Review Article

Ethnobotanical Description and Biological Activities of Senna alata

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Senna alata is a medicinal herb of Leguminosae family. It is distributed in the tropical and humid regions. The plant is traditionally used in the treatment of typhoid, diabetes, malaria, asthma, ringworms, tinea infections, scabies, blotch, herpes, and eczema. The review is aimed at unveiling the ethnobotanical description and pharmacological activities of S. alata. Different parts of the plant are reported in folk medicine as therapeutic substances for remediation of diverse diseases and infections. The extracts and isolated compounds displayed pronounced pharmacological activities. Display of antibacterial, antioxidant, antifungal, dermatophytic, anticancer, hepatoprotective, antilipogenic, antidiabetic, antihyperlipidemic, antimalarial, anthelmintic, and antiviral activities could be due to the array of secondary metabolites such as tannins, alkaloids, flavonoids, terpenes, anthraquinone, saponins, phenolics, cannabinoids, 1,8-cineole, caryophyllene, limonene, α-selinene, β-caryophyllene, germacrene D, cinnamic acid, pyrazol-5-ol, methaqualone, isoquinoline, quinones, reducing sugars, steroids, and volatile oils present in different parts of the plant. The review divulges the ethnobotanical and pharmacological activities of the plant and also justifies the ethnomedical claims. The significant medicinal value of this plant necessitates a scientific adventure into the bioactive metabolites which constitute various extracts.

1. Introduction

The primary and safest therapeutic approach since prehistoric time is herbal medicine which has displayed significant role in primary health care development [1]. The World Health organization (WHO) appraised that 80% of inhabitants in developing countries basically rely on herbal medicines [2, 3]. Recently, it was discovered that one-third of the commonly used drugs are obtained from natural sources. This has led to the documentation of about 40,000–70,000 medicinal plant species with outstanding therapeutic potentials [4].

The scientific appraisal of the pharmacological activities of herbal plants revealed about 200,000 phytochemicals. These compounds contribute to the apparent medicinal activities displayed by plants and invariably justify the involvement of natural products in the development of novel drugs [5]. Despite these achievements, the use of herbal drugs was not universally accepted in contemporary medicine due to lack of scientific evidence and proper documentation. However, the significance of herbs in pharmacology has necessitated the provision of scientific facts on bioactive compounds and pharmacological assays of plants [6, 7].

Medicinal plants with immense biological applications have been viewed as the principal sources of therapeutic substances which could lead to novel therapeutic compounds. The search for these compounds from medicinal
plants usually ends in the isolation of novel compounds and, eventually, drug developments [8]. Several medicinal plants with diverse interesting pharmacophore have been scientifically investigated, and one of these plants is *Senna alata*.

*S. alata*, also known as *Cassia alata*, is a widely distributed herb of the Leguminosae family. It is commonly known as candle bush, craw-craw plant, acapulo, ringworm bush, or ringworm plant. The plant is commonly found in Asia and Africa, and has many local names [9]. It has arrays of bioactive chemical compounds. Some of the reported chemical constituents are phenolics (rhein, chrysaphanol, kaempferol, aloemodin, and glycosides), anthraquinones (alatnone and alatonal), fatty acids (oleic, palmitic, and linoleic acids), steroids, and terpenoids (sitosterol, stigmasterol, and campesterol) [10, 11]. These secondary metabolites are reported to display numerous biological activities [12–17].

The flower, root, leaves, seed, and bark displayed diverse biological activities [18–20]. These pharmaceutical activities include antimicrobial [21–23], antifungal [24], anticyptococcus [25], antibacterial [26, 27], antitumor [28], anti-inflammatory [29, 30], antidiabetic [31], antioxidant [18], wound healing [32], and antimelmintic activities [33]. In recent times, the outbreak of drug-resistant diseases has led to several health issues. In an attempt to resolve these issues, pharmacological research has been tailored towards the discovery of innovative, potent, and safe drugs from natural compounds. This review appraises the ethnobotanical and pharmacological activities of *S. alata*, thus justifying diverse traditional applications of the plant.

### 2. Review Methodology

Relevant documents were obtained from major scientific catalogues such as Pubmed, Google Scholar, EBSCO, SciFinder, Scopus, Medline, and Science Direct. Many publications sites were queried to procure information on ethnobotanical description and pharmacological activities of *S. alata*.

### 3. Ethnobotanical Description

3.1. Description and Classification. *S. alata* (L.) Roxb. is a flowering shrub of the Fabaceae family. It has the name “candle bush” owing to the framework of its inflorescences [34]. It is an annual and occasionally biannual herb, with an average height of 1 to 4 m, burgeoning in sunlit and humid zones. The leaves are oblone, with 5 to 14 leaflet sets, robust petioles (2 to 3 mm), caduceus bracts (2 × 3 by 1 × 2 cm), and dense flowers (20 × 50 by 3 × 4 cm). Zygomorphic flowers have bright yellow color with 7 stamens and a pubertal ovary. The fruit exists as a 10 to 16 × 1.5 cm tetragonal pod, thick, flattened wings, brown when ripe with many diamond-shaped brown seeds. It is propagated by seeds and dispersed to about 1,500 m above the sea level [35, 36].

Taxonomically, *S. alata* is classified as kingdom: Plantae; order: Fabales; family: Fabaceae; subfamily: Caesalpinioideae; tribe: Cassieae; subtribe: Cassini; genus: Senna; species: *S. alata*.

3.2. Geographical Distribution. *S. alata* is widely distributed in Ghana, Brazil, Australia, Egypt, India, Somalia, Sri Lanka, and all over Africa [37]. It is an ornamental plant native to the Amazon Rainforest [38]. Like other *Senna* species, it is cultivated in humid and tropic regions of Africa, Asia, West Indies, Mexico, Australia, South America, the Caribbean Islands, Polynesia, Hawaii, Melanesia, and different parts of India [39]. In Philippines, Thailand, and Indonesia, this shrub is widely dispersed and is cultivated for medicinal purposes [40].

3.3. Ethnobotanical Uses. In Ayurvedic, Sinhala, Chinese, and African traditional medicine, various parts of *S. alata* have shown diverse therapeutic activities in diseases control. In northern Nigeria, the stem, leaf, and root decoctions is used in treatment of wound, skin and respiratory tract infection, burns, diarrhoea, and constipation [41, 42]. Also, in the southwestern regions, leaf decoction serves as an antitodie to body and abdominal pain, stress, and toothache [43]. It also cures dermal infections, convulsion, and as purgative [44, 45]. In Egypt, the leaf decoction was observed to be used as a bowel stimulant to stimulate peristaltic shrinkages and decrease water absorption from the colon in attempt to prevent constipation [46]. In Cameroon, the stem, bark, and leaves were reported to be used as a remedy for gastroenteritis, hepatitis, ringworm, and dental infections [47].

In India, Philippines, and China, *S. alata*’s stem, bark, and leaf decoction were found to be effective in treating haemorrhoids, inguinal hernia, syphils, intestinal parasitis, and diabetes [48]. Currently, seeds and roots are used in regulating uterus disorder and worms [18, 49]. The leaves and flowers are typically used as antifungal agents and laxatives [35]. In China, the seeds are used in treating asthma and to improve visibility [50]. In Guatemala, Brazil, and Guinea, the whole plant is currently used in the treatment of flu and malaria [36]. The flower and leaves decoction was observed to be used in treatment of ringworms, scabies, blotch, eczema, scabies, and tine infections [11, 51]. The leaves are currently used in Sierra Leone to relieve abortion pain and facilitate baby delivery [51]. In west and east Africa, bark decoction is spread on cuts during tribal mark incision and tattoo making [52]. In China, India, Benin republic, Ghana, Nigeria, and Togo, the whole plant is used as a curative for Diabetes mellitus [34, 53]. Fresh leaves of the plant are used in the treatment of skin rashes, mycosis, and dermatitis [54]. From the traditional uses, the frequent use of *S. alata* leaves is more than that of roots, flowers, roots, and stem-bark owing to more active metabolites reported in the leaves. Besides its pharmacological activities, it is processed into capsule, pellet, and tea in Nigeria for preventing diseases and maintaining sound health.

3.4. Pharmacological Activities. Medicinal plants belonging to the Fabaceae family have extensively been investigated for their pharmacological activities. Plants synthesised array of secondary metabolites which contribute to its therapeutic activities (Figure 1). Therapeutic appraisal of *S. alata*...
authenticates the ethnobiological claims and establishes the pharmacological activities (Table 1). There are many published articles connected to diverse therapeutic activities of S. alata which are mainly related to antibacterial, antidiabetic, antilipogenic, antifungal, antioxidant, dermatophytic, anti-hyperlipidemic, and anthelmintic activities among others. Few studies have also reported its antimalarial activities.

3.4.1. Antibacterial Activities. The antibacterial potentials of medicinal herbs are appraised using zone of inhibition (ZOI) or minimum inhibitory concentration (MIC). The in vivo antibacterial potential of S. alata was assessed against methicillin-resistant S. aureus (MRSA), extended spectrum beta-lactamase, and carbapenemase-resistant. Enterobacteriaceae was isolated from infectious patients, via Mueller–Hinton broth via the microdilution technique. The extract showed significant activities at 512 mg/ml due to the flavonoids, quinones, tannins, sterols, alkaloids, and saponins analysed [75]. S. alata leaves collected from an Indian aboriginal tribe, displayed significant ZOI of 21 to 27 mm against clinical isolates of multidrug-resistant (MDR) bacteria, obtained from infected patients, when subjected to ASTs via Kirby Bauer’s disc diffusion assay (KBDD) [58]. Ciprofloxacin (30 μg/disc) and vacuum liquid chromatographic (VLC) fractions of S. alata methanolic extract were assessed against Staphylococcus aureus, Bacillus subtilis, Bacillus cereus (Gram positive), Shigella boydii, Shigella dysenteriae, Pseudomonas aeruginosa, Vibrio mimicus, Salmonella paratyphi, Vibrio parahaemolyticus, and Salmonella typhi, (Gram negative) using the disc diffusion assay. The

![Bioactive compounds with therapeutic potencies in S. alata.](image-url)

**Figure 1:** Bioactive compounds with therapeutic potencies in S. alata.
Table 1: Pharmacological activities of *S. alata*.

| Parts used | Country | Ethnomedicinal use | Solvent used | Pharmacological activity | Model used | Phytochemicals | References |
|------------|---------|--------------------|--------------|--------------------------|------------|----------------|------------|
| (1) Leaves | Nigeria | Treatment of diarrhoea, upper respiratory tract infection, and to hasten labour | Aqueous | Abortifacient | Pregnant rats | Saponins, flavonoids, cardiac glycosides, cardenolides, dienolides, phenolics and alkaloids | [55] |
| (2) Leaves | India | To manage diabetes | Ethanolic | Hepato-renal protective effects | Male albino Wistar rats | Lipoxigenase (LOX) enzyme; High-fat diet-induced obese mice | [56] |
| (3) Leaves | India | Treatment of allergy/asthma; To manage diabetes and weight | Hydromethanolic | Antiallergic | Rhein and kaempferol | [7] |
| (4) Leaves | Thailand | Treatment of bacterial infections | Aqueous | Antilipogenic | Pathogenic bacterial strains | [57] |
| (5) Leaves | India | To manage diabetes | Methanol | Antibacterial | Multidrug-resistant (MDR) *Vibrio cholerae* and *Shigella flexneri*; a-Glucosidase enzyme; STZ-induced diabetic rats | [58] |
| (6) Leaves | Cameroon | Treatment of gonorrhoea, gastrointestinal and skin diseases | Methanol | Antibacterial | Kaempferol, luteolin and aloe-emodin | [59] |
| (7) Leaves | India | To manage diabetes | Methanol | Antidiabetic | Kaempferol 3-O-gentiobioside | [31] |
| (8) Leaves | Thailand | Treatment of skin infections | Anthraquinone | Antifungal | Anthraquinone | [60] |
| (9) Leaves | Nigeria | To wash the uterus | Hexane | Anti-implantation, antigonadotropic, antiprogesteronic | Ovariectomized female rats | Alkaloids | [61] |
| (10) Flower | Nigeria | Treatment of urinary tract infections and gonorrhoea | Methanol | Antibacterial | Bacterial strains | Steroids, anthraquinone glycosides, volatile oils and tannin | [62] |
| (11) Flower | India | To treat scabies and ringworm | Aqueous | Antifungal | Aflatoxin producing and human pathogenic fungi | [63] |
| (12) Leaves and barks | Malaysia | To treat superficial fungal infections | Ethanol and water | Antimicrobial | Bacterial and fungal strains | [64] |
| (13) Leaves | Cameroon | Used as purgative expectorant, astringent, vermicide; Treatment of malaria; antioxidant and antibacterial | Ethanol | Antioxidant and anti-inflammatory | White blood cells | Alkaid, flavonoids, saponins, tannins glycosides | [30] |
| (14) Leaves | India | As an immune stimulant | Ethanol | Anticancer | Male Wistar rats | Flavonoid | [65] |
| (15) Leaves | Indonesia | Cardiac glycosides, phenols, anthraquinone, alkaloids | Ethanol | Antiviral | DENV-2 and Huh 7 cells | Flavonoid | [66] |
| (16) Petals | India | As an immune stimulant | Petroleum ether | Immunomodulatory | *Garra rufa* fish | [67] |
fractions exhibited significant inhibitory activities against bacteria isolates at 100 µg/ml [76]. Bioactive compounds such as kaempferol, luteolin, and aloe emodin isolated from the methanolic leaves extract was assessed against MDR bacteria strains. Aloe emodin exhibited strong MIC activities (4 to 128 μg/ml). Marked activities could be linked to the anthraquinone and flavonoids compounds detected [59]. The antibacterial activity of chrysoeriol-7-O-(2″-O-beta-D-mannopyranosyl)-beta-D-allopyranoside, 3-O-gentiobioside, quercetin, naringenin, and rhamnetin-3-O-(2″-O-beta-D-mannopyranosyl)-beta-D-allopyranoside isolated from chloroform, ethanol, petroleum ether, methanol, and aqueous leaves extract of S. alata, significantly inhibited the growth of B. subtilis, V. cholerae, Streptococcus sp., S. aureus, and E. coli. The extracts displayed pronounced activities which are in close proximity to penicillin, chloramphenicol, flucosazide, and ciprofloxacin [77].

3.4.2. Antioxidant Activities. The antioxidant or scavenging activities is important in appraisal of therapeutic potential of medicinal herbs. Plants played significant role in protecting cell against oxidative stress caused by active free radicals [79]. The free radical scavenging potentials of plants are appraised by antibiotic sensitivity tests (ASTs); 2,2-diphenyl-1-picrylhydrazyl (DPPH); ferric-reducing antioxidant power (FRAP); 2,2′-azino-bis(3-ethylbenzothiazoline-6-sulphonic acid) (ABTS); hydroxyl radical scavenging activity (HRSA), and metal ion chelating activity (MICA). The methanolic and n-hexane leaves extracts of S. alata were explored for their scavenging effects via DPPH assay. The methanolic extract displayed pronounced scavenging activities when compared to n-hexane extract. The methanolic extract was fractionated, leading to isolation of three major bioactive compounds (kaempferol, butylated hydroxytoluene, and emodin). The kaempferol fraction displayed pronounced scavenging activity than the butylated hydroxytoluene and emodin fractions [80].

### Table 1: Continued.

| Parts used | Country | Ethnomedicinal use | Solvent used | Pharmacological activity | Model used | Phytochemicals | References |
|------------|---------|--------------------|--------------|--------------------------|------------|----------------|------------|
| (17) Root  | Nigeria | As an abortifacient in women, for the termination of early pregnancy | Ethanol      | Uterine smooth muscle    | Male and female Albino mice | Alkaloids     | [68]       |
| (18) Leaves | Burkina Faso | Treatment of asthma-induced bronchospasm | Aqueous and ethanolic | Bronchorelaxant, genotoxic, and antigenotoxic | Male and female Wistar rats | Palmitic, linoleic, linoleic, stearic acid | [69]       |
| (19) Leaves | Egypt | Treatment of skin tumour | Methanol      | Antitumor                | Human cancer cell lines (HepG2, MDA-MB-231, and Caco2) Tert-butyl hydroperoxide-induced oxidative stress in HaCaT cells | Anthraquinone, flavonoids | [70]       |
| (20) Leaves | Thailand | Laxative          | Methanol      | Anti-inflammatory         | Tert-butyl hydroperoxide-induced oxidative stress in HaCaT cells | Rhein         | [71]       |
| (21) Leaves, flower and fruit | Nigeria | Laxative and treatment of microbial infections | Methanol and ethanol | Antifungal and antibacterial | Clinical bacterial and fungal isolates | Flavonoids   | [72]       |
| (22) Leaves | Thailand | In regulating glucose level in the blood | Aqueous       | Antilipogenic            | Male ICR mice | Flavonoids    | [73]       |
| (23) Leaves | Cameroon | To cure fever     | Aqueous and methanolic | Antiplasmodial           | RPMI 1640 and albumax | Flavonoids | [74]       |

and S. alata leaves was examined on clinical isolates of B. subtilis and S. aureus. The dried leaves were processed into a local antiseptic herbal soap and the antibacterial potential was assessed via hole-in-plate agar diffusion assay. The herbal soap significantly inhibited the growth of the tested organisms [78].
Different parts of *S. alata*, significantly inhibited the action of free radicals causing oxidative stress [82]. The *in vitro* DPPH assay of ethyl acetate-DCM, methanol-DCM, and oil fractions of *S. alata* leaves was assessed using L-ascorbic acid as control. The radical scavenging activities measured at 517 nm significantly inhibited the free radicals at 500 g/ml. The concentration at 50% inhibition (IC$_{50}$) of the fractions revealed activities of methanol-DCM (65.03%), ethyl acetate-DCM (62.33%), and oil fraction (64.10%). The strong scavenging activities could be due to polyphenol and flavonoid analysed [76].

#### 3.4.3. Antifungal Activities

Several bioactive compounds isolated from *S. alata* exhibit strong *in vitro* and *in vivo* antifungal activities. The antifungal activities of cannabinoid alkaloid (4-butylamino 10-methyl-6-hydroxy cannabinoid dronabinol), 1,8-cineole, caryophyllene, limonene, α-selinene, β-caryophyllene, germacrene D, hexadecanoic acid methyl ester, hexadecanoic acid, (6Z)-7,11-dimethyl-3-methylenedodeca-1,6,10-triene, octadecanoic acid methyl ester, cinnamic acid, 3,7-dimethylocta-1,6-diene, pyrazol-5-methylidenedodeca-1,6-triene, were investigated using the disc diffusion approach. Ethanol extracts against the fungi isolates. The inhibitory activities displayed by *S. alata* seeds were incorporated in a local antiseptic soap. The soap significantly hindered the spread of ringworms, eczemas, carbuncles, boils, infantile impetigo, and breast abscesses [84]. The leaf, stem-bark, flower exudates, and ethanolic leaf extract examined against clinical isolates of *T. jirrucosum, M. canis, T. mentagrophyte, E. fiorrcosum, B. dermatitidis, A. flavus, and C. albicans* displayed strong inhibitory activities against the causative organisms [18,92–94].

#### 3.4.4. Dermatophytic Activities

Currently, the leaves, flowers, and bark of *S. alata* are used for treating various kinds of skin infections and diseases. In Thailand, the plant was mentioned as one of the 54 medicinal plants used for treating scabies, shingles, urticarial, itching, pityriasis versicolor, and ringworm [88]. The dermatophytic activities displayed by *S. alata* are linked to the bioactive compounds such as anthranols, anthrones, flavonoids, phenols, tannins, and anthracene derivatives [89]. Leaves decoction displayed strong inhibitory activities against *S. pyogenes, S. aureus, K. pneumoniae, E. coli, S. narrescens, P. cepacia, and P. aeruginosa* [90, 91].

Cannabinoid alkaloid (4-butylamine 10-methyl-6-hydroxy cannabinoid dronabinol) and apigenin isolated from *S. alata* seeds were incorporated in a local antiseptic soap. The soap significantly hindered the spread of ringworms, eczemas, carbuncles, boils, infantile impetigo, and breast abscesses [84]. The leaf, stem-bark, flower exudates, and ethanolic leaf extract examined against clinical isolates of *T. jirrucosum, M. canis, T. mentagrophyte, E. fiorrcosum, B. dermatitidis, A. flavus, and C. albicans* displayed strong inhibitory activities against the causative organisms [18,92–94].

Diabetes is a threat to man leading to stern socio-economic and high rate of mortality [95]. Herbal decoction of *S. alata* is commonly used in Caribbean [96], Africa [34], and India [97] for the treatment of diabetes. The marked α-glucosidase inhibitory effect and antidiabetic activities displayed by *S. alata* are linked to bioactive compounds such as astragalin and kaempferol-3-O-gentioside [31, 98]. Traditionally, the leaves decoction is used in regulation of sugar level in serum [99] and enhances the defence of hepato and renal organs to oxidative stress [56]. It also reduces fasting blood glucose and improves metabolic state via acivation of PKB/Akt which helps regulate glucose uptake in the liver and muscles [100].

The antidiabetic potency of acarbose, n-butanol, and ethyl acetate fractions of methanolic *S. alata* leaf extract was assessed via inhibitory carbohydrate digestion mechanism. The antidiabetic drug (acarbose) significantly inhibits α-glucosidase with inhibitory concentration (IC$_{50}$, 107.31 ± 12.31 µg/ml). n-Butanol and ethyl acetate fractions displayed inhibitory activities of *S. alata* 25.80 ± 2.01 µg/ml and IC$_{50}$, 2.95 ± 0.47 µg/ml, respectively, due to kaempferol 3-O-gentioside analysed by HPLC and Combiflash chromatography [31, 83]. α-Amylase and α-glucosidase inhibitory potential of acetone, hexane, and ethyl acetate leaf extracts of *S. alata* was assessed via Lineweaver–Burk plot. Acetone extract significantly inhibited α-amylase (IC$_{50}$ = 6.41 mg/mL), while hexane displayed strong inhibition against α-glucosidase (IC$_{50}$ = 0.85 mg/mL). n-Hexane
substantially reduces \( p < 0.05 \) postprandial blood glucose in sucrose-induced rats after 2 h of treatment [101].

The reduction in the oxidative stress in the aorta and heart of streptozotoc, hyperglycemic rats was investigated by DPPH free radical scavenging and antioxidant catalase assays. The aqueous leaf extract significantly reduced lipid peroxidation (MDA levels), blood glucose; however, it increases in the antioxidant catalase and DPPH free radical scavenging activity was observed. The reversal of oxidative stress induced by cardiac dysfunction in hyperglycemic condition justified the ethnobiological claim of the plant [102]. In a similar study, the \( S. \text{alata} \) leaf extract significantly reduces oxidative stress causing diabetes in treated mice. Prominent activities were observed in the kidney and liver. The activity resulted in critical changes in the urea, protein, creatinine, and uric acid level in the blood serum [56].

3.4.6. Antimalarial Activities. Malaria is a global threat contributing to serious sociocultural and health issues in humid and tropical regions [103, 104]. Chemotherapy reported the antimalarial activities of \( S. \text{alata} \) could be linked to quinones, alkaloids, and terpenes [105, 106]. Quinones isolated from \( S. \text{alata} \) significantly displayed \textit{in vitro} antimalarial activity, against \textit{Plasmodium falciparum} via the microdilution test of Desjardin [107]. Terpenes isolated from \( S. \text{alata} \) leaves displayed pronounce \textit{in vitro} antimalosomal assays against \( P. \text{falciparum} \) in ethylene glycol-water fractions. Significant activity was observed at concentration below 1 \mu g/ml [108]. The appraisal of aqueous leaf extract justifies the ethnomedical applications of \( S. \text{alata} \) as remedy for malaria and fever. The leaf extract considerably inhibited 3D7 strain of the \textit{P. falciparum} parasite in Wistar mice [109].

3.4.7. Anthelmintic Activity. Traditionally, \( S. \text{alata} \) leaf and flower decoctions are used in treatment of intestinal worm infestation and stomach disorder. The anthelmintic potency of alcoholic leaves extract of \( S. \text{alata} \) and \( T. \text{angustifolia} \) at 10 to 100 mg/ml were assessed in clinical isolates of \textit{Ascardia galli} and \textit{Pheretima posthuma} by observing time of paralysis and point of death of the worms. The leaves extract significantly inhibit the worms (test organisms) more than pipermanate citrate (standard anthelmintic drug) [110].

3.4.8. Antiviral Activities. \( S. \text{alata} \) is an indispensable bactericidal and fungicidal natural therapy. However, the justification of antiviral activities is not properly documented. The antiviral efficacy of n-hexane, ethyl acetate, butanol, and aqueous leaf extracts was assessed on dengue virus (DENV) obtained from an infected pregnant woman in Indonesia via focus assay. The extracts significantly inhibited DENV-2 with IC\(_{50}\) (<10 \mu g/ml), CC\(_{50}\) (645.8 \mu g/ml) and SI (64.5 \mu g/ml) [111].

4. Nutritional Constituents of \( S. \text{alata} \)

In appraisal of the therapeutic potentials of medicinal herbs, phytochemical, pharmacological, toxicological, and nutritional details are indispensable. In appraisal of the nutritional constituents of \( S. \text{alata} \) leaf, several nutrients assessed include moisture content (9.53 ± 0.06), carbohydrate (298.61 ± 0.40), crude lipid (47.73 ± 0.01), crude fibre (18.23 ± 0.13), and ash (15.73 ± 0.03). The nutritional contents analysed in flower revealed ash (7.00 ± 1.0), crude protein (13.14 ± 0.02), carbohydrate (57.04 ± 0.04), moisture (6.16 ± 0.14), and crude lipid (1.81 ± 0.09). It is observed that storage capacity, easy absorption of food, antimicrobial and anaesthetic properties are connected to the nutritional composition of herbs [112]. Several minerals such as potassium, iron, manganese, calcium, zinc, copper, and chromium have been assessed in \( S. \text{alata} \). These mineral constituents help in formulation of herbal drugs and dietary supplements [113–115].

5. Toxicological Studies of \( S. \text{alata} \)

Lately, medicinal plants and herbal products have come under spotlight owing to health hazards connected to indiscriminate handling of herbs and herbal products. Several reports were published relating to the use of herbal drugs. Despite the risks ascribed to most medicinal and herbal products, the number of herbal users still increases. This initiates the appraisal of herbs in an attempt to establish their safety [116]. The \( S. \text{alata} \) leaf extract was appraised by oral administration of Wistar rats (10 g/kg weight). The acute and subacute effects were assessed in every 24 h for 14 days at different dosages (250, 500, and 1000 mg/kg). After 24 h, no significant variation was observed in the liver, urea, bicarbonate, creatinine, and kidney of the tested organisms and control [117]. Aqueous flower extract at doses of 100, 400, and 800 mg/kg was orally administered to ten Wistar rats for 28 days. No significant difference on histological sections of the lung, liver, kidney, heart, and kidney was observed during the postmortem analysis of the mice [118].

Different doses (1,000, 2,000, and 3,000 mg/kg body weight) of ethanolic leaf extract do not display any behavioural, biochemical, haematological, and histopathological variations in the tested Swiss albino mice and control after 15 days of oral administration [119]. Hydroethanolic leaf extract increased the body weight, blood level, liver homogenates, and serum index after proper monitoring of the administered rats every 48 h for 26 days. Haematological parameters assessed displayed dose-dependent response, however, no significant variation was observed in liver histopathology [120]. Alkaloids isolated from aqueous \( S. \text{alata} \) leaf extract significantly reduces alkaline phosphate, uric acid, globulin, liver and kidney body weight ratio, urea, phosphate ions, bilirubin, potassium ions, serum concentrations of albumin, creatinine, gamma glutamyl transferase, alanine transaminases, and aspartate in the liver and kidney of pregnant rats after periodic observation for 18 days. This led to variation in serum enzymes, excretory, and secretory functions of liver and kidney of the test organisms [61].

Documented toxicological appraisals of \( S. \text{alata} \) present positive information regarding its safety; however, there is need to authenticate these reports through \textit{in vitro} and \textit{in vivo} assessments on clinical isolate. Fresh and dried plant
parts, low-dose concentrations, test organisms of different age groups and effect on other vital organs such as brain, intestine, and bladder should be considered during toxicological appraisals of medicinal plant or products. Ethnobotanical appraisals described that ulcer patients, pregnant women, and children under the age of two should avoid S. alata decoction. Also, studies should be focused on appraisals of recommended dosage, safest mode of administration, and reaction mechanisms of the metabolites in living organisms.

6. Limitation, Conclusion, and Future Prospects

Based on this review, further studies on S. alata have become evident. Most studies focused on lipid-soluble and volatile components; however, appraisals on metabolites prepared in hydrophilic medium are deficient. Most phytochemical studies of S. alata focused on leaves, stems, and flowers, though study on seeds and roots are lacking. Many therapeutic appraisals have been investigated in cell and animal experiments; still, there remain important tasks. These include secondary metabolites dictating the pharmacological activities are not well stated; relatively, few studies analytically appraised the mechanisms of action of secondary metabolites; systemic toxicological studies remain ambiguous. The phytochemical appraisals revealed there is a variation in some metabolites investigated due to geographical and climatic factors. This gives room for qualitative approach to authenticate the metabolites in this plant. The plant secondary metabolites contributed to the pronounced wound healing and antibacterial and antifungal activities [92, 121]. Industrially, the plant is a key ingredient in detergents (foaming and surface active agents), molluscicides and pesticides. Summarily, comprehensive ethnobotanical and pharmacological activities of S. alata, limitations, and future prospects were explored which could present novel research directions.

Abbreviations

ZOI: Zone of inhibition  
MIC: Minimum inhibitory concentration  
MDR: Multidrug resistant  
ASTs: Antibiotic sensitivity tests  
DPPH: 2,2-Diphenyl-1-picrylhydrazyl  
FRAP: Ferric-reducing antioxidant power  
ABTS: Chemiluminescence, 2,2′-azino-bis(3-ethylbenzothiazoline-6-sulphonic acid)  
HRSA: Hydroxyl radical scavenging activity  
MICA: Metal ion chelating activity.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

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