditional medicines all over the world. Despite advances in conventional chemistry and pharmacology in the production of effective drugs, the plant kingdom may be a useful source of new medicines and pharmaceutical entities, or it may be used as simple

dietary adjuncts to existing therapies. Pharmacological studies on *S. grandiflora* confirmed that it has many medicinal properties, making it an important medicinal plant with a variety of pharmacologically active phytochemicals. As pharmacologists seek new drugs from natural sources, the development of modern drugs from *S. grandiflora* can be emphasized for the treatment of various diseases. Systematic research and development should be carried out in order to cultivate and conserve *S. grandiflora*, as well as to develop products for improved nutritional and therapeutic utilization. Based on the review's findings, it is concluded that most pharmacological studies confirm the traditional claim of *S. grandiflora*'s medicinal properties, which may be due to the presence of numerous bioactive substances in the plant.

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