A Review of Recent Studies on the Antioxidant and Anti-Infectious Properties of Senna Plants

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The use of phytochemicals is gaining interest for the treatment of metabolic syndromes over the synthetic formulation of drugs. *Senna* is evolving as one of the important plants which have been vastly studied for its beneficial effects. Various parts of *Senna* species including the root, stem, leaves, and flower are found rich in numerous phytochemicals. *In vitro, in vivo*, and clinical experiments established that extracts from *Senna* plants have diverse beneficial effects by acting as a strong antioxidant and antimicrobial agent. In this review, *Senna* genus is comprehensively discussed in terms of its botanical characteristics, traditional use, geographic presence, and phytochemical profile. The bioactive compound richness contributes to the biological activity of *Senna* plant extracts. The review emphasizes on the *in vivo* and *in vitro* antioxidant and anti-infectious properties of the *Senna* plant. Preclinical studies confirmed the beneficial effects of the *Senna* plant extracts and its bioactive components in regard to the health-promoting activities. The safety, side effects, and therapeutic limitations of the *Senna* plant are also discussed in this review. Additional research is necessary to utilize the phenolic compounds towards its use as an alternative to pharmacological treatments and even as an ingredient in functional foods.

1. Introduction

*Senna*—a genus belonging to family *Fabaceae*, subfamily *Caesalpinioideae*, tribe *Cassieae* ser. *Aphyllae*—has roughly 350 species of tree shrubs and subshrubs [1, 2]. It was set apart from *Cassia* s.l. with the identification of three definite genera, viz., *Senna*, *Cassia* L. (s.s), and *Chamaecrista* Moench [3, 4]. This genus can be found in wide-ranging habitats, in distinct climatic conditions, latitudes, and continents such as America, Africa, and Oceania and to a minor extent in Asia and Pacific islands [5]. *Senna* plants colonized forests (both humid and dry), deserts (both cold and dry), and rock outcrops [6]. Some ornamental species are widely used for landscape gardening due to the attractive yellow inflorescences and the high adaptability in terms of soil and environmental conditions [7]. Recently, some species from desert climates were proposed to prevent or block desertification in arid zones. The use of *Cassia* species is reported in the ancient Ayurvedic literature as a laxative, antimalarial, relaxant, and anti-inflammatory [8]. To date, the genus is also commonly recognized for its biologically active compounds and medicinal properties [9, 10].

The cosmopolitan presence of the *Senna* genus and its medicinal properties lead to its various traditional medicinal uses and health-promoting effects. These beneficial effects of the *Senna* genus are contributed by the diverse group of phytoconstituents present in its leaves, stem, and seeds. By phytochemical research, more than 350 compounds were extracted from *Senna*, together with forty secondary metabolites extracted from *Senna spectabilis* (DC.) H.S.Irwain & Barneby. These phytochemicals mainly included classes of pentacyclic triterpenes and piperidine alkaloids displaying health-promoting properties [11]. Many of the parts such as leaves, pods, roots, and fruits of the natural plants have beneficial pharmacological properties against diseases. The studied pharmacological activities of *Senna* plants include anti-infectious, antioxidant, anticyprtococcus, antitumor, antimutagenic, antiplasmodial, anti-inflammatory, antitumor, anti-diabetic, wound healing, and anthelmintic activities [12, 13]. Some studies have shown the antidiabetic activity of *Senna* plants due to the content of phenols and flavonoids [14]. The antidiabetic effects have as mechanisms the decrease of the expression levels of different adipokines and the reduction of glucose absorption [15]. Its anti-infectious and antioxidant properties are established using various experiments, i.e., *in vitro* or *in vivo*.

The current review is focused on the traditional medicinal uses, phytoconstituents, antioxidant and anti-infectious properties, clinical trials, and toxicological data of *Senna* species.

2. Review Methodology

Information on the antioxidant and anti-infective pharmacological studies of *Senna* species has been collected from various scientific databases such as PubMed, ScienceDirect, and Google Scholar. The selected studies were analyzed for the phytochemical, antioxidant and anti-infective, toxicological aspects of *Senna* plants. The next MeSH keywords have been used for searching: "*Senna* Plant/growth & development," "*Senna* Plant/chemistry," "*Senna* Extract," "Cassia/chemistry," "Plant Extracts," "Plant Extracts/chemistry," "Oxidative Stress," "Reactive Oxygen Species," "Antioxidants," "Antioxidants/chemistry," "Malondialdehyde," "Anti-Infective Agents/pharmacology," "Antioxidants/pharmacology," "Anti-Bacterial Agents," "Anti-HIV Agents," "Reverse Transcriptase Inhibitors," "Antifungal Agents/pharmacology," "Antiprotozoal Agents/pharmacology," "*Senna* Plant/toxicity," "Animals," and "Humans." The scientific names of the *Senna* species were validated using the Plant List database and the chemical formulas with ChemSpider [16, 17].

3. Botanical Description and Distribution

Among the plants of the genus *Senna*, there is a semishrubby or shrubby habit, reaching 4-9 meters in height. *Senna* plants will tolerate moistly and very poorly draining soils...
in which it grows naturally. Giving a unique description of general botanical characteristics is tedious given the numerous species included in this genus. *Senna* has paripinnate compound leaves, with leaflets facing opposite, and globose, cylindrical, or clavate glands on rachis, petiole, or stalk [18]. The flowers are generally yellow and appear in dense racemes. It has large, lateral, terminal inflorescences with branched leafy panicles and can be up to 15–30 cm long. The flowers have fragrance and are made of 5 bristly bracts that usually are oval, 4–5 mm long, and caduceus and pedicels (2–3 mm). The sepal/calyx are unequal, oval to circular, coloured yellow-orange, and 5–7 mm long in size. The flower has 5 (uneven) golden-yellow-coloured petals and an ellipsoidal or spoon-like structure and is 2–3.5 cm in length. Anthers are opening by apical pores and a slit. It has sterile stamens that are 7 large and 3 small, while the pistil is curvy, slender, and hairless. The ovary is smooth and recurved with an inconspicuous style and stigma. The fruits of *Senna* are green in colour that turns black or dark with ripening, and their shape is cylindrical or column-like long pods. These pods are hard, end in a short, none splitting [7]. The size of the seeds is nearly 5 mm in diameter as they are brown coloured with flattened shapes.

The flowers of genus *Senna* present an interesting structural specialization that includes outstanding androecial diversity and several floral asymmetry patterns [7]. Classification of *Senna* flower traits becomes even more complicated due to its extraordinary level of specialization of the buzz-pollination. Ten stamens are present in heterantherous flowers of *Senna*, out of which 3 adaxial stamens are staminodial and the rest are fertile. These are further divided into two sets, viz., one set of four middle stamens from which the bees buzz and extract pollen, while another set includes 2-3 sets, viz., one set of four middle stamens from which the nodial and the rest are fertile. These are further divided into long, subtriangular to triangular. Floral asymmetry is also oblates-spheroidic to prolate, nearly circular, and copli is present an interesting structure [19].

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*Senna* can be propagated by seeds that remain viable for several years [21]. Most of the species of *Senna* require the scarification of the seeds to favour germination. The plant has numerous lateral roots and a robust primary root that contribute to the colonization of different substrates. Among the several species of *Senna* the series Aphyllae (Benth.) H.S.Irwin & Barneby is a taxonomically complex group of xeromorphic shrubs and subshrubs of the caesalpinoid legume *Senna* Mill., from arid, semiarid, and xerophilous areas of southern South America. Among all the *Senna* species, these seven are morphologically distinct. Fully grown mature plants are without leaves, and stems are junciform, green, and photosynthetic, while roots are woody and deep. These xerophytic attributes assist their survival in harsh conditions [22].

The monophyletic nature of *Senna* was revealed by phylogenetic investigations making it occupy the place next to *Cassia sensu stricto* and *Chamaecrista* [6], and all of these together form the subtribe *Cassinae* are morphologically identified based on traits of their androecium, floral architecture, corolla, bracteoles, and fruits [23]. To date, taxonomy is not simply based on floral and vegetative characters, but on several other information, such as anatomy, cytology, serological, and molecular biology, that is useful for determining relationships and affinities among the *Senna* genus. DNA sequencing of various chloroplast gene sections of *Senna* plants (matK, rpl16, rps16) depicted that majority of them are polyphyletic [5]. The chromosome counts exist only for about 20% of *Senna* species, with a prevalence of 2n = 28. There are also records of 2n = 22, 24, and 26 [24, 25] and records of polyploidy, such as 2n = 42, 56, and 112 in *Senna rugosa* (G.Don) H.S.Irwin & Barneby [26]; 2n = 56 in *Senna aversiflora* (Herb) H.S.Irwin & Barneby; and 2n = 52 and 104 in *Senna gardneri* (Benth.) H.S.Irwin & Barneby [27]. Recently, Cordeiro and Felix [23] demonstrated that the karyotypic differences noted in *Senna*, either interspecific or intraspecific, are making this genus among the most representative taxa of the *Fabaceae* in several world territories [22].

Plants of *Senna* genus are present in all the tropical regions and grow well on wasteland, river banks, damp/moist uncultivated fields, or similar areas in the low-lying coastal region; they also grow at places with altitudes up to 1000-1400 meters [28] (Figure 1).

*Senna*’s evolutionary history is also linked to the arid lands that this genus currently populates, such as deserts and xerophilous regions of South America in southern Bolivia, southeastern Paraguay, and central and northwestern Argentina [22]. Several types of research conducted in plants of genus *Senna*, growing in diverse climatic conditions, revealed a variation in phenotype between individuals within species that could arise from phenotypic plasticity.

Geographical separation and/or morphological variation among individuals of *Senna* causes the formation of species and subspecies in a different habitat, thanks to the adaptive strategies. America has the majority of *Senna* species (74%), followed by Australia with 13 percent of species and Africa and/or Madagascar having 10 percent, while only a few species are obtained from Near East, South-East Asia, and on the Pacific Islands [29]. Soladoye et al. [30] reported about 19 species in the West African floristic region with the whole 19 species in Nigeria and at least 8 species in South-Western Nigeria, with a high variety in habits, ranging from trees (approaching 34 m in height) to prostrate annual herbs. There are about 18 species of *Senna* in southern Africa, of which the majority is naturalized, but only *Senna italica* subsp. *archoideas* (Burch.) Lock and *Senna petersiana* (Bolle) Lock are native [31].
In Thailand, Larsen [32] studied Senna and stated that there are three native species, namely, Senna timoriensis (DC.) H.S.Irwin & Barneby, Senna siamea (Lam.) H.S.Irwin & Barneby, and Senna garrettiana (Craib) H.S.Irwin & Barneby, and fourteen exotic species, namely, Senna alata (L.) Roxb. (syn. Cassia alata L.), Senna singueana (Delile) Lock (syn. Cassia singueana Delile), Senna alexandrina Mill. (syn. Cassia angustifolia M.Vahl), Senna bicapsularis (L.) Roxb., Senna hirsuta (L.) H.S.Irwin & Barneby, Senna fruticosa (Mill.) H.S.Irwin & Barneby, Senna occidentalis (L.) Link, Senna pallida (Vahl) H.S.Irwin & Barneby, Senna septemtrionalis (Viv.) H.S.Irwin & Barneby, Senna sophera (L.) Roxb., S. spectabilis, Senna sulphurea (Collad.) H.S.Irwin & Barneby, and Senna tora (L.) Roxb (syn. Cassia tora L.) [33].

4. Ethnobotanical Uses

Senna genus is widely used in southern countries in different spheres of life such as building, decoration, rituals, nutrition, poisons, and medicine. Some plants of Senna genus are used as building wood and as a shade plant and landscape ornamental [33, 34]. S. alata bark decoction has been applied by the west and east Africans while tribal mark incision and tattoo was making on to the cuts [12].

In Uganda Senna obtusifolia (L.) H.S.Irwin & Barneby is used as a good luck charm before travelling [35]. Shoots and leaves of S. garrettiana and S. siamea are cooked in a dish called kaeng khi lek (a kind of curry) which is found in two forms—with and without coconut milk [33].

Other species consumed as boiled vegetables along with chili sauce include S. timoriensis for its tender leaves and flowers and S. sophera for its tender fruits and shoots [33]. The crude pounded bark of S. alata is used as fish poison [36]. And the most popular usage of Senna genus is as a traditional medicine used as a remedy for a vast range of diseases in various countries and cultures (Table 1).

5. Phytoconstituents

Ahmed and Shohael [68] reported the presence of anthraquinones named aloe-emodin, chrysophanol, emodin, and rhein from the S. alata leaves. Bradley Morris et al. [3] studied the variation in the concentration of sennosides A and B from pods and leaves of S. alata, S. alexandrina, Senna cowesii (A.Gray) H.S.Irwin & Barneby, Senna angulata (Vogel) H.S.Irwin & Barneby, S. hirsuta, S. occidentalis, and Senna uniflora (Mill.) H.S.Irwin & Barneby [3]. Essien et al. [69] isolated oils from hydrodistillation of S. alata, S. hirsuta, and S. occidentalis. The following compounds are reported after analyzing samples using GC-MS (gas chromatography-mass spectrometry) analysis, viz., ar-turmerone, β-caryophyllene, (E)-phytol, and 6,10,14-trimethyl-2-pentadecanone. (E)-Phytol and pentadecanal were the main components of S. hirsuta while S. occidentalis had (E)-phytol, hexadecanoic acid, and 6,10,14-trimethyl-2-pentadecanone. Epifano et al. [70] isolated madagascin (3-isopentenyloxyemodin) and 3-geranyloxymodine from dried fruits and leave samples of S. alexandrina.

Ahmed et al. [71] isolated the flavonoids quercimeritrin, scutellarein, and rutin from the leaves. Arrieta-Baez et al. [72] reported the isolation of alizarin and purpurin from S. alexandrina.

New compounds of pyridine alkaloids (12′-hydroxy-8′-multijugunol, 12′-hydroxy-7′-multijuguinol, methyl multijugunate, 7′-multijuguinol, and 8′-multijuguinol) were isolated using leaves of Senna multijuga (Rich.) H.S.Irwin & Barneby by Francisco et al. [73]. Similarly, Serrano et al.
Table 1: Traditional and folk medical usage of *Senna* species.

| *Senna* species                     | Country/culture | Part of plant | Internal usage                                                                 | External usage                        | Ref    |
|------------------------------------|-----------------|---------------|--------------------------------------------------------------------------------|---------------------------------------|--------|
| *Senna alata* (L.) Roxb.           | Bangladesh      | Leaves        | Helminthiasis                                                                  | Ringworm, eczema                       | [37, 38]|
|                                    | Benin Republic  | Whole plant   | Diabetes                                                                        | —                                     | [12]   |
|                                    | Bolivia         | Root, leaves  | Malaria, salmonella, fever, cold                                              | Bath                                  | [39]   |
|                                    | Brazil          | Root, whole plant, flower, leaves | Flu, cough, malaria | Ringworms, scabies, blotch, eczema, tinea infections | [12, 40]|
|                                    | Cameroon        | Stem, bark, leaves | Gastroenteritis, hepatitis | Ringworm, dermal infections | [12]   |
|                                    | China           | Stem, bark, leaves seed, root, leaves, flower, whole plant | Intestinal parasitosis, helminthiasis, diabetes, uterus disorder, asthma, constipation, fungal infections, poor eyesight diabetes | — | [12]   |
|                                    | Cuba            | Whole plant   | Diabetes                                                                        | —                                     | [41]   |
|                                    | Egypt           | Leaves        | Constipation                                                                    | —                                     | [12]   |
|                                    | Ghana           | Whole plant   | Diabetes                                                                        | —                                     | [12]   |
| *Senna alata* (L.) Roxb.           | Guinea          | Whole plant flower, leaves | Flu, malaria | Ringworms, tinea infections scabies, eczema, blotch | [12]   |
|                                    | Philippines     | Stem, bark, leaves seed, root leaves, flower the whole plant, leaves | Diabetes, hemorrhoids, inguinal hernia, intestinal parasitosis, syphilis, uterus disorder, helminthiasis constipation, fungal infection diseases | — | [12]   |
|                                    | Nigeria         | Stem, leaves, root whole plant | Constipation, diarrhoea, respiratory tract infection, body and abdominal pain, stress, convulsion, diabetes | Wound, skin diseases, burns, toothache, dermal infections | [12]   |
|                                    | Togo            | Whole plant   | Diabetes                                                                        | —                                     | [12]   |
|                                    | Cyprus          | Fruit         | Constipation                                                                    | —                                     | [45]   |
|                                    | Djibouti        | Leaves        | Constipation, injuries                                                         | Skin diseases                         | [46]   |
|                                    | Egypt           | Leaves        | Constipation                                                                    | —                                     | [47]   |
|                                    | Senegal         | Leaves        | Abortion pain, facilitate delivery                                             | —                                     | [12]   |
|                                    | Thailand        | Leaves        | Constipation, flatulence, inflammation                                         | Abscesses, wounds, ringworm, itching | [33, 44]|
|                                    | Togo            | Whole plant   | Diabetes                                                                        | —                                     | [12]   |
| *Senna alexandrina* Mill.          | Pakistan        | Leaves, pod   | Constipation, rheumatism, backache, asthma, anaemia typhoid fever, jaundice, pneumonia, leprosy | Wound, pimples | [48]   |
|                                    | Qatar           | Leaves        | Constipation, stomach cramps                                                   | —                                     | [49]   |
|                                    | Sudan           | Leaves, fruits | Constipation, git-disorders                                                      | —                                     | [50]   |
|                                    | Thailand        | Leaf pod      | Constipation, stomach pain                                                      | —                                     | [33]   |
|                                    | UAE             | Leaves        | Constipation, stomach cramps                                                   | —                                     | [49]   |
| *Senna auriculata* (L.) Roxb.      | India           | Flower leaves | Diabetes                                                                        | —                                     | [51]   |
| Senna species                  | Country/culture | Part of plant | Internal usage                                      | External usage                  | Ref    |
|-------------------------------|-----------------|---------------|----------------------------------------------------|---------------------------------|--------|
| *Senna didymobotrya* (Fresen.) H.S.Irwin & Barneby | South Africa    | Leaves        | Blood coagulation                                  |                                 | [52]   |
| *Senna fruticosa* (Mill.) H.S.Irwin & Barneby       | Panama          | Stem, leaves  | —                                                  | Body ache                       | [53]   |
| *Senna garrettiana* (Craib) H.S.Irwin & Barneby      | Thailand        | Heartwood     | Constipation, cough, emmenagoge                    |                                 | [33]   |
| *Senna hirsuta* (L.) H.S.Irwin & Barneby              | Thailand        | Debarked stem | Fever, muscle spasm, poisoning, drunkenness        |                                 | [33, 44] |
| Bahrain                        | Leaves, seed    | Constipation, stomach cramps | —                                      |                                 | [49]   |
| Djibouti                       | Leaves          | Constipation   | —                                                  |                                 | [46]   |
| Egypt                          | Leaves          | Constipation, bacterial infection, tumors          | —                                  |                                 | [47]   |
| Iran                           | Leaves          | Constipation, obesity, hemorrhoids                 | —                                  |                                 | [54]   |
| Pakistan                       | Leaves          | Backache joints pain, headache, migraine          | —                                  |                                 | [55]   |
| Qatar                          | Leaves, seed    | Constipation, stomach cramps                       | —                                  |                                 | [49]   |
| Saudi Arabia                   | Leaves, seed    | Constipation, stomach cramps                       | —                                  |                                 | [49]   |
| UAE                            | Leaves, seed    | Constipation, stomach cramps                       | —                                  |                                 | [49]   |
| Peru                           | Not specified   | —            | Wound disinfectant agent                          |                                 | [56]   |
| Bolivia                        | Root, seed      | Dysentery     | Bath, ringworm                                     |                                 | [39]   |
| Cuba                           | Not specified   | Liver pain, rheumatism, arthritis, arthritis, arthritis, cataract, muscular pain, hemorrhoids, pneumonia, venereal diseases, impotence | —                                  |                                 | [41]   |
| Guatemala                      | Leaves, aerial part | Fever, measles, chickenpox                          | —                                  |                                 | [57]   |
| India                          | Leaves, root seed | Respiratory diseases, cough, constipation, malaria, diabetes, indigestion, urinary disorder | Skin problems, skin disorders, pimples | [42, 58, 59] |
| Tanzania                       | Root            | Spasms, malaria, helminthias                        | —                                  |                                 | [60]   |
| Thailand                       | Leaves, fruit   | Diarrhoea                                             | —                                  |                                 | [44]   |
| Uganda                         | Leaves          | Malaria                                               | —                                  |                                 | [35]   |
| Eastern Africa                 | Not specified   | Flatulence                                            | —                                  |                                 | [61]   |
| Tropical Africa                | Not specified   | Constipation, gonorrhea                              | —                                  |                                 | [61]   |
| South Africa                   | Seed            | Venereal diseases, infertility constipation, gonorrhea | —                                  |                                 | [61, 62] |
| *Senna siamea* (Lam.) H.S.Irwin & Barneby              | Thailand        | Leaves, flower | Constipation, insomnia hypertension | —                              | [33, 44] |
| *Senna singueana* (Delile) Lock | Sudan           | Root                                                   | Constipation                        | —                              | [63]   |
| Tanzania                       | Root            | Diabetes                                              | —                                  |                                 | [64]   |
Table 1: Continued.

| Senna species                  | Country/culture | Part of plant | Internal usage                                                                 | External usage | Ref |
|--------------------------------|-----------------|---------------|--------------------------------------------------------------------------------|----------------|-----|
| **Senna sophera** (L.) Roxb.   | Bangladesh      | Leaves root   | Dyspepsia, asthma, bronchitis, hiccup, gonorrhoea                               | —              | [37, 38, 65] |
|                                | India           | Bark          | Respiratory disorders                                                           | —              | [42] |
| **Senna timoriensis** (DC.) H.S.Irwin & Barneby | Thailand | Heartwood      | Stimulate menstruation                                                          | —              | [33] |
| **Senna tora** (L.) Roxb.      | Thailand        | Seed leaves   | Stomach disorders, liver diseases, poor eyesight, weakness, diuretic            | —              | [66] |
|                                | India           | Seed leaves   | Constipation, urethral stones, diuretic, constipation, insomnia                 | —              | [33, 44] |
| **Senna uniflora** (Mill.) H.S.Irwin & Barneby | Cuba            | Not specified | Rheumatic swelling and pain, skin diseases                                       | —              | [42, 67] |

[74] in leaves identified compounds like isolated 7'-multi-juguinone and 12'-hydroxy-7'-multi-juguinone. Vargas Rechia et al. [75] extracted from seed (aqueous) extract compounds, viz., galactomannan and O-acetyl-glucuronorabinoxylan. Abegaz et al. [76] separated anthraquinones, emodin, floribudone-1, torosanin-9', 10'-quinone, anhydrophlegmacin, and 9-physcion-7'-yl)-5,10-dihydroxy-2-methoxy-7-methyl-1,4-anthraquinone from Senna multiglandulosa (Jacq.) H.S.Irwin & Barneby.

Alemayehu and Abegaz [77] reported the presence of physcion, torosachryzone, floribudone-1, anhydrophlegmacin, and 9-physcion-7'-yl)-5,10-dihydroxy-2-methoxy-7-methyl-1,4-anthraquinone (isosengulone) from the seeds of S. multiglandulosa.

Essien et al. [78] identified the following volatile oils from the fruits of S. hirsuta and S. occidentalis by GC-MS analysis. Compounds identified in S. hirsuta are as follows: α-pinene, germacrene, camphene, selinene, β-pinene, valencene, viridiflorene, 2-tridecanone, p-cymene, α-muurolene, limonene, 1,8-cineole, (Z,Z)-α-earnesene, γ-terpinene, β-bisabolene, trans-γ-cadinene, δ-cadinene, methyl chavicol, (E)-α-bisabolene, isothymol methyl ether, occidentalol, methyl thymol, caryophyllene oxide, bornyl acetate, cedrol, 1,10-di-epicubenol, α-copaene, 1-epi-cubenol, cyperene, γ-cadinol, β-caryophyllene, α-cadinol, 2,5-dimethoxy-pycymene, valerianol, α-humulene, cyperotundone, pentadecanal, benzyl benzoate, and γ-muurolene. Compounds identified in S. occidentalis are as follows: α-pinene, selinene, β-pinene, valencene, myrcene, α-selinene, α-phellandrene, viridiflorene, δ-3-carene, p-cymene, limonene, β-himachalene, β-bisabolene, terpinolene, 1,8-cineole, linalool, 7-epi-α-selinene, α-terpinol, δ-cadinene, methyl chavicol, caryophyllene oxide, bornyl acetate, myrtenyl acetate, humulene epoxyide II, α-terpinyl acetate, α-copaene, 1-epi-cubenol, daucene, γ-eudesmol, cyperene, τ-cadinol, β-caryophyllene, valerianol, trans-α-bergamotene, (Z)-6,7-dihydrofarnesol, α-humulene, α-patchoulen, alloaromadendrene, γ-himachalene, and γ-muurolene.

Maia et al. [79] from methanolic extracts of S. gardneri and Senna georgica H.S.Irwin & Barneby separated compounds, viz., vanillic acid, 3,4-dihydroxybenzoic acid, syringic acid, dihydromyricetin, rutin glucoside, quercetin diglucoside, rutin pentoside, kaempferol rhamnoglucoside, quercetin glucarabinoside, kaempferol diglucoside, ellagic acid, rutin, oxyresveratrol, methoxy oxyresveratrol, quercetin glucoside, rubrofusarin tetraglucoside, quercitrin, kaempferol rhamnoglucoside, rubrofusarin triglucoside, rubrofusarin gentibioside, myricetin, quercetin, rubrofusarin glucoside, and emodin.

Monteiro et al. [80] reported the preliminary investigation on the qualitative phytochemicals present in Senna cana (Nees & Mart.) H.S.Irwin & Barn and Senna pendula (Willd.) H.S.Irwin & Barneby and reported the presence of saponins, anthraquinones, triterpenoids, steroids, flavonoids, flavones, tanins, and xanthones.

Barba et al. [81] extracted different compounds from the leaves of Senna corymbosa (Lam.) H.S.Irwin & Barneby and roots of Senna lindeimeriana (Scheele) H.S.Irwin & Barneby. They were chrysophanol, methoxyhydroquinone, emodin, 5,7'-biphasicn (floribudone-l), physcion, p-hydroxybenzaldehyde, hydroquinone monomethyl ether, 3-hydroxy-4-methoxyphe nol, β-sitosterol, stigmasterol, and linoleic acid in S. corymbosa; while S. lindeimeriana had chrysophanol, xanthorin, chrysophanol 8-methyl ether, emodin, quentin, physcion, 1-hydroxy-3-methyl-2,6,7,8-tetramethoxy-9,10-anthraquinone, 3,4,3'5'-tetrahydroxystilbene (piceatannol), 4,2',4'-trihydroxychalcone (isoliquiritigenin), 2,4,5-trimethoxyphenol, betulinic acid, and stigmasterol.

Zavala-Sánchez et al. [82] analyzed the GC-MS result from the Senna crotalariaoides (Kunth) H.S.Irwin & Barneby
leaf (chloroform) extracts and reported the following compounds. 1-octacosanol, 1-triacontanol, palmitic acid, beta-sitosterol, neophytadiene, 1-hexacosanol, and stigmastanol.

Alemayehu et al. [83] from the pods of Senna didymobotrya (Fresen.) H.S.Irwin & Barney isolated compounds, namely, kniphofine, emodin, chrysophanol, 10-hydroxy-10-(physcion-7'-yl)-chrysophanol anthrone, phycisin, and 5,10-dihydroxy-2-methyl-9-(physcion-7'-yl)-1,4-anthraquinone.

Ochieng et al. [84] reported that the root extracts (ethyl acetate) resulted in nataloemedin-8-methyl ether, obtusifolin, 1,6-di-O-methylmodin, chrysophanol, phycisin, phycisin-10,10'-bianthrone, chrysophanol-10,10'-bianthrone, and stigmastanol. Rao et al. [85] extracted compounds, namely, kaempferol 3-O-α-L-rhamnopyranosyl (1→2)-α-L-rhamnopyranoside, kaempferol 3-O-rutinoside, and rutin from the flowers of S. hirsuta.

Silva et al. [86] identified the following compounds from S. gardneri, Senna macranthera (Collad.) H.S.Irwin & Barney, Senna splendida (Vogel) H.S.Irwin & Barneby, and Senna trachyphus (Benth.) H.S.Irwin & Barneby through GC-MS. S. gardneri contains succinic acid, glyceric acid, β-caryophyllene, malic acid, pyrogulatic acid, 3-hydroxy-3-methylglutaric acid, 3,4-dihydroxy benzonic acid, citric acid, neophytadiene, gluconic acid, hexadecanoic acid, linolenic acid methyl ester, phytol, quercetin, α-linolenic acid, linoleic acid, stearic acid, α-tocopherol, eicosanoic acid, squalene, tetracosanoic acid, β-stigmasterol, and stigmastanol. Rao et al. [87] identified the phytol (3,7,11,15-tetrahydroxy-7,7′-dimethyl-(10,10′-bianthracen)-9,9′-dione (or chrysophanol-phycisin), 1,8,1′,8′-tetrahydroxy-7′-methoxy-3,3′-dimethyl-(10,10′-bianthracen)-9,9′-dione (or chrysophanol-isophycin-10,10′-bianthrone) and 1,8,1′,8′-tetrahydroxy-7,7′-dimethoxy-3,3′-dimethyl-(10,10′-bianthracen)-9,9′-dione (or isophycin-10,10′-bianthrone) from the leaves and root bark of Senna longiracemosa (Vatke) Lock. Branco et al. [92] communicated the presence of rubrofusarin (5,6-dihydroxy-8-methoxy-2-methylbenzol[c]resorcin-4-one, 1) in S. macranthera. Klika et al. [93] confirmed the (2R,3S,4S,2′R,3′S)-guibourtinidol-(4α→8)-catechin (procyanidin) in root isolates.

Pires et al. [94] isolated mannose and galactose from the endosperm of S. macranthera seeds. Messana et al. [95] isolated 10-demethylflavaspirone-10-sulphate, 10-demethylflavaspirone-10-O-β-D-apiofuranosyl-(1→6)O-β-D-glucopyranoside, and cassiapryrone-10-sulphate (7-methyl-10-demethylflavaspirone-10-sulphate); quinquangulin-6-O-β-D-apiofuranosyl-(1→6)O-β-D-glucopyranoside, rubrofusarin-6-O-β-D-glucopyranoside, quinquangulin-6-O-β-D-glucopyranoside and chrysophanol dimethyl ether, chrysophanol, phycisin, cis-3,3′,5,5′-tetrahydroxy-4-methoxystilbene, trans-3,3′,5,5′-tetrahydroxy-4-methoxystilbene, and cassiaside B from the root methanolic extracts [96]. de Macedo et al. [97] reported the presence of bianthrone glycoside, namely, martianine 1 (10,10′-il-chrysophanol-10-oxi-10,10′-bi-glucosyl) from the stalks of Senna martiana (Benth.) H.S.Irwin & Barney.

Graham et al. [98] isolated quinquangulin and rubrofusarin from the stem and fruit extract (methylanic) of Senna obliqua (G.Don) H.S.Irwin & Barney.

Pang et al. [99] communicated extractions from seeds of S. obtusifolia and those included obtusifolin-2-O-β-D-(6′-O-acetyl)glucopyranoside and epicatechin glycoside (procyanidin). Klika et al. [100] described the existence of cardenolides, flavonoids, saponins, alkaloids and anthraquinones in the leaves of S. occidentalis.

Javaid et al. [101] extracted 1,3-benzenedicarboxylic acid, bis(2-ethylhexyl) ester, 9,10-diethylcyclclohexane (2,6,10,14,18,22-hexamethyldodecane), 1,heptacosanol; α-tocopherol-β-D-mannoside; 1,2-epoxynedacase; stigmastanol; γ-sitosterol and lupulo from hexane extract of Senna italica Mill. leaves through GC-MS analysis.

Khalaf et al. [88] used aerial parts and isolated phycisin, emodin, 2-methoxy-emodin-6-O-D-glucopyranoside, quercetin 3-O-L-rhamnopyranosyl-(16)-D-glucopyranoside (rutin), 1-hydroxy-2-acetyl-3-methyl-6-hydroxy-8-methoxyphthalene (tinnevelin), and 1,6,8-trihydroxy-3-methoxy-9,10-dioxo-9,10-dihydroanthracene. Similarly, Madkour et al. [89] identified n-hexadecanoic acid, (Z,Z,Z)9,12,15-octadecadienoic acid, vitamin E, from hexane extract and 3-methyl-4-oxo-pentanoic acid, (E)-stilbene, and 2,6-di-tet-butylphenol from methylene chloride extract by GC-MS analysis. Mokgotho et al. [90] extracted 3,4′,5-trihydroxystilbene (resveratrol) from aqueous extracts of the roots.

Alemayehu et al. [91] isolated 1,8,1′,8′-tetrahydroxy-6′-methoxy-3,3′-dimethyl-(10,10′-bianthracen)-9,9′-dione (or chrysophanol-phycisin), 1,8,1′,8′-tetrahydroxy-7′-methoxy-3,3′-dimethyl-(10,10′-bianthracen)-9,9′-dione (or chrysophanol-isophycin-10,10′-bianthrone) and 1,8,1′,8′-tetrahydroxy-7,7′-dimethoxy-3,3′-dimethyl-(10,10′-bianthracen)-9,9′-dione (or isophycin-10,10′-bianthrone) from the leaves and root bark of Senna longiracemosa (Vatke) Lock. Branco et al. [92] communicated the presence of rubrofusarin (5,6-dihydroxy-8-methoxy-2-methylbenzol[c]resorcin-4-one, 1) in S. macranthera. Klika et al. [93] confirmed the (2R,3S,4S,2′R,3′S)-guibourtinidol-(4α→8)-catechin (procyanidin) in root isolates.

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Li et al. [104] isolated cyclodentinal acids A and B, cyclodentinalides I-V, quercetin, luteolin, eriodictyol, robustin, chrysoeriol, 3-methylquercetin, 7,4'-dihydroxy-3' -methoxyflavone, 7,3',4'-trihydroxyflavone, 3-methoxy-7,3' ,4'-trihydroxychalcone, chrysoeriol 5-methyl ether, 2',3',4',4'-tetrahydroxychalcone, ajugasterone C, 20-hydroxyecdysone 2-acetate, 20-hydroxyecdysone 3-acetate, calonesterone, and poststerone. S. F. Li and S. L. Li [105] isolated cyclodentinal acid C and cyclodentinaliside VI.

Ogunwande et al. [106] identified the (E)-geranyl acetone, hexahydrofarnesylacetone, and (E)-phytol acetone through GC-MS. Qin et al. [107] extracted nor-sesquiterpenoids, 3-isopropyl-1,6-dimethoxy-5-methyl-naphthalene-7,ol, and 2,7-dihydroxy-4-isopropyl-6-methyl-naphthalene-1-carbaldehyde. Singh et al. [108] reported the isolation of emodin, rhamnetin 3-neohesperidoside, chrysoeriol, 3-methylquercetin, 7,4'-dihydroxy-3-methoxy-1,6,8-trihydroxyanthraquinone, 3-methoxy-1,6,8-trihydroxyanthraquinone, 5,7'-bears, 3,4-methylenedioxy-4-methoxyphenol from the leaves. Sansores-Peraza et al. [117] isolated Schoepfiol extracts of leaves and roots. Genta-Jouve et al. [114] isolated schoepiuranols, 3,3',4'-tetrahydroxyfavanol, ß-sitosterol, and chrysophanol.

Tshikalange et al. [109] extracted luteolin from the seeds of S. rugosa. Malmir et al. [113] isolated rhein, emodin, chrysophanol, and inositol methyl ether from the leaves. Ogura et al. [115] isolated quinquangulin.

S. F. Li and S. L. Li [105] isolated cycloccidentalic tetrahydroxychalcone, ajugasterone C, 20-hydroxyecdysone, hexahydrofarnesylacetone, and (E)-phytol acetate from the stem. Qin et al. [107] extracted nor-sesquiterpenoids, 3-isopropyl-1,6-dimethoxy-5-methyl-naphthalene-7,ol, and 2,7-dihydroxy-4-isopropyl-6-methyl-naphthalene-1-carbaldehyde. Singh et al. [108] reported the isolation of emodin, rhamnetin 3-neohesperidoside, chrysoeriol, 3-methylquercetin, 7,4'-dihydroxy-3-methoxy-1,6,8-trihydroxyanthraquinone, 3-methoxy-1,6,8-trihydroxyanthraquinone, 5,7'-bears, 3,4-methylenedioxy-4-methoxyphenol from the leaves. Sansores-Peraza et al. [117] isolated Schoepfiol extracts of leaves and roots. Genta-Jouve et al. [114] isolated schoepiuranols, 3,3',4'-tetrahydroxyfavanol, ß-sitosterol, and chrysophanol.

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, 9′-trihydroxy-1′-oxo-1′, 2′, 3′, 4′-tetrahydro-anthracene-7′-yl)-5, 10-dihydroxy-2-methoxy-7-methyl-1, 4-antraquinone, phycien biantarone, xanthorin, florilumidine-1, isosenguyen, sengulone, and anhydrophragemacin-9, 10-quinoines A2 and B2. Kharaat et al. [142] extracted hexahydroxydiphenic acid and kaempferol from manetholic extract of leaves.

Malhotra and Misra [143] isolated 1, 3, 6, 8-tetrahydroxy 2-methyl 7-vinyl anthraquinone (sopharanin), 3-sitosterol, chrysophanol, phycien, and emodin from the roots and flowers. Mondal et al. [144] isolated 2-(3, 4-dihydroxy-phenyl)-3, 5-dihydroxy-7-methoxy-chromen-4-one.

Mushtaq et al. [145] isolated palmitic acid, palmitoleic acid, oleic acid, phytol, neophytadiene, and solasodine from S. sophera and S. tora. S. spectabilis is one of plant widely studied and reported. Selegato et al. [163] reviewed the chemical aspects of S. spectabilis. Silva et al. [146] isolated caffeine, lupeol, α-amin, β-amin, cycloexcalen, friedelin, ursolic, oleandonic, and betulinic acids, sitosterol, and stigmasterol and their respective glucosides from the leaves. Lim et al. [147] isolated (S)-spectaline and iso-6-spectaline from the leaves.

For this plant, flowers are recognized by (-)-cassine, (-)-cassine, (-)-spectaline, and iso-6-spectaline [148-150]. Sriphong et al. [151] isolated 3(R)-benzoyloxy-2(R)-methyl-6(R)-(11′-oxododecyl)-piperidin, 5, 6-dihydroxy-2-methyl-6-(11′-oxododecyl)-pyridin, 5-hydroxy-2-methyl-6-(11′-oxododecyl)-pyridin N-oxide, and (-)-cassine from the flowers. Viegas Junior et al. [152] isolated (S)-7-hydroxycassine, (-)-cassine, (-)-spectaline, (-)-3-O-acetylspectaline, (-)-7-hydroxyxpectaline and (-)-iso-6-spectaline, β-sitosterol, luteolin, 3-methoxyluteolin, betulinic acid, and trans-cinnamic acid from the green fruits and flowers, whereas few other researchers reported piperidine alkaloid (-)-3-O-acetylspectaline, (-)-3-O-acetyl-spectaline, (-)-spectaline, (-)-3-O-acetylcassine, iso-6-cassine, (-)-3-O-acetyl-spectaline, (-)-cassine, and (-)-spectaline [153-157].

Maia et al. [79] isolated quercetin diglucoside from the leaves, methoxy oxerysaretrol from the roots, quercetin-3-O-rhamnoso-4′-O-glucoside from the flowers (2, 885 g/kg), while the bark of S. splendida had quercetin rhamnoside. Valenca et al. [158] isolated 5-(3-formyl-4-hydroxyfenoxo)-2-hydroxybenzaldehyde from stems and leaves of Senna stipulacea (Aiton) H.S. Irwin & Barneby.

El-Sawi and Sleem [159] isolated quercetin 3-O-glucoside 7-O-rhamnoside, quercetin, and rutin from the leaves of S. surattensis. Anu and Madhusudana [160] isolated kleinoxanthone-1 and 2 from the aerial sections of S. tora [161] while roots had kleinoxanthone-3 and 4. el-Halawany et al. [162] isolated torachrysone 8-[β-D-glucopyranosyl (1→3)-O-β-D-glucopyranosyl (1→6)-O-β-D-glucopyranoside], torachrysone 9- [β-D-glucopyranosyl (1→3)-O-β-D-glucopyranosyl (1→6)-O-β-D-glucopyranoside], aurantio-obtusin 6-O-b-D-glucoside, torachrysone 8-O-b-D-gentibioside, torachrysone 9-0-b-D-gentibioside, 6-hydroxymusizin 8-O-b-D-glucoside, torachrysone tetraxilucoside, rubrofusarin triglucoside, and chrysoanol triglucoside from ethanolic extract of the seed. In another work, Fathalla et al. [163] identified chrysoanol, chrysoarbin, 10-hydroxy-5-methoxy-2-methyl-1, 4-antrachenedione, rubrofunarin, pariatin, grisoxanthone-B, isotorachrysone, and cumbiasin B from the seeds through GC-MS. Lee et al. [164] isolated rubrofusarin-6-O-β-D-gentiobioside, cassiaside, and toralantoc-9-O-β-D-gentiobioside from the seeds.

Hatano et al. [165] isolated rubrofusarin-6-O-β-D-gentiobioside, cassiaside, cassiaside C, chrysophanol-1-O-β-D-tetraglucoside, torosachrysin-8-O-β-D-gentiobioside, cassiaside C2, rubrofusarin triglucoside, torachrysin tetraglucoside, demethylflavasperone gentiobioside, norrubrofusarin gentiobioside, torachrysin gentiobioside, and torachrysin apialoglucoside from the seeds. Lee et al. [166, 167] extracted emodin, 7-methoxy-obtusifolin, chrysoobtusin, obtusin, aurantio-obtusin, chrysoanol, obtusifolin, phycien, cassiaside, rubrofusarin-6-O-β-D-gentiobioside, obtusifolin-2-glucoside, cassitoreside, toralactone-9-O-gentiobioside, chryso-obtusin-2-O-glucoside, physcion-8-O-gentiobioside, glaucouarantio-obtusin, and alaternin 2-O-β-D-glucopyranoside from the seeds. In an independent study, Park and Kim [168] isolated chryso-obtusin-6-glucoside, norrubrofusarin-6-glucoside, and obtusifolin-2-glucoside, using seeds. Cherg et al. [169] extracted aloe-emodin, emodin, chrysoanol, and rhein. Hyun et al. [170] extracted emodin, alaternin, gluco-aaurantioobtusin, gluco-obtusifolin, cassiaside, cassitoreside, chrysoanol triglucoside, toralactone gentiobioside, questin, and 2-hydroxyemodin 1-methylether from the methanol extract. Jimenez-Coello et al. [171] isolated (8-hydroxymethylen)-trieicosanyl acetate from the Senna villosa (Mill.) H.S. Irwin & Barneby. Guzmán et al. [172] isolated (8-hydroxymethylen)-trieicosanyl acetate from the leaf extract (chlofoform extract).

The chemical structures of some representative phytochemical compounds with therapeutic potencies in Senna plants are represented in Figure 2.

6. Antioxidant Activity of Senna Plants

Antioxidants are chemical compounds which are naturally present in food and also in human body [173-175]. These substances play a vital role for preventing cell damage caused by oxidative destruction as a result of free radical generation [176-178].

According to the literature, there are different pathways to acting as antioxidant agents [179, 180]:

(1) Inhibiting the spread of free radicals or peroxide radicals by exchange of one or more protons

(2) Reducing or blocking free radical formations with help of "metal chelating agents"

(3) Reduction in reactive oxygen species (ROS) formation

(4) Decreasing cellular ROS creation by hindering the oxidant enzymes

(5) Influencing the complete antioxidant mechanism in the body by synergies of different antioxidant-rich ingredients

ROS are considered causative for various detrimental effects and persistent diseases like cancer, cardiovascular
diseases (CVD), neurodegenerative dysfunction, like Alzheimer’s, Parkinson’s, and Huntington’s diseases, sepsis, and diabetes [181–183].

The antioxidant activity of Senna genus was correlated with phenolic and flavonoid content which includes chemical compounds such as catechins, proanthocyanidins, scutellarein, rutin, quercimeritrin, kaempferol glycosides, rhein, chrysophanol, aloe-emodin, and physcion [184–186].

Neutralization of free radicals by the contained polyphenols justifies the antioxidant activities of the genus Senna. These polyphenols also quench singlet, and triplet oxygen, or decompose peroxides [187]. The antioxidant capacity and total polyphenol content of genus Senna were investigated by conducting both in vitro and in vivo experiments (Figure 3).

Commonly used in vitro techniques for determining the antioxidant activities of extracts are DPPH (2,2-diphenyl-1-picrylhydrazyl radical) and FRAP (ferric reducing antioxidant power) assay. The literature study indicates that various species under Senna genus were investigated using different methodologies, and they are indicated in Table 2. According to the study of Silva et al. [188] with four species of Senna from northeast Brazil, some of the phenolic compounds such as anthraquinones and flavonoids which are detected in the phytochemical screening especially in root extracts more than other parts can act as radical scavengers by donating hydrogen. They also mentioned that root extract of S. trachypus had a higher radical scavenging activity level than two standards (butylated hydroxyanisole (BHA) and quercetin) used in the assays.

Campos et al. [185] examined the chemical makeup of Senna velutina (Vogel) H.S.Irwin & Barneby leaf extracts (ethanol) and antioxidant activities with the DPPH method. In this study, IC50 (minimum sample concentration needed for scavenging 50 percent free radicals) values of the extract of S. velutina leaf extract, ascorbic acid and butylated hydroxytoluene (BHT) were found (6.3 μg/mL, 2.6 μg/mL, and 21.3 μg/mL, respectively). This indicates that the antioxidant activity of S. velutina leaves is higher with a 3.5-fold than BHT but lower than ascorbic acid according to these results.

Ita and Ndukwe [189] studied the antioxidant activity of S. alata roots in different in vitro models. They used three different solvents such as acetone, ethanol, and water for

Figure 2: Chemical structures of mostly identified phytochemical compounds in Senna plants.
extraction and measured its ferric reducing power, DPPH, ABTS (2,2'-azino-bis(3-ethylbenzothiazoline-6-sulfonic acid) radical-scavenging abilities, and metal chelating activity to determine antioxidant properties of roots. Researchers stated that ethanol extract had high amounts of total phenolics and flavonoids with values of 78.21 mg gallic acid equivalent (GAE)/g and 39.29 mg quercetin equivalent (QE)/g and exhibited the best antioxidant capacity in terms of DPPH and ABTS protocols. Besides, the aqueous extract showed more potential in metal chelating and reducing power. Khalaf et al. [88] analyzed the phenolic compounds, antioxidant, antimicrobial, and anticancer activities of *S. italica* aerial parts extracted using ethyl acetate and n-butanol. The researchers isolated and identified six compounds from this plant as they did bioguided fractionation. The names of these compounds are as follows: quercetin 3-O-α-L-rhamnopyranosyl-(1→6)-β-D-glucopyranoside (rutin), physcion, emodin, 1-hydroxy-2-acetyl-3-methyl-6-hydroxy-8-methoxynaphthalene (tinnellin), 2-methoxy-emodin-6-O-β-D-glucopyranoside, and 1,6,8-trihydroxy-3-methoxy-9,10-dioxo-9,10-dihydroanthracene. Antioxidant activity was measured with ABTS method, and the ethyl acetate and n-butanol extracts showed 82.9% and 85.7% inhibition against ABTS radical, respectively, in comparison with ascorbic acid (89.2% inhibition). According to the literature, anthraquione compounds which are already in this plant are given to their antioxidant potentials. Therefore, the researchers said that these anthraquione-rich extracts (ethyl acetate and n-butanol) might be the reasons behind the high antiradical capacity. At last, it is noted that the aerial parts of *S. italica* may possess antioxidant activity and can serve as natural sources of antimicrobial and anticancer factors.

Phaiphan and Baharin [190] focused on determining effects of various extraction methods on some bioactive properties of *S. siamea* leaf. Researchers focused the study on comparing the solvent extraction with that of ultrasound-assisted extraction with regard to total phenolic content and antioxidant and antibacterial activity. In solvent extraction and ultrasound-assisted extraction (UAE), ethanol/water mixture (49%) and ethanol/water mixture (40%) were used, respectively, under the optimized conditions which were predetermined. The study showed that extracts from the ultrasound-assisted extraction had higher yield, total phenolic content (TPC), and antioxidant activities than those acquired from the solvent extraction. Furthermore, UAE extracts had greater antibacterial activity compared to solvent extracts. This can be attributed to the fact that the cavitational effect caused by ultrasound resulted in a more porous cell wall causing more release of phenolic bioactive in the solvent. It is evident from the literature that higher concentrations of bioactive have a direct correlation with antioxidant activity and antimicrobial activity. Similarly, Laghari et al. [191] investigated the comparison between 5 different extraction methods (microwave, Soxhlet, marination, reflux, and sonication) during the extraction of flavonoids to evaluate the antioxidative properties of *S. alexandrina*. As a result of this study, a greater quantity of flavonoids was obtained with microwave extraction in the aqueous ethanol (70%) fractions of *S. alexandrina* flowers and leaves.

**Figure 3:** Antioxidant activity of bioactive compounds of *Senna* plants. The antioxidant bioactive molecules contained in *Senna* species neutralize free radicals by releasing electrons.
Table 2: Summary of several in vitro studies about the antioxidant activity and total phenolic content of genus *Senna*.

| *Senna* genus                      | Part of plant—solvent—procedure (if any) | Method | Result | References |
|-----------------------------------|------------------------------------------|--------|--------|------------|
| *Senna gardneri* (Benth.) H.S.Irwin & Barneby | Root = Sg, solvent—ethanol | DPPH (IC<sub>50</sub> mg/mL) | 0.396 | 57.13 | 214.25 | [188] |
| *Senna macranthera* (Collad.) H.S.Irwin & Barneby | Root, leaves—ethanol | DPPH, ABTS—Folin-Ciocalteu | Sm 0.534 | 53.72 | 122.09 | |
| *Senna splendidia* (Vogel) H.S.Irwin & Barneby | Leaves = Sg | ABTS—Folin-Ciocalteu | St 0.253 | 64.47 | 1277.34 | |
| *Senna trachypus* (Benth.) H.S.Irwin & Barneby | Root, leaves—ethanol | DPPH | Sm 0.424 | 26.72 | 207.71 | |
| *Senna velutina* (Vogel) H.S.Irwin & Barneby | Leaves—ethanol | DPPH | O x = Sg | 0.089 | 47.91 | 338.76 | |
| *Senna reticulata* (Wild.) H.S.Irwin & Barneby | Aerial parts—Methyl tert-butyl ether (MTBE)/methanol (90:10) | DPPH, ORAC-Folin-Ciocalteu | DPPH (mg/mL) | 72.90 | 2.68 | 79.3 | [193] |
| *Senna alata* (L.) Roxb. | Roots—acetone, ethanol, water | DPPH, ABTS (IC50) | Acetone 82.42 | 64.93 | 21.42 | |
| *Senna bicapsularis* (L.) Roxb. | Flowers—ethanol, water | DPPH, FRAP—Folin-Ciocalteu | Ethanol 99.51 | 2403.15 | 26223.78 | |
| *Senna italica* mill. | Aerial parts—ethyl acetate, n-butanol | ABTS | Ethyl acetate 96.51 | 1966.30 | 9468.18 | |
| *Senna siamea* (Lam.) H.S.Irwin & Barneby | Leaves—ethanol (49%)—ultrasound-assisted (UA) | DPPH, FRAP—Folin-Ciocalteu | Ethanol 80.49 | 8.08 | 455.42 | |
| *Senna alexandrina* Mill. | Flowers—ethanol | DPPH—HPLC-ESI-MS/MS | % Inhibition (IC50) = microwave | 3.1 | 5.3 | 5.9 | [191] |
| Senna genus      | Part of plant—solvent—procedure (if any) | Method                          | Result | References |
|-----------------|------------------------------------------|---------------------------------|--------|------------|
|                 | Flowers, leaves—ethanol (70%)—microwave, Soxhlet, marination, reflux and sonication | Leaves                          | 3.6    |            |
| Senna alata (L) |                                          |                                 | 4.2    |            |
| Roxb.            |                                          |                                 | 5.6    | [192]      |
|                 | Leaves—ethanol                           | Chemiluminescence measurement   | 6.2    |            |
|                 |                                          |                                 | 7.4    |            |
| Senna alata (L) | Root, stem, seed, leaves and flower—methanol/water (80%) | FRAP-Folin-Giocalteu            |        |            |
| Roxb.            |                                          |                                 |        | [195]      |
|                 | root                                      |                                 | 0.255  |            |
|                 | stem                                      |                                 | 0.457  |            |
|                 | seed                                      |                                 | 0.345  |            |
|                 | leave                                     |                                 | 0.560  |            |
|                 | flower                                    |                                 | 0.565  |            |
|                 |                                          |                                 | 1.36   |            |
In some of the studies, the antioxidant activity of some plants is compared with each other. In a study, five different medicinal plants (S. alata, Eleusine indica (L.) Gaertn., Eremomastax speciosa (Hochst.) Cufod., Carica papaya L., and Polyscias fulva (Hiern) Harms) collected from Cameroon were examined according to their scavenger activities against superoxide anion and hydrogen peroxide [192]. The results show that S. alata plant extracts at less than 12.5 μg had the best scavenger activity with a 67% reduction in luminol-amplified chemiluminescence signal.

Navarro et al. [193] obtained and characterized (UPLC-DAD-EST-TQ-MS) phenolic extracts from Petiveria alliaceae L., Phyllanthus niruri L., and S. reticulata. Researchers also evaluated the antioxidant potential via conducting DPPH and ORAC (oxygen radical absorbance capacity) assay, and TPC was measured by the Folin-Ciocalteu method. Correlation analysis was carried out as well. It was reported that P. niruri has the highest phenolic content with 328.8 GAE/g, followed by S. reticulata with 79.3 GAE/g. In addition, P. niruri exhibited the best DPPH and ORAC values among these three plants. About the phenolic acid’s characterization, for S. reticulata, the main compound was ferulic acid (52.6%) followed by 4-hydroxybenzoic acid, cinnamic acid, vanillic acid, p-coumaric acid, and protocatechuic acid. S. reticulata had IC50 of 72.9 μg/mL for DPPH and 2.68 mmol Trolox equivalents (TE)/g for ORAC. It was concluded that as TPC and UPLC increased ORAC values increased indicating a strong correlation.

Mak et al. [194] investigated the antioxidant capacity and antibacterial properties of ethanolic and distilled water extracts of hibiscus (Hibiscus rosa-sinensis L.) and S. bicapsularis flower. DPPH radical scavenging activity and FRAP were used as antioxidant assay while total phenolic content was analyzed by using the Folin-Ciocalteu method. DPPH inhibition values were 99.51 ± 0.2 for ethanol extracts and 96.51 ± 0.3 for aqueous extracts. The FRAP values found in the study were like 2403.15 ± 307.3 μmol Fe (II)/100 g for ethanol extract and 1966.30 ± 12.7 for aqueous extract. Total phenolics were also determined in the study, and results are as follows: 26223.75 ± 450.3 mg GAE/100 g for ethanol extract and 9468.18 ± 91.9 mg GAE/100 g for aqueous extract. Researchers stated that these results were significantly different from each other and the other hibiscus flower extracts. Similarly, too many studies in literature, Cassia flower extracts (ethanolic) exhibited the highest TPC, total flavonoid, and flavonoid content, which in turn had the highest DPPH radical scavenging activity. In addition to that, they suggested that all hibiscus and cassia flowers—because of their significant antioxidant activities—can be used as a natural preservative in formulations of new and creative functional products or nutraceuticals.

Channa et al. [195] studied medicinal properties, biochemical parameters, and antibacterial activity of S. alata’s various sections such as roots, stem, seed, leaves, and flower. To analyze the antioxidant capacity, the FRAP method was chosen and 80% methanol-water was used as a solvent. Researchers noted that the seeds were found rich in phenolic compounds compared to other parts. The seeds of S. alata contained a sufficient amount of total flavonoid whereas the leaves of the plant were quite rich in tannins. However, flowers were found the strongest antioxidative content. As a result, researchers suggested that these extracts have important potential for health benefits, so the plant needs to be isolated and test in detail.

Maduny and Ode [196] investigated the antioxidant potential of the S. singueana leaves with an in vivo malondialdehyde test. Malondialdehyde is an oxidative stress marker which is the end product of lipid peroxidation in the cells. In this study, all doses (0.25, 0.50, and 1.00 g/kg feed) of S. singueana extract significantly decreased malondialdehyde (MDA) level in the blood samples of test rats in comparison to the control group up to day 56. Similar to that study, treating rats using the methanolic extract of S. singueana root extracts was able to decrease malondialdehyde levels, the same as aspartate aminotransferase, alanine aminotransferase, and bilirubin level which are the indices of liver damage and lipid peroxidation, in all tissues especially in the liver and kidney [197].

7. Anti-infectious Activity of Senna Plants

7.1. Antibacterial and Antifungal. The most studied genus Senna for its anti-infectious activity was found to be S. alata. Different parts of S. alata are used as a vermicide, astringent, purgative, and expectorant and for treating skin diseases such as eczema, pruritus, itching, ulcers, scabies, and especially ringworm [198, 199]. Other species having antimicrobial activity are S. spectabilis, S. alexandrina, S. occidentalis, S. podocarpa, S. tora, S. racemosa, and S. siamea. The bioactive substances that provide bioactivity to genus Senna are steroids, flavonoids, anthraquinones, anthrones, and miscellaneous other compounds. They are located in the leaves, stems, roots, flowers, bark, seeds, and fruits.

Especially antibacterial and antifungal activities of Senna extracts are obtained from the extraction of leaves mostly. In the studies generally, minimum inhibitory concentration (MIC) is calculated which is described as the smallest concentration of sample necessary to prevent microbial growth. The MIC value of 100–200 μg/mL is generally acceptable for plant materials [200]. Although the extracts of the parts of the genus Senna could not reach such MIC values, when the bioactive compounds are isolated from the extracts, MIC values decrease, and the antimicrobial properties increase [201]. Some of these bioactive components include stigmasterol, beta-sitosterol, kaempferol, luteolin, santal, aloes-emodin, alquinone, chrysophanol, emodin, physcion, rhein, alarone, benzoquinone, coumarin, ellagitaninn, naphthalene, phenolic acid, purine, xanthone, and cassine [202]. Anti-infectious effects of genus Senna are presented in Table 3.

The antifungal and antibacterial activity of the genus Senna varies depending on the species of the plant, the species of the microorganism, and the factors that affect the yield of the extraction process, such as the extraction method, the solvent used, the portion of the plant, and the secondary metabolite.

Ogunjobi and Abiala [203] investigated in vitro antimicrobial effect of different solvent extracts of S. alata leaves.
| Effect | Microorganism      | Antimicrobial assay                        | Senna genus       | Plant part-solvent              | Result-solvent | References |
|--------|--------------------|--------------------------------------------|------------------|--------------------------------|----------------|------------|
| Antiprotozoal | *Haemonchus contortus* | Effective dose determination for ED50 | *Senna occidentalis* | Crude plant-aqueous extract | 0.13 mg/mL | [221] |
| Antiprotozoal | *Haemonchus contortus* | Effective dose determination for ED50 | *Senna occidentalis* | Crude plant-hydroalcoholic extract | 0.17 mg/mL | [221] |
| Schistosoma mansoni | Effective dose determination for ED50 | | | | | |
| Bacillus cereus | Diameter of the inhibition zone | *Senna alexandrina* | Leaves-methanol | 11.0 mm | [211] |
| Bacillus cereus | Diameter of the inhibition zone | *Senna spectabilis* | Leaves-ethanol extract | 495.4 μg/mL | [210] |
| Candida albicans | Diameter of the inhibition zone | *Candida albicans* | Aerial part-n-butanol extract | 9.3 mm | [88] |
| Entrobacter aerogenes | Diameter of the inhibition zone | *Entrobacter aerogenes* | Aerial part-n-butanol extract | 12.4 mm | [88] |
| Erwinia spp. | Diameter of the inhibition zone | *Erwinia spp.* | Aerial part-n-butanol extract | 10 mm | [88] |
| Erwinia spp. | Diameter of the inhibition zone | *Erwinia spp.* | Aerial part-n-butanol extract | 8 mm | [88] |
| *Erwinia chrysanthemi* | Agar well diffusion | *Senna spectabilis* | Leaf dichloromethane/leaf-methanol | 12.00 ± 1.70 mm | 13.00 ± 2.10 mm | [223] |
| *Erwinia chrysanthemi* | Agar well diffusion | *Senna spectabilis* | Flower dichloromethane/flower-methanol | 9.70 ± 0.60 mm | 10.00 ± 2.50 mm | [223] |
| *Erwinia chrysanthemi* | Agar well diffusion | *Senna spectabilis* | Stem dichloromethane/stem-methanol | 9.30 ± 1.20 mm | 16.00 ± 1.20 mm | [223] |
| *Escherichia coli* | Agar well diffusion | *Senna alata* | Leaf-ethanol | 17.2 ± 0.3 mm | [203] |
| *Escherichia coli* | Agar well diffusion | *Senna alata* | Leaf-water | 10.2 ± 0.2 mm | [203] |
| *Escherichia coli* | Inhibition zone (filter paper disc diffusion method) | *Senna occidentalis* | Whole plant ethanol extract | 7.8 mm | [212] |
| *Escherichia coli* | Diameter of the inhibition zone | *Senna italica* | Aerial part-n-butanol extract | 19 mm | [88] |
| *Escherichia coli* | Diameter of the inhibition zone | *Senna italica* | Aerial part-n-butanol extract | 16 mm | [88] |
| *Escherichia coli* | The cup plate agar diffusion method | *Senna alata* | Leaf hot water/leaf-methanol/leaf-acetone | 3 mm/4 mm/3 mm | [205] |
| *Escherichia coli* | The cup plate agar diffusion method | *Senna alata* | Root hot water/root-methanol/root-acetone | 4 mm/4 mm/3 mm | [205] |
| *Escherichia coli* | Minimum inhibitory concentration | *Senna alata* | Leaf-methanol/root-methanol | 8 mg/mL/6 mg/mL | [205] |
| *Klebsiella aerogenes* | Inhibition zone (filter paper disc diffusion method) | *Senna occidentalis* | Whole plant ethanol extract | ND | [212] |
| *Klebsiella pneumoniae* | Agar diffusion method, zone of inhibition | *Senna bicapularis* | Flower-ethanol extract | 7 mm | [194] |
| *Klebsiella pneumoniae* | Agar diffusion method, zone of inhibition | *Senna bicapularis* | Flower-distilled water | 9 mm | [194] |
| *Listeria monocytogenes* | Agar diffusion method, zone of inhibition | *Senna bicapularis* | Flower-ethanol extract | ND | [194] |
| *Listeria monocytogenes* | Agar diffusion method, zone of inhibition | *Senna bicapularis* | Flower-distilled water | ND | [194] |
| Effect Microorganism | Antimicrobial assay | Senna genus | Plant part-solvent | Result-solvent | References |
|---------------------|--------------------|-------------|-------------------|--------------|------------|
| Neisseria gonorrhoeae | Minimum inhibitory assay | *Senna podocarpa* | Root hydroethanol extract | 100 to 400 mg/L | [113] |
| Propionibacterium acnes | Disc diffusion assay, minimum inhibitory concentration | *Senna alata* | Crude plant extract | 0.625 mg/mL | [224] |
| Propionibacterium acnes | Disc diffusion assay, minimum inhibitory concentration | *Senna occidentalis* | Crude plant extract | 2.5 mg/mL | [224] |
| Propionibacterium acnes | Disc diffusion assay, minimum inhibitory concentration | *Senna siamea* | Crude plant extract | 1.25 mg/mL | [224] |
| Proteus mirabilis | The cup plate agar diffusion method | *Senna alata* | Leaf hot water/leaf-methanol/leaf-acetone | 2 mm/3 mm/2 mm | [205] |
| Proteus mirabilis | The cup plate agar diffusion method | *Senna alata* | Root hot water/root-methanol/root-acetone | 3 mm/3 mm/2 mm | [205] |
| Proteus mirabilis | Minimum inhibitory concentration | *Senna alata* | Leaf-methanol/root-methanol | 10 mg/mL/8 mg/mL | [205] |
| Proteus mirabilis | Minimum microbicidal concentration | *Senna alata* | Leaf-methanol/root-methanol | 10 mg/mL/6 mg/mL | [205] |
| Proteus vulgaris | Inhibition zone (filter paper disc diffusion method) | *Senna occidentalis* | Whole plant ethanol extract | 7-10 mm | [212] |
| Pseudomonas aeruginosa | The cup plate agar diffusion method | *Senna alata* | Leaf hot water/leaf-methanol/leaf-acetone | 3 mm/3 mm/3 mm | [205] |
| Pseudomonas aeruginosa | The cup plate agar diffusion method | *Senna alata* | Root hot water/root-methanol/root-acetone | 3 mm/3 mm/3 mm | [205] |
| Pseudomonas aeruginosa | Minimum inhibitory concentration | *Senna alata* | Leaf-methanol/root-methanol | 10 mg/mL/8 mg/mL | [205] |
| Pseudomonas aeruginosa | Minimum microbicidal concentration | *Senna siamea* | Leaf-methanol/root-methanol | 10 mg/mL/8 mg/mL | [205] |
| Pseudomonas aeruginosa | Paper disk diffusion method, MIC | *Senna siamea* | Leaf ethanol/water mixture extract | 300 mg/mL | [190] |
| Pseudomonas aeruginosa | Diameter of the inhibition zone | *Senna alexandrina* | Leaf-methanol | 9.0 mm | [211] |
| Salmonella typhimurium | Agar well diffusion | *Senna alata* | Leaf-ethanol | 12.1 ± 0.1 mm | [203] |
| Salmonella typhimurium | Agar well diffusion | *Senna alata* | Leaf-water | 10.1 ± 0.1 mm | [203] |
| Salmonella typhimurium | The cup plate agar diffusion method | *Senna alata* | Leaf hot water/leaf-methanol/leaf-acetone | 3 mm/4 mm/4 mm | [205] |
| Salmonella typhimurium | The cup plate agar diffusion method | *Senna alata* | Root hot water/root-methanol/root-acetone | 3 mm/4 mm/4 mm | [205] |
| Salmonella typhimurium | Minimum inhibitory concentration | *Senna alata* | Leaf-methanol/root-methanol | 8 mg/mL/6 mg/mL | [205] |
| Salmonella typhimurium | Minimum microbicidal concentration | *Senna alata* | Leaf-methanol/root-methanol | 6 mg/mL/8 mg/mL | [205] |
| Salmonella typhimurium | Paper disk diffusion method, MIC | *Senna siamea* | Leaf ethanol/water mixture extract | 300 mg/mL | [190] |
| Shigella spp. | Disc agar technique, inhibition zone | *Senna italica* | Aerial part-n-butanol extract | 7.8 mm | [88] |
| Shigella spp. | Disc agar technique, inhibition zone | *Senna italica* | Aerial part-ethyl acetate extract | 8.6 mm | [88] |
| Shigella flexneri | The cup plate agar diffusion method | *Senna alata* | Leaf hot water/leaf-methanol/leaf-acetone | 4 mm/4 mm/4 mm | [205] |
| Shigella flexneri | The cup plate agar diffusion method | *Senna alata* | Root hot water/root-methanol/root-acetone | 3 mm/3 mm/3 mm | [205] |
| Shigella flexneri | Minimum inhibitory concentration | *Senna alata* | Leaf-methanol/root-methanol | 8 mg/mL/5 mg/mL | [205] |
| Shigella flexneri | Minimum microbicidal concentration | *Senna alata* | Leaf-methanol/root-methanol | 6 mg/mL/5 mg/mL | [205] |
| Staphylococcus aureus | Inhibition zone (filter paper disc diffusion method) | *Senna occidentalis* | Whole plant ethanol extract | 8-9 mm | [212] |
| Staphylococcus aureus | Agar disk diffusion method, zone of inhibition | *Senna bicapsularis* | Flower-ethanol extract | ND | [194] |
| Staphylococcus aureus | Agar disk diffusion method, zone of inhibition | *Senna bicapsularis* | Flower-distilled water | 7 mm | [194] |
| Staphylococcus aureus | Agar well diffusion | *Senna alata* | Leaf-ethanol | 20.1 ± 0.1 mm | [203] |
| Staphylococcus aureus | Agar well diffusion | *Senna alata* | Leaf-water | 18.2 ± 0.3 mm | [203] |
| Staphylococcus aureus | Disc agar technique, inhibition zone | *Senna italica* | Aerial part-n-butanol extract | 11 mm | [88] |
| Staphylococcus aureus | Disc agar technique, inhibition zone | *Senna italica* | Aerial part-ethyl acetate extract | 6 mm | [88] |
| Staphylococcus aureus | The cup plate agar diffusion method | *Senna alata* | Leaf hot water/leaf-methanol/leaf-acetone | 5 mm/5 mm/5 mm | [205] |
| Staphylococcus aureus | The cup plate agar diffusion method | *Senna alata* | Root hot water/root-methanol/root-acetone | 4 mm/4 mm/4 mm | [205] |
| Staphylococcus aureus | Minimum inhibitory concentration | *Senna alata* | Leaf-methanol/root-methanol | 6 mg/mL/5 mg/mL | [205] |
| Staphylococcus aureus | Minimum microbicidal concentration | *Senna alata* | Leaf-methanol/root-methanol | 6 mg/mL/5 mg/mL | [205] |
### Table 3: Continued.

| Effect                  | Microorganism          | Antimicrobial assay                                      | Senna genus          | Plant part-solvent                                      | Result-solvent                     | References |
|-------------------------|------------------------|----------------------------------------------------------|----------------------|--------------------------------------------------------|-------------------------------------|------------|
| **Staphylococcus aureus** |                         | Disc diffusion assay, minimum inhibitory concentration    | Senna alata          | Crude plant extract                                    | 2.5 mg/mL                          | [205]      |
| **Staphylococcus aureus** |                         | Disc diffusion assay, minimum inhibitory concentration    | Senna occidentalis   | Crude plant extract                                    | >5 mg/mL                           | [205]      |
| **Staphylococcus aureus** |                         | Disc diffusion assay, minimum inhibitory concentration    | Senna siamea         | Crude plant extract                                    | >5 mg/mL                           | [205]      |
| **Staphylococcus pneumonia** |                          | The cup plate agar diffusion method                        | Senna alata          | Leaf hot water/leaf-methanol/leaf-acetone              | 6 mm/6 mm/5 mm                     | [205]      |
| **Streptococcus pyogenes** |                          | The cup plate agar diffusion method                        | Senna alata          | Root hot water/root-methanol/root-acetone             | 5 mm/6 mm/5 mm                     | [205]      |
| **Streptococcus pyogenes** |                          | Minimum inhibitory concentration                           | Senna alata          | Leaf-methanol/root-methanol                            | 6 mg/mL/1.3 mg/mL                  | [205]      |
| **Streptococcus pyogenes** |                          | Minimum inhibitory concentration                           | Senna alata          | Leaf-methanol/root-methanol                            | 6 mg/mL/1.3 mg/mL                  | [205]      |
| **Xanthomonas axonopodis** |                          | Agar well diffusion                                       | Senna spectabilis    | Leaf-dichloromethane plant-methanol                    | 9.70 ± 0.60 mm                     | [203]      |
| **Xanthomonas axonopodis** |                          | Agar well diffusion                                       | Senna spectabilis    | Leaf-dichloromethane flower-methanol                   | 11.00 ± 1.20 mm                    | [203]      |
| **Xanthomonas axonopodis** |                          | Agar well diffusion                                       | Senna spectabilis    | Flower-dichloromethane flower-methanol                 | 14.00 ± 5.50 mm                    | [203]      |
| **Aspergillus flavus**    |                         | Inhibition zone (filter paper disc diffusion method)       | Senna occidentalis   | Whole plant ethanol extract                            | 12-30 mm                           | [203]      |
| **Aspergillus flavus**    |                         | Agar well diffusion                                       | Senna alata          | Leaf-ethanol                                           | 22.1 ± 0.1 mm                      | [203]      |
| **Aspergillus flavus**    |                         | Agar well diffusion                                       | Senna alata          | Leaf-water                                             | 20.1 ± 0.1 mm                      | [203]      |
| **Aspergillus niger**     |                         | Cup-plate method, mean zone of inhibition                 | Senna alata          | Ethanol leaf extract                                   | 17.6-25.8 mm                       | [207]      |
| **Aspergillus niger**     |                         | Cup-plate method, mean zone of inhibition                 | Senna alata          | Aquous leaf extract                                    | 10.5-33.8 mm                       | [207]      |
| **Aspergillus niger**     |                         | The cup plate agar diffusion method                        | Senna alata          | Leaf hot water/leaf-methanol/leaf-acetone              | 2 mm/3 mm/2 mm                     | [205]      |
| **Aspergillus niger**     |                         | The cup plate agar diffusion method                        | Senna alata          | Root hot water/root-methanol/root-acetone             | 2 mm/3 mm/3 mm                     | [205]      |
| **Aspergillus niger**     |                         | Minimum inhibitory concentration                           | Senna alata          | Leaf-methanol/root-methanol                            | 50 mg/mL/50 mg/mL                  | [205]      |
| **Aspergillus niger**     |                         | Minimum microbicidal concentration                         | Senna alata          | Leaf-methanol/root-methanol                            | 50 mg/mL/50 mg/mL                  | [205]      |
| **Candida albicans**      |                         | Cup-plate method, mean zone of inhibition                 | Senna alata          | Ethanol leaf extract                                   | 19.8-36 mm                         | [207]      |
| **Candida albicans**      |                         | Cup-plate method, mean zone of inhibition                 | Senna alata          | Aquous leaf extract                                    | 20.2-30.0 mm                       | [207]      |
| **Candida albicans**      |                         | Agar cup method, clearing zone                            | Senna alata          | Leaf-ethyl acetate extract                              | ND                                 | [222]      |
| **Candida albicans**      |                         | Agar cup method, clearing zone                            | Senna alata          | Leaf-ethyl acetate extract                              | 15-20 mm                           | [222]      |

**Antifungal**
| Effect | Microorganism | Antimicrobial assay | Senna genus | Plant part-solvent | Result-solvent | References |
|-------|---------------|---------------------|-------------|-------------------|---------------|------------|
|       | Candida albicans | The cup plate agar diffusion method | *Senna alata* | Leaf hot water/leaf-methanol/leaf-acetone | 2 mm/4 mm/5 mm | [205] |
|       | Candida albicans | The cup plate agar diffusion method | *Senna alata* | Root hot water/root-methanol/root-acetone | 3 mm/4 mm/4 mm | [205] |
|       | Candida albicans | Minimum inhibitory concentration | *Senna alata* | Leaf-methanol/root-methanol | 35 mg/mL/25 mg/mL | [205] |
|       | Candida albicans | Minimum microbicidal concentration | *Senna alata* | Leaf-methanol/root-methanol | 25 mg/mL/25 mg/mL | [205] |
|       | Colletotrichum gloeosporioides | Percent inhibition at 1,000 ppm | *Senna spectabilis* | Leaf-methanol/root-methanol | 13 mg/mL/6 mg/mL | [205] |
|       | Cryptococcus neoformans | The cup plate agar diffusion method | *Senna alata* | Leaf hot water/leaf-methanol/leaf-acetone | 3 mm/4 mm/5 mm | [205] |
|       | Cryptococcus neoformans | The cup plate agar diffusion method | *Senna alata* | Root hot water/root-methanol/root-acetone | 3 mm/4 mm/4 mm | [205] |
|       | Cryptococcus neoformans | Minimum inhibitory concentration | *Senna alata* | Leaf-methanol/root-methanol | 13 mg/mL/6 mg/mL | [205] |
|       | Cryptococcus neoformans | Minimum microbicidal concentration | *Senna alata* | Leaf-methanol/root-methanol | 13 mg/mL/6 mg/mL | [205] |
|       | Epidermophyton floccosum | Agar diffusion and broth dilution method, minimum inhibitory concentration | *Senna alata* | Leaf-crude ethanol extract | 3.75 mm | [206] |
|       | Epidermophyton floccosum | Agar diffusion method | *Senna spectabilis* | Ethanolic steam bark 5.00 mg/mL & 10 mg/mL | 15.50 mm/20.05 mm | [206] |
|       | Epidermophyton floccosum | Minimum inhibitory concentration | *Senna alata* | Steam bark-ethanol | 5 mg/mL | [206] |
|       | Epidermophyton floccosum | Minimum fungicidal concentration | *Senna alata* | Steam bark-ethanol | 10 mg/mL | [206] |
|       | F. moniliforme | Inhibition zone (filter paper disc diffusion method) | *Senna occidentalis* | Whole plant ethanol extract | 16-26 mm | [212] |
|       | Fusarium oxysporum | Percent inhibition at 1,000 ppm | *Senna spectabilis* | Leaf-dichloromethane | 4.81 ± 1.13 | [223] |
|       | Fusarium oxysporum | Percent inhibition at 1,000 ppm | *Senna spectabilis* | Flower-dichloromethane | 17.78 ± 1.73 | [223] |
|       | Fusarium oxysporum | Percent inhibition at 1,000 ppm | *Senna spectabilis* | Stem-dichloromethane | 5.19 ± 0.58 | [223] |
|       | Helminthosporium oryzae | Minimum inhibitory concentration | *Senna alata* | Aqueous flower extracts | 15 mg/mL | [198] |
|       | Microsporum audouinii | Minimum inhibitory concentration | *Senna alata* | Aqueous flower extracts | 15 mg/mL | [198] |
|       | Microsporum canis | Cup-plate method, mean zone of inhibition | *Senna alata* | Ethanolic leaf extract | 14.4-30 mm | [207] |
|       | Microsporum canis | Cup-plate method, mean zone of inhibition | *Senna alata* | Aqueous leaf extracts | 17.20-32.0 mm | [207] |
|       | Microsporum canislaeomyces | Agar diffusion method | *Senna alata* | Ethanolic steam bark 5.00 mg/mL & 10 mg/mL | 12 mm/3.5 mm | [206] |
|       | Microsporum canislaeomyces | Minimum inhibitory concentration | *Senna alata* | Steam bark-ethanol | 5 mg/mL | [206] |
|       | Microsporum canislaeomyces | Minimum fungicidal concentration | *Senna alata* | Steam bark-ethanol | 5 mg/mL | [206] |
|       | Microsporum gypseum | Agar diffusion and broth dilution method, minimum inhibitory concentration | *Senna alata* | Leaf-crude ethanol extract | 10.42 mm | [208] |
|       | Microsporum gypseum | Hyphal growth inhibition concentration (IC50) | *Senna tora* | Leaf-methanol | 1.8 mg/mL | [209] |
|       | Microsporum gypseum | Hyphal growth inhibition concentration (IC50) | *Senna alata* | Leaf-methanol | 0.8 mg/mL | [209] |
| Effect | Microorganism | Antimicrobial assay | Senega genus | Plant part-solvent | Result-solvent | References |
|--------|---------------|---------------------|--------------|-------------------|---------------|------------|
|        | Microsporum gypseum | Agar diffusion and broth dilution method, minimum inhibitory concentration | Senega alata | Leaf-crude ethanol extract | 10.42 mm | [208] |
| Penicillium notatum | Cap-plate method, mean zone of inhibition | Senega alata | Ethanol leaf extract | 19.4-30 mm | [207] |
| Penicillium notatum | Cap-plate method, mean zone of inhibition | Senega alata | Aqueous leaf extracts | 15.20-22.0 m | [207] |
| Penicillium marneffei | Hyphal growth inhibition concentration (IC50) | Senega alata | Leaf-methanol | 1.8 mg/mL | [209] |
| Penicillium marneffei | Hyphal growth inhibition concentration (IC50) | Senega alata | Leaf-methanol | 6.6 mg/mL | [209] |
| Phytophthora parasitica | Percent inhibition at 1,000 ppm | Senega spectabilis | Leaf-dichloromethane | –28.57 ± 0.00 | [223] |
| Phytophthora parasitica | Percent inhibition at 1,000 ppm | Senega spectabilis | Flower-dichloromethane | –24.29 ± 2.65 | [223] |
| Phytophthora parasitica | Percent inhibition at 1,000 ppm | Senega spectabilis | Stem-dichloromethane stem-methanol | –17.62 ± 2.08 | [223] |
| Rhizoctonia solani | Percent inhibition at 1,000 ppm | Senega spectabilis | Leaf-dichloromethane | 0.00 ± 0.00 | [223] |
| Rhizoctonia solani | Percent inhibition at 1,000 ppm | Senega spectabilis | Leaf-methanol | 27.41 ± 0.58 | [223] |
| Rhizoctonia solani | Percent inhibition at 1,000 ppm | Senega spectabilis | Flower-dichloromethane | 47.04 ± 2.52 | [223] |
| Rhizoctonia solani | Percent inhibition at 1,000 ppm | Senega spectabilis | Flower-methanol | 22.22 ± 4.58 | [223] |
| Trichophyton mentagrophytes | Cup-plate method, mean zone of inhibition | Senega alata | Aqueous leaf extracts | 20.20-35.0 m | [207] |
| Trichophyton mentagrophytes | Agar diffusion and broth dilution method, minimum inhibitory concentration | Senega alata | Leaf-crude ethanol extract | 19.64 mm | [208] |
| Trichophyton mentagrophytes | Cap-plate method, mean zone of inhibition | Senega alata | Ethanol leaf extract | 16.4-30 mm | [207] |
| Trichophyton mentagrophytes | Agar cup method, clearing zone | Senega alata | Leaf-hexane extract | 14-18 mm | [222] |
| Trichophyton mentagrophytes | Agar cup method, clearing zone | Senega alata | Leaf-chloroform extract | 22-26 mm | [222] |
| Trichophyton mentagrophytes | Agar cup method, clearing zone | Senega alata | Leaf-ethyl acetate extract | 16-18 mm | [222] |
| Trichophyton mentagrophytes | Agar diffusion method | Senega alata | Ethanol leaf extract & 10 mg/mL | 17 mm/19 mm | [206] |
| Trichophyton mentagrophytes | Minimum inhibitory concentration | Senega alata | Steam bark-extract | 5 mg/mL | [206] |
| Trichophyton mentagrophytes | Minimum fungicidal concentration | Senega alata | Steam bark-extract | 5 mg/mL | [206] |
| Trichophyton rubrum | Hyphal growth inhibition concentration (IC50) | Senega alata | Leaf-methanol | 1.2 mg/mL | [209] |
| Trichophyton rubrum | Hyphal growth inhibition concentration (IC50) | Senega alata | Leaf-methanol | 0.5 mg/mL | [209] |
| Trichophyton rubrum | Agar diffusion and broth dilution method, minimum inhibitory concentration | Senega alata | Leaf-crude ethanol extract | 18.75 mm | [208] |
| Trichophyton verrucosum | Agar diffusion method | Senega alata | Ethanol steam bark 5.00 mg/mL & 10 mg/mL | 15 mm/21 mm | [206] |
| Trichophyton verrucosum | Minimum inhibitory concentration | Senega alata | Steam bark-extract | 5 mg/mL | [206] |
| Trichophyton verrucosum | Minimum fungicidal concentration | Senega alata | Steam bark-extract | 5 mg/mL | [206] |
| Herpes simplex | Plaque-inhibition method, reduction factor was measured | Senega occidentalis | Whole plant-ethanolic extract | 1.0 μg/mL | [212] |
| HIV-1 | HIV-1 RT inhibitory assay, % inhibition ratio | Senega alata | Aerial part-ethanolic extract | 35.86 | [216] |
| HIV-1 | HIV-1 RT inhibitory assay, % inhibition ratio | Senega alata | Aerial part-water extracts | 37 | [216] |
| Coxsackie | Plaque-inhibition method, reduction factor was measured | Senega occidentalis | Whole plant-ethanolic extract | 1 μg/mL | [212] |
| Measles | Plaque-inhibition method, reduction factor was measured | Senega occidentalis | Whole plant-ethanolic extract | 1 μg/mL | [212] |
| Effect                                      | Microorganism       | Antimicrobial assay                                                                 | Senega genus         | Plant part–solvent                | Result–solvent | References |
|--------------------------------------------|---------------------|--------------------------------------------------------------------------------------|----------------------|-----------------------------------|----------------|------------|
| Poliomyelitis                              | Semliki forest      | Plaque-inhibition method, reduction factor was measured                               | Senna occidentalis   | Whole plant–ethanolic extract     | 1 μg/mL        | [212]      |
| Vesicular stomatitis                      | Vesicular stomatitis| Plaque-inhibition method, reduction factor was measured                               | Senna occidentalis   | Whole plant–ethanolic extract     | 1 μg/mL        | [212]      |
|                                            |                     |                                                                                      |                      |                                   |                |            |
|                                            | Brassica chinensis  | Percent inhibition germination at 10,000 ppm                                           | Senna spectabilis    | Leaf–dichloromethane              | 12.66 ± 2.89   | [223]      |
|                                            |                     |                                                                                      |                      | Leaf–methanol                     | 25.28 ± 7.77   |            |
|                                            | Brassica chinensis  | Percent inhibition germination at 10,000 ppm                                           | Senna spectabilis    | Flower–dichloromethane            | 71.38 ± 3.06   | [223]      |
|                                            |                     |                                                                                      |                      | Flower–methanol                    | 8.03 ± 0.58    |            |
|                                            | Brassica chinensis  | Percent inhibition germination at 10,000 ppm                                           | Senna spectabilis    | Stem–dichloromethane              | 6.90 ± 1.00    | [223]      |
|                                            |                     |                                                                                      |                      | Stem–methanol                      | 1.14 ± 1.53    |            |
|                                            | Brassica chinensis  | Percent inhibition hypocotyl at 10,000 ppm                                            | Senna spectabilis    | Leaf–dichloromethane              | 68.09 ± 4.00   | [223]      |
|                                            |                     |                                                                                      |                      | Leaf–methanol                      | 97.33 ± 1.31   |            |
|                                            | Brassica chinensis  | Percent inhibition hypocotyl at 10,000 ppm                                            | Senna spectabilis    | Stem–dichloromethane              | −42.94 ± 5.18  | [223]      |
|                                            |                     |                                                                                      |                      | Stem–methanol                      | 34.75 ± 2.88   |            |
|                                            | Brassica chinensis  | Percent inhibition radical 10,000 ppm                                                  | Senna spectabilis    | Leaf–dichloromethane              | 84.48 ± 2.63   | [223]      |
|                                            |                     |                                                                                      |                      | Leaf–methanol                      | 100.00 ± 0.00  |            |
|                                            | Brassica chinensis  | Percent inhibition radical 10,000 ppm                                                  | Senna spectabilis    | Flower–dichloromethane            | 100.00 ± 0.00  | [223]      |
|                                            |                     |                                                                                      |                      | Flower–methanol                    | 100.00 ± 0.00  |            |
|                                            | Brassica chinensis  | Percent inhibition radical 10,000 ppm                                                  | Senna spectabilis    | Stem–dichloromethane              | −46.94 ± 7.82  | [223]      |
|                                            |                     |                                                                                      |                      | Stem–methanol                      | 99.94 ± 1.74   |            |
|                                            | Chloris barbata     | Percent inhibition germination at 10,000 ppm                                           | Senna spectabilis    | Leaf–dichloromethane              | 72.71 ± 0.00   | [223]      |
|                                            |                     |                                                                                      |                      | Leaf–methanol                      | 100.00 ± 0.00  |            |
|                                            | Chloris barbata     | Percent inhibition germination at 10,000 ppm                                           | Senna spectabilis    | Flower–dichloromethane            | 100.00 ± 0.00  | [223]      |
|                                            |                     |                                                                                      |                      | Flower–methanol                    | 95.50 ± 0.58   |            |
|                                            | Chloris barbata     | Percent inhibition germination at 10,000 ppm                                           | Senna spectabilis    | Stem–dichloromethane              | 4.50 ± 1.00    | [223]      |
|                                            |                     |                                                                                      |                      | Stem–methanol                      | 95.50 ± 0.58   |            |
|                                            | Chloris barbata     | Percent inhibition germination at 10,000 ppm                                           | Senna spectabilis    | Leaf–dichloromethane              | 85.31 ± 7.45   | [223]      |
|                                            |                     |                                                                                      |                      | Leaf–methanol                      | 100.00 ± 0.00  |            |
|                                            | Chloris barbata     | Percent inhibition shoot at 10,000 ppm                                                 | Senna spectabilis    | Flower–dichloromethane            | 100.00 ± 0.00  | [223]      |
|                                            |                     |                                                                                      |                      | Flower–methanol                    | 98.82 ± 2.68   |            |
|                                            | Chloris barbata     | Percent inhibition shoot at 10,000 ppm                                                 | Senna spectabilis    | Stem–dichloromethane              | 38.82 ± 3.19   | [223]      |
|                                            |                     |                                                                                      |                      | Stem–methanol                      | 96.93 ± 4.59   |            |
|                                            | Chloris barbata     | Percent inhibition root at 10,000 ppm                                                  | Senna spectabilis    | Leaf–dichloromethane              | 88.18 ± 8.75   | [223]      |
|                                            |                     |                                                                                      |                      | Leaf–methanol                      | 100.00 ± 0.00  |            |
|                                            | Chloris barbata     | Percent inhibition root at 10,000 ppm                                                  | Senna spectabilis    | Flower–dichloromethane            | 100.00 ± 0.00  | [223]      |
|                                            |                     |                                                                                      |                      | Flower–methanol                    | 98.72 ± 1.79   |            |
|                                            | Chloris barbata     | Percent inhibition root at 10,000 ppm                                                  | Senna spectabilis    | Stem–dichloromethane              | 25.56 ± 2.55   | [223]      |
|                                            |                     |                                                                                      |                      | Stem–methanol                      | 96.49 ± 3.53   |            |

↓: inhibition; HIV: human immunodeficiency virus; RT: reverse transcriptase.
by using the agar well diffusion method. Except for Aspergil-
lus niger inhibition, ethanol extract of S. alata showed a
more inhibition zone than water extract. The best antimicro-
bial properties of S. alata ethanolic extract were shown in A.
niger with a 25.2 mm zone of inhibition, and the least was
Salmonella typhimurium with a 12.1 mm inhibition zone.
Escherichia coli and Candida albicans had similar inhibition
zone with 17.2 mm and 18.2 mm. In addition, ethanol extract of S. alata demonstrated effective antimicrobial activ-
ity of Staphylococcus aureus and Aspergillus flavus with
20.1 mm and 22.1 mm zone of inhibition. S. alata water
extract observed the best effective antimicrobial characteris-
tics against A. niger and A. flavus with 27.2 mm and 20.1.
The other zone of inhibition was followed by S. aureus with
18.2 mm and C. albicans with 14.1 mm. The least effective
 antimicrobial activity was of aqueous extracts of S. alata
against E. coli and S. typhimurium having inhibition zones
of 10.2 mm and 10.1 mm, respectively.

Makinde et al. [204] research was about the methanol-
water extract of S. alata leaves, and extract was assessed for
 antimicrobial activity by using a disc diffusion method
(in vitro assay). The results indicated that S. alata leaves are
more effective against fungi. S. alata phenolics and terpe-
noids, alkaloid salt, alkaloid base, and aqueous extract
showed antimicrobial activity against Microsporum canis,
Blastomyces dermatitidis, Trichophyton mentagrophytes, C.
albicans, and A. flavus with 10–30 mm zone of inhibition.
Phenolics and terpenoids, alkaloid salt, and alkaloid base
extract of S. alata leaves had provided 5 mm of inhibition
of S. aureus, Corynebacterium parvum, Nocardia asteroides,
and Clostridium septicum; however, the aqueous extract
had not shown antimicrobial activity of these bacteria. Phen-
nolic and terpenoids and aqueous extract of S. alata leaf had
5–10 mm inhibition zone of Dermatophilus congolensis.
Alkaloid salt and alkaloid base S. alata extract’s inhibition
zone of D. congolensis was 10–20 mm and 20–30 mm.
Besides, S. alata antimicrobial activity was not observed
against Proteus vulgaris and Bacillus pumilus.

Ehiowemwengan et al. [205] examined the S. alata
leaves and roots antimicrobial effect by using the cup plate
agar diffusion method. Except for Streptococcus pyogenes,
all inhibition zone is less than 5 mm; moreover, hot water
extract, methanol extract, and acetone extract S. alata root
and leaves did not differentiate among their inhibition zone.
S. pyogenes had the highest inhibition zone at 5–6 mm both
root and leaf extract independent of solvent type. S. alata
root and leaves exhibited antimicrobial and antifungal reac-
tion against E. coli, Proteus mirabilis, Pseudomonas aerugi-
nosa, Salmonella typhi, Shigella flexneri, S. aureus, A.
flavus, A. niger, C. albicans, and Cryptococcus neoformans.
S. alata root extract’s MIC level was changed (5–8 mg/mL)
for bacteria species except for S. pyogenes (3 mg/mL); how-
ever, fungi needed more concentration, approximately 25-
50 mg/mL for inhibition except for C. neoformans (6 mg/
ml). The results of MIC level of leaves for bacteria were sim-
ilar to root extract; yet, MIC range was between 6 and 10 mg/
ml for bacteria. The leaf extract MIC was 35–50 mg/mL
except C. neoformans (13 mg/mL). The minimum micro-
bial concentration of S. alata leaf extract for bacteria was
determined between 6 and 10 mg/mL, and fungi had more
minimum microbial concentration at 25–50 mg/mL except
C. neoformans (13 mg/mL). The minimum microbial con-
centration of root extract results was similar to leaf extract
except for S. pyogenes (3 mg/mL) and C. neoformans
(6 mg/mL).

Channa et al. [195] also detected antibacterial activity in
root, stem, seeds, leaves, and flower extracts (methanol, eth-
anol, and water) of S. alata. In this study, a good diffusion
method was used, and the results were between 8 and
34 mm. The least inhibition zone, 8 mm, was observed
against S. aureus and Klebsiella pneumoniae by root-metha-
ol, root-ethanol, leave-ethanol, stem-ethanol, and stem-
water extraction. The maximum inhibition zone was
observed against E. coli by leaves-methanol extraction. Fur-
thermore, the results showed that flowers and leaves of S.
alata possess antibacterial activity as compared to commer-
cial drugs such as ciprofloxacin, penicillin, ampicillin, tetra-
cycline, and gentamicin.

Sule et al. [206] experimented to determine in vitro anti-
fungal activities of S. alata crude stem bark extract by using
the agar diffusion method. Zones of inhibition were
observed at 5 mg/mL and 10 mg/mL ethanol solvent of S.
alata crude steam bark except for T. mentagrophytes. T.
mentagrophytes has the highest inhibition zone with
17 mm at 5 mg/mL concentration. The inhibition zone
followed the order as Epidermophyton floccosum with
15.5 mm, Trichophyton verrucosum with 15.0 mm, and
Microsporum canis with 12.0 mm at 5 mg/mL con-
centration. T. verrucosum and E. floccosum showed the best
inhibition of zone with 21.0 mm and 20.5 mm at 10 mg/mL
concentration. M. canis has the least zone of
inhibition with 13.50 mm at a concentration of 10 mg/
ml. However, a concentration of 10 mg/mL was effective
against T. mentagrophytes with 19 mm inhibition of the
zone. In addition, T. mentagrophytes was the only fungi that
affected the inhibition at 2.5 mg/mL concentration with
10 mm zone. The MIC was evaluated at 5 mg/mL for all
fungi. Minimum 5 mg/mL fungicidal concentration was
appropriate for inhibition of fungi, except E. floccosum.
The minimum fungicidal concentration of E. floccosum
was determined at 10.0 mg/mL.

Abubacker et al. [198] conducted a study for in vitro
antifungal properties of S. alata aqueous flower extracts,
using three different fungal groups including fungi that pro-
duce aflatoxin (A. flavus and Aspergillus parasiticus), plant
pathogenic fungi (Fusarium oxysporum and Helminthospor-
ium oryzae), and human pathogenic fungi (C. albicans and
Microsporum audouinii). The results highlighted the strong
antifungal activity of S. alata. While 15 mg/mL of flower
extract concentration provides 100% inhibition of all the
fungus, 10 mg/mL was enough in inhibiting A. flavus. The
MIC values of the flower extract of S. alata ranged from
5.75 to 8.0 mg/mL.

In a different investigation, Timothy et al. [207] assessed
leaf extracts of S. alata (aqueous and ethanol) against five
pathogenic fungi which are C. albicans, M. canis, T. menta-
agrophyte, Penicillium notatum, and A. niger. According to
the calculated zones of inhibition, there was no inhibition
for water extract of leaves whereas ethanol extracts exhibited inhibition for all tested microorganisms. Furthermore, MIC of ethanol extracts for all tested fungi was lower than the water extract indicating that ethanol extract includes more bioactive compounds than the water extract. The reason ethanol is being more effective than the water was told to be because of the presence of anthraquinone which is not found in the water extraction. Intense antifungal activities of S. alata were depicted from the study outcomes.

Wuthi-udomlert et al. [208] remarked on the importance of anthraquinone derivatives in the *in vitro* evaluation. Anthraquinone glycosides including emodin, rhein, and chrysophanol found in *S. alata* are the source of laxative effects. In the study, extraction of leaves is obtained in five different ways using anthraquinone aglycone, anthraquinone glycoside, anthraquinone aglycone from glycosidic fraction, crude ethanol, and anthraquinone aglycone from crude ethanol extract. Extraction yields were monitored by thin-layer chromatography, and the highest yield is obtained from crude ethanol extraction which was 34.94% w/w. As a result of the *in vitro* antifungal activity against *Trichophyton rubrum*, *T. mentagrophytes*, *E. floccosum*, and *Microsporum gypseum* by diffusion and broth dilution methods, anthraquinone aglycone from glycosidic fraction presented greater activity among five different extracts.

Phongpaichit et al.’s [209] experiment was about antifungal activities of *S. alata* and *S. tora*. Except *Penicillium marneffe*, 10 mg/mL methanolic extract obtained from leaves of *S. alata* and *S. tora* were enough in inhibiting all the *M. gypseum*, and *T. rubrum*. 10 mg/mL *S. alata* leaves inhibited only 77% of *P. marneffe*; still, *S. tora* extract was sufficient to inhibit all *P. marneffe*. In addition, IC*50* result of *T. rubrum* followed the order as *S. alata* at 0.5 mg/mL and *S. tora* at 1.2 mg/mL. *S. alata* with 0.8 mg/mL IC*50* value was the best inhibition for *M. gypseum*; also *S. tora* have an IC*50* value at 1.8 mg/mL. The IC*50* values of *P. marneffe* of *S. alata* and *S. tora* were 6.6 mg/mL and 1.8 mg/mL, respectively.

Malmir et al. [113] drew attention to the bioactive substances called “rhizin” isolated from *S. podocarpa* root hydroethanol extract. In their study, *S. podocarpa* root extracts were evaluated for *in vitro* anti-Neisseria gonorrhoeae activity. Gonorrhoea is a widespread sexually transmitted infectious disease induced by *N. gonorrhoeae* bacterium infection. *N. gonorrhoeae* infects the mucous membranes of the reproductive organs that include the fallopian tubes, uterus, and cervix in women, while in men and boys it infects the urethra. *N. gonorrhoea* can also harm the mucous membranes of the mouth, throat, and eyes [210]. *S. podocarpa* root demonstrated anti-*N. gonorrhoeae* activity against all strains. MIC ranged from 100 to 400 mg/L. The most active fractions having 50–100 mg/L MIC values, had rhein, emodin, chrysophanol, and physcion as their key compounds as detected by LC-UV/DAD cochromatography with reference standards. Among all the isolates, rhein (MIC: 3.13 mg/L against *P. aeruginosa*) was the most effective. In addition to rhein, Sansores-Peraza et al. [117] highlighted the antibacterial and antifungal activity of cassine, isolated from *S. racemosa*, with MIC of 2.5 mg/mL against *S. aureus* and *Bacillus subtilis* and 5.0 mg/mL for *C. albicans*.

Albayrak et al. [211] indicated that infusion of *S. alexandrina* leaves is the only herb that has antibacterial effect against *Bacillus cereus* among infusions of eight plants in Turkey which are *Foeniculum vulgare* Mill. (fennel), *Pimpinella anisum* L. (anise), *Laurus nobilis* L. (laurel), *Tilia × europaea* L. (linden tea), *Urtica dioica* L. (nettle), *Petroselinum crispum* (Mill) Fuss (parsley), and *Anethum graveolens* L. (dill). In the study, they extracted *S. alexandrina* leaves by four methods which are methanol extraction, infusion, decoction, and hydrosol. The *in vitro* antimicrobial activities of *S. alexandrina* leaves were evaluated, and the results showed that infusion of *Senna* leaves has antibacterial effect against *B. cereus* and methanol extracts of *Senna* have antibacterial activity against *B. cereus* and *P. aeruginosa*.

As a result of *in vitro* antibacterial analysis conducted by Jain et al. [212], although *Klebsiella aerogenes* exhibited resistance to all extracts, ethanol extracts of flowers and pods of *S. occidentalis* provide inhibition of growth of *E. coli* and *P. vulgaris*. In addition, a descending sort among bioactive compounds according to the antibacterial activities against test bacteria which are *E. coli*, *K. aerogenes*, *P. vulgaris*, and *S. aureus* was reported as anthraquinones>sennosides>flavonoids. Antifungal activity of ethanol extracts of *S. occidentalis* was found to be higher than the antibacterial activity. Among the metabolite-rich fractions, the maximum inhibition was shown by sennosides against *A. flavus*, followed by anthraquinones and flavonoids against *Curvularia lunata*.

7.2. Antiviral. Antiviral activity of genus *Senna* is generally found quite low; however, the extraction yield and the isolation of bioactive compounds provide an increase in the antiviral activity.

Jain et al. [212] investigated the antimicrobial, antitumor, and antiviral activity of ethanol extracts of *S. occidentalis*. They conducted *in vitro* analysis for antiviral and *in vivo* analysis for antitumor activity. The antiviral activity against *Herpes simplex* was quite inadequate; the reduction factor of titre was found 10 μg/mL. In addition, *S. occidentalis* did not exhibit any antitumor activity or cytotoxicity.

Ogabe et al. [213] highlighted the antiviral agents that *S. siamea* includes which are lupenone, lupeol, betulinic acid, chrysophanol, physcion, and β-sitosterol glucoside. Among tested anthraquinones and triterpenoids, lupeol was the most effective constituent against poliovirus having 0.014 μg/mL of IC*50* value. Antipoliovirus, antitobacco mosaic virus, and anti-HIV-1 effects were observed in the extract of *S. siamea* stem bark [135, 214].

Another genus which is analyzed for the antiviral activity is *S. alata*. Shaheen et al. [215] determined the antiviral activity of methanol, chloroform, ethyl acetate, n-butanol, and aqueous extracts of *S. alata* by *in vitro* and *in vivo* experiments. The results justified the antiviral activity of *Senna*; all extracts exhibited antiviral effects against cardiac coxsackievirus B3. As a result of *in vitro* analysis, the therapeutic index varied between 0.2 and 12. *In vivo*, virus titer values were between 0 log10 and 2.5 log10. Both *in vitro* and *in vivo* analyses exhibited that the most effective extracts against cardiac coxsackievirus B3 were aqueous extracts.
Woradulayapinij et al. [216] investigated *in vitro* HIV-1 reverse transcriptase inhibitory activity of ethanol and water extracts of aerial part of *S. alata*. Even though the results were quite close to each other, water extract depicted higher activity than the ethanol extract; inhibition ratios were 37 and 35.86% for water and ethanol extracts, respectively.

7.3. Antiprotozoal. Numerous studies reported antiprotozoal activities of genus *Senna*. de Castro et al. [201] conducted a study about the schistosomicidal activity of *S. spectabilis* flower extracts. *Schistosoma* is an intestinal parasite that causes a chronic disease called Schistosomiasis. The disease has been reported in 78 countries; especially, 90% of the cases have been reported in Africa where access to safe drinking water is a challenge. According to the WHO [217], at least 229 million people needed the treatment of *Schistosoma* in 2018. de Castro et al. [201] extracted and isolated (-)-cassine and (-)-spectaline substances from *S. spectabilis* flowers. *In vitro* activity of extracts, their fractions, and the mixture of (-)-cassine and (-)-spectaline against *S. mansoni* worms were analyzed. Obtained data indicated that the mixture of (-)-cassine and (-)-spectaline exhibited a multitarget mechanism against the excretory activity, tegument lesions, and neuromotor activity. It also showed a toxic effect on the larval period of cercariae. Therefore, *S. spectabilis* flower extracts (-)-cassine and (-)-spectaline have a great potential for their schistosomicidal activity. Furthermore, de Albuquerque Melo et al. [218] mentioned about leishmanicidal activity of *S. spectabilis* and the two major alkaloidal metabolites (-)-cassine/(-)-spectaline. Caamal-Fuentes et al. [219] studied antiprotozoal properties of *S. racemosa* against *Giardia intestinalis* and observed that methanic extracts of *S. racemosa* bark in both *in vitro* and *in vivo* experiments had activity against *G. intestinalis* [219, 220]. Eguale et al. [221] mentioned the *in vitro* anthelmintic activity of *S. occidentalis*, and the extract concentration required to inhibit 50% (ED50) of the eggs of *Haemonchus contortus* was found to be 0.13 mg/mL and 0.17 mg/mL for aqueous and hydroalcoholic extracts, respectively.

A scheme with anti-infectious properties of *Senna* plants is summarized in Figure 4.

7.4. Other Biological Properties. Villaseñor et al. [222] also conducted research on *S. alata* leaf extracts with hexane, chloroform, and ethyl acetate to investigate antimutagenic, antifungal, analgesic, anti-inflammatory, and hypoglycemic activities. Chloroform extract exhibited a reduction in the mutagenic activity of tetracycline by 65.8% at a dosage of 2 mg/20 g mouse as a result of the *in vivo* analysis. Against fungi, *T. mentagrophytes* chloroform extract was the most effective. The hexane extract was having the highest analgesic property which provides a decrease of 59.9% at a dosage of 5 mg/20 g mouse among other extracts. The analgesic activity of hexane extract was similar to the activity of mefenamic acid which is a widely known analgesic. For the anti-inflammatory activity, all three extracts are observed hourly, for three hours. At the end of three hours, hexane and ethyl acetate extracts demonstrated 65.5% and 68.2% inhibition, respectively, at a dosage of 5 mg/20 g mouse. Ethyl acetate extract also showed hypoglycemic activity more effectively than the other extracts by providing a 56.7% reduction in blood glucose level.

8. Clinical Studies

Health-promoting effects of *Senna* and its other species have been evaluated by a large number of researchers around the world while clinical trials have been conducted in limited
cases (Table 4). Therefore, in this section, we are presenting quantified data on *Senna* and its clinical trials (previous and latest).

Mcnicol [225] performed a clinical experiment to evaluate the activity of tablets prepared using *Senna* (standardized preparation) on human bowel function and its possible side effects. The experiment was carried out in two phases: (a) first is the administration of the drug to 52 ward patients; (b) the drug was administered to 126 volunteer medical students. The *Senna* tablets were prepared in two different batches. The results demonstrated that the mean values for “speed of action” of *Senna* preparation (3 tablets) were recorded as 9.7 hours with ward patients and 12.15 hours among student volunteers, respectively. The frequency of griping, looseness of stool, and multiple bowel movements in ward patients have been recorded in dose-dependent patterns (increased with rising dosage). In addition, results confirmed that there is no significant difference between male and female responses. Thamlilkitkul et al. [226] performed a randomized controlled experiment to evaluate the efficacy of *S. alata* against constipation. A total of 80 candidates participated in this study, and the differences observed between both groups (placebo & mist. Alba; and placebo & *S. alata*) were statistically highly significant ($p < 0.001$).

Kinnunen et al. [227] evaluated the safety and efficacy profile of laxatives containing *Senna* in treating constipation patients using lactulose as standard medication. The present study was carried out in a total of 30 patients (mainly bedridden due to degenerative diseases, age: 65-94 years). One week run-in without laxatives was followed by 5 weeks (a) of a daily dose of 14.8 mg (20 mL) laxative plus *Senna* or 20.1 mg (30 mL) lactulose and (b) crossed medicines (5-week period). The results indicated that bulk laxative plus *Senna* (14.8 mg dose) when given daily resulted in significantly ($p < 0.005$) more frequent bowel habits (4.5 vs. 2.2-19/week) compared to that of lactulose (daily dose of 14.8 mg). In other words, bulk laxative plus *Senna* produced efficiently treated constipation patients.

Damodaran and Venkataraman [228] from India reported the therapeutic effectiveness of *S. alata* leaves against *Pityriasis versicolor* in humans. The study was completed among 200 candidates (age: 16-60 years) of Tamil Nadu (Indian State) within 10 years. Different concentrations of plant extract (80%, 90%, and 100%) were used at affected areas (trunk, neck, hands, and face) of the body. The results indicated that *S. alata* leaf extract could be employed as a herbal remedy having no side effects, for curing *P. versicolor*.

Ramesh et al. [229] carried out a controlled comparative study of *Misrakasneham* (Ayurvedic formulation) and laxative *Senna* tablets (purified *Senna* extract) against opioid-induced constipation. *Misrakasneham* (a combination of 21 different types of herbs, castor oil, purified butter, and milk) is a centuries-old Ayurvedic medicine. The present study was conducted in 50 patients with advanced cancer aged 15 years and categorized into two groups (25 each). The first group received *Misrakasneham* while the second group received *Senna* tablets in three steps during the 14-day study. The results demonstrated that 85% of the *Misrakasneham* group and 69% of the laxative *Senna* group had satisfactory bowel movements with no statistical difference ($p > 0.2$). In addition, *Misrakasneham* data showed interesting results in terms of efficacy and was recommended as a possible candidate for opioid-induced constipation.

van Gorkom et al. [230] reported the effects of sennosides on histology of colonic mucosa and bowel preparation. In this experiment, a total of 171 candidates participated who were further split into two groups: (a) $n = 84$ candidates treated with 1 mL/kg of a syrup containing 2 mg/mL sennosides A and B and 3-5 L of a lavage solution and (b) $n = 87$ candidates treated with 3-5 L of lavage solution. The results demonstrated that both groups showed no difference in tolerance or quality of bowel preparation. In addition, group a (10/19) also showed a rapid increase of mononuclear infiltrate in the lamina propria compared to group b (2/21), respectively ($p = 0.0005$).

9. Safety and Side Effects

In traditional medicine, the leaves of *Senna* traditionally are used as laxatives in the form of pellets prepared with dried figs and plums. The anthraquinone laxatives like *Senna* are extremely useful drugs, but appropriate usage is highly important, although most of the reported side effects are mild and transient.

*Senna* is generally safe and well tolerated but can cause adverse events when it is used in high doses and for a long period (Figure 5). Most of the adverse effects are mild and transient. The liver injury, including hepatotoxicity, has been reported in several case studies where *Senna* has been used prolonged, and the symptoms were mild-to-moderate in severity and solved rapidly with discontinuation [243–245]. In all cases, the correlation between side effects was explained by abuse of *Senna* in laxative purpose.

Derivatives of sennosides present in the leaves and pods may affect increasing irritability on the intestinal mucosa, which could cause abdominal pain and spasm in a sensitive person. It can also lead to diarrhoea, intensification of menstrual bleeding, and dark urine. It is recommended to take herbal tea or capsules/tablets/syrup of *Senna* in the evening before sleep, as effects start 6 to 12 hours later. Also, drugs that contain *Senna* are available in the form of rectal suppositories.

The prolonged use of *Senna* causing the spasm is the sign that it is necessary to stop future taken. In rare cases, vomiting and nausea may occur. Chronic use of *Senna* and other laxative herbs leads to increased potassium excretion, resulting in spasms, muscle weakness, and heart failure. However, in very well-explained patient conditions, these types of herbal drugs should be avoided. However, the full safety profile of these herbals is controversial like the opponent attitude of FDA and EMA regarding their consumption in some vulnerable groups of people.

10. Therapeutic Perspectives and Clinical Gaps

Traditional and modern medicines, in case of decreasing the intestine motility, take into consideration two classes of
| Samples         | Type of study/findings/results                                                                 | Country   | Ref  |
|-----------------|-----------------------------------------------------------------------------------------------|-----------|------|
| *Senna alata* (L.) Roxb. | Randomized controlled trial  
Evaluating the use and safety of *S. alata* on bowel function recovery among women with gynecologic cancer  
90 women candidates diagnosed with gynecologic cancer were randomly assigned to postoperative consumption (45 with *S. alata* tea and 45 with warm water)  
Usage of *S. alata* significantly reduced the time of first passage of flatus (mean difference: -8.5 h; 95% confidence interval: -3.7, -13.4 h) and time of first defecation (mean difference: -19.8 h; 95% confidence interval: -11.2, -28.5 h) compared with the controls  
The use of *S. alata* showed a positive impact during the postoperative care of gynecologic cancer patients | Thailand  | [231] |
| *Senna*         | Randomized controlled and crossover study  
Assessing the efficacy and safety of *Senna* versus polyethylene glycol in treating constipation in children  
The proportional formula was used to calculate the sample size and 28 patients were obtained  
Effectiveness of laxative therapy was evaluated by mean of a three-variable construct  
(a) Daily bowel movement  
(b) Faecal soiling  
(c) *S* clean abdominal X-ray  
The study was completed before the time because an interim analysis showed effective results of *Senna* (*p* = 0.026)  
The maximum daily dose of *Senna* and polyethylene glycol was recorded as 38.7 mg and 17 g  
*Senna* therapy showed promising results against constipation in children with anorectal malformation | Mexico    | [232] |
| *Senna*         | Comparative study  
Evaluating of *Senna* and other oral bowel medicines for treating constipation in pediatric oncology patients getting opioids  
The results of 5-year investigation demonstrated that 41.8% (*n* = 245) had blood cancer, 50.3% (*n* = 295) had solid cancer, and 7.9% (*n* = 46) had brain cancer out of 586 matched samples (age: 0-20 years, ave. age: 11.5 years)  
Initializing *Senna* therapy, over another oral bowel medication, reduced the subsequent risk of surrogate markers of problematic constipation. Adjusted effect of *Senna* on enema (hazard ratio, 0.31; 95% confidence interval, 0.11-0.91), abdominal radiographic imaging (hazard ratio, 0.74; 95% confidence interval, 0.55-0.98), and escalation of oral bowel medicine (hazard ratio, 0.78; 95% confidence interval, 0.59-1.03) were recorded | Philadelphia | [233] |
| *Senna*         | Control single-blinded randomized study  
Assessing the efficacy of gum chewing added to high dose *Senna* before colonoscopy promotes bowel cleaning  
129 candidates participated and were further divided into two groups  
(a) *n* = 65 patients treated with *Senna* solution (150 mL) and sennoside tablet (80 mg) daily for 3 days before the colonoscopy  
(b) *n* = 64 patients were additionally advised to chew sugarless gum half an hour (three times) daily for 3 days  
The results demonstrated that gum chewing enhanced colonoscopy bowel preparation quality and is considered a physiologically sound, safe, and impassive part of the colonoscopy bowel preparation. The gum chewing group showed better cleaning compared to other groups | Turkey    | [234] |
| *Senna*         | Placebo-controlled, double-blinded, randomized study  
Evaluating the use of *Senna* with docusate for constipation after pelvic surgery  
96 candidates completed a baseline seven-day bowel diary pre- and postsurgery. After pelvic surgery, candidates were divided into two groups: (a) *n* = 45 in the placebo group and (b) *n* = 48 in *Senna* (8.6 mg) with docusate (50 mg) group.  
The findings demonstrated that the use of *Senna* with docusate decreases the time to first bowel movement in those undergoing pelvic surgery than placebo (3.00 vs. 4.05 days; *p* = 0.001). | Philadelphia | [235] |
| Samples       | Type of study/findings/results                                                                 | Country     | Ref  |
|--------------|-----------------------------------------------------------------------------------------------|-------------|------|
| **Senna**    | Case study Case of a 31-year-old female patient who, after prolonged ingestion of *Senna* extract, developed severe weight loss, cyclic oedema, and dyspepsia, accompanied by an asymptomatic increase in markers of liver and muscle damage, dyslipidemia, electromyographic alterations, and mitochondrial myopathy in the muscle biopsy. This clinical case is of particular significance, given that *Senna* is widely used for its pharmacological properties, with failure to consider its potentially toxic effects. | Portugal    | [236]|
| **Senna**    | Single-blinded randomized study The effectiveness of *Senna* tablets and sodium phosphate solution for bowel preparation before colonoscopy was examined for its efficiency A total of 134 candidates were treated with *Senna* tablets (180 mg) and sodium phosphate solution (95 mL) on the day before colonoscopy The results demonstrated that the mean cleanliness scores in the four segments of the colon (rectum, sigmoid segments, descending colon, and transverse colon) except the cecum were higher in the sodium phosphate group than in the *Senna* group (7.9 vs. 8.3, 8.0 vs. 8.5, 7.9 vs. 8.5, 7.9 vs. 8.2, and 7.2 vs. 6.9, respectively) The taste of *Senna* was more effective compared to sodium phosphate solutions. | Thailand    | [237]|
| **Senna tora** (L.) Roxb. | Experimental study Supplementation of *Senna tora* fibre on the serum lipid profile of diabetic Korean patients was evaluated. *S. tora* fibre supplement of a combination of soluble fibre extracted from *S. tora* (2 g), alpha-tocopherol (200 mg), ascorbic acid (500 mg), and maltodextrin (300 mg) was prepared in a pack and given to a total of 15 candidates 2 packs per day up to 2 months The results demonstrated that *S. tora* fibre products were safe for consumption and additionally provided the necessary amount of dietary fibre for helping in the maintenance of lipid status in diabetic (type II) patients. | Korea       | [238]|
| **Senna**    | Controlled randomized single-blinded study Evaluating efficiency and acceptability of high dose *Senna* tablets and its comparison with standard polyethylene glycol in adult patients 192 patients participated and were treated into two groups: (a) \( n = 91 \) in polyethylene glycol group and (b) \( n = 101 \) in *Senna* group The *Senna* tablet group showed acceptable results for colon cleansing and tolerance compared to the polyethylene glycol group (\( p < 0.001 \)). | —           | [239]|
| **Senna**    | Controlled study Highly purified *Senna* extract was evaluated against cell proliferation, crypt length in the entire colon and gene expression (p53 and bcl-2). 171 patients (84 with sennoside-containing syrup and 87 without sennoside-containing syrup) were included 15 patients with *Senna* and 17 without *Senna* from 32 randomized patients were used for biopsies Proliferation activity in four areas of colon and gene expression (p53 and bcl-2) was evaluated by using 5-bromo-2′-deoxyuridine labelling, immunohistochemistry, and immunohistochemical The results demonstrated that crypts were shorter in the *Senna* group than without *Senna* group in the transverse and sigmoid colon. In the entire colon, the labelling index was higher in the *Senna* group than without the *Senna* group. In addition, bcl-2 expression was higher in both groups when crypts were shorter and proliferation was enhanced while no difference was recorded in p53 expression. | Netherlands | [240]|

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cureative substances: drugs that increase the volume of the gut contents and facilitate mass flow [246, 247]. Among herbal substances, here, we have substances rich in sugars (dried plums and figs) and herbas with mucus, such as flax seeds. Another approach is medicines that contain substances that have a mild irritant effect on the intestinal mucosa to promote intestinal motility [248, 249]. Among these remedies are the species from the genus Senne.

Genus Senne is well recognized as the most used laxative herbal treatment, also available without a prescription. Even before we knew its composition, Senne was used for centuries in phytotherapy for the same purpose. The main type of Senne genus used in medicine is S. alexandrina, known in commerce as Alexandria Senne, and Tinnevelly Senne [250]. Senne plants are widely used herbal medicine in the treatment of functional constipation. As the beneficial parts of the plant in phytotherapy, both the mature pods and the dried leaves are used. They contain natural chemical compounds, called anthraquinone, which are glycoside derivatives of anthracene, and the major compounds are sennosides A and B, which are available in the market [251]. The sennosides A and B have been broken down by the bacterial flora in the colon and result in the production of the main active metabolites rhein and rheinanthrone [252]. The working of anthraquinones includes the hindrance of NaCl absorption in the colon and the stimulation of Cl secretion, by inhibiting the (Na⁺, K⁺)-ATPase [253].

Additionally, S. alexandrina is used in case of bowel irritable colon, as a pretreatment before diagnostic tests like colonoscopy [254] and as a supplement for weight reduction [255]. While the treatment with active compounds from genus Senne is widely used in different laxative drugs taken orally in liquid or solid dosage forms, in the form of instant tea and herbal tea, however, there are controversies in their usage.

European Medical Agency (EMA) reference the use of Senne [256] only in cases of periodical constipation, while long term is not recommended due to acute dehydration which is followed by loss of electrolytes. Also, EMA do not recommend Senne in case of pregnancy, breast feeding, dehydration, different forms of intestinal obstructions, ulcers, and ulcerative colitis, inflammatory bowel disease including Crohn’s disease, pain and spasm in stomach, unknown etiology, and rectal bleeding.

EMA does not recommend using the Senne as a laxative treatment in children under 12, but off-label use has been reported (Figure 5). On the other hand, the USA Food and Drug Administration (FDA) prescribes 17.2 mg (7.5 to 30 mg) per day for people 12 years and older and 8.5 mg for children under 12 and allowing the usage of botanical laxatives containing Senne in children under 12. Based on a recently published review on Senne side effects as a long-term therapy in children by Vilanova-Sanchez et al. [257], Senne can be a safely employed option in treating functional constipation in children. However, more evidences are needed to confirm this conclusion and to change the attitude of EMA, who recently revised the herbal monography of Senne still stated that Senne is not recommended for children under 12 years [256].

Although some researches of Senne have found that it is effective in a short-term usage of constipation treatment in pregnancy [258–260] and does not have the teratogenic potential [261], intake of Senne during the pregnancy is allowed only in some countries like the USA.

Senne is still contraindicated by EMA recommendation because of experimental data that indicated possibly a
genotoxic risk of several anthranoids, e.g., emodin and aloe-emodin [262]. While the use of *Senna* in breastfeeding women is not recommended, there is evidence that anthraquinone drugs in lactating mothers do not carry a risk of producing a laxative effect in the infant [263–265]. However, there are available data from other studies in which laxative effect on the bowels was observed in infants [258]. Despite controversial findings, still, the official recommendation is to avoid the use of it.

*Senna* should not be used for a longer period, no longer than 1–2 weeks, nor with medicines that lead to loss of potassium (diuretics, cardiotonic drugs, and corticosteroids). The caution should be exercised when used with antiarrhythmic and cardiotonic drugs and medicinal products inducing QT-prolongation, as it may potentiate their effect. All of these effects are correlated with hypokalemia [266, 267]. It has been found that usage of sennosides and digoxin in combination is linked with a modestly increased risk of digoxin toxicity in heart failure patients [268].

Particular attention, based on the animal studies, should be exerted in the patients with kidney and liver disorders during chronic use of *Senna*-based products [269]. Additionally, studies performed on rats showed that long-term administration of extracts of *Senna* does not promote gastrointestinal, liver, kidney, or adrenal tumors in the rats [270–272].

11. Concluding Remarks

This review showed that various parts of the *Senna* plant such as roots, stem, leaves, and seeds are traditionally used to treat many ailments and its extract has antioxidant, antimicrobial, and important health-promoting activities. These biological activities are attributed to the many phytochemicals contained in the genus Senna. Epicatechin, proanthocyanidins, scutellarein, rutin, and sennosides are just a few bioactive compounds of the genus *Senna* that are responsible for their bioactivity. Numerous studies *in vitro* and *in vivo* have been performed to establish the anti-infective and antioxidant properties of *Senna* extracts. Studies on the consumption of *Senna* over a period have shown that *Senna* is safe, but chronic use has adverse and limiting effects in medical practice. Among them, the laxative disease is a condition related to the massive use of *Senna*-based laxatives with an increased loss of potassium ions and the possibility of interaction with other drugs prescribed for heart disease. Based on the analysis of the studies selected in the study, this review opens new therapeutic perspectives of the *Senna* plant for antioxidant and especially anti-infective effects in the digestive tract.

Data Availability

The data supporting this review are from previously reported studies and datasets, which have been cited. The processed data are available from the corresponding authors upon request.

Conflicts of Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

References

[1] N. Azani, M. Babineau, C. D. Bailey et al., “A new subfamily classification of the Leguminosae based on a taxonomically comprehensive phylogeny: the legume phylogeny working group (LPWG),” *Taxon*, vol. 66, no. 1, pp. 44–77, 2017.
[2] F. O. Robbati, A. Anton, B. Marazzi, M. Vásquez-Cruz, and R. H. Fortunato, “The evolutionary history of *Senna* ser. *Aphyllae* (Leguminosae–Caesalpinioideae), an endemic clade of southern South America,” *Plant Systematics and Evolution*, vol. 303, no. 10, pp. 1351–1366, 2017.
[3] J. Bradley Morris, B. D. Tonnis, and M. L. Wang, “Variability for Sennoside a and B concentrations in eight *Senna* species,” *Industrial Crops and Products*, vol. 139, article 111489, 2019.
[4] H. S. Irwin and R. C. Barney, *The American cassiinaea syn-optical revision of leguminosae tribe cassieae subtribe cassinae in the New World*, New York Botanical Garden Bronx, New York USA, 1982.
[5] B. Marazzi, P. K. Endress, L. P. Queiroz, and E. Conti, “Phylogenetic relationships within *Senna* (Leguminosae, Cassiinae) based on three chloroplast DNA regions: patterns in the evolution of floral symmetry and extrafloral nectaries,” *American Journal of Botany*, vol. 93, no. 2, pp. 288–303, 2006.
[6] L. Acharya, A. K. Mukherjee, and P. C. Panda, “Separation of the genera in the subtribe Cassinae (Leguminosae:
Caesalpinioideae) using molecular markers,” Acta Botânica Brasílica, vol. 25, no. 1, pp. 223–233, 2011.

[7] B. Marazzi and M. J. Sanderson, “Large-scale patterns of diversification in the widespread legume genus Senna and the evolutionary role of extrafloral nectaries,” Evolution: International Journal of Organic Evolution, vol. 64, no. 12, pp. 3570–3592, 2010.

[8] M. O. Rahman, M. Z. Rahman, and A. Begum, “Numerical taxonomy of the genus Senna mill. from Bangladesh,” Bangladesh Journal of Plant Taxonomy, vol. 20, no. 1, pp. 77–83, 2013.

[9] H. A. Spiller, M. L. Winter, J. A. Weber, E. P. Krenzelok, D. L. Anderson, and M. L. Ryan, “Skin breakdown and blisters from Senna-containing laxatives in young children,” Annals of Pharmacotherapy, vol. 37, no. 5, pp. 636–639, 2003.

[10] M. A. Nassar, H. R. Ramadan, and H. M. Ibrahim, “Morphological characteristics of vegetative and reproductive growth of Senna occidentalis (L) link (Caesalpinioideae),” Research Journal of Agriculture and Biological Sciences, vol. 7, no. 2, pp. 260–270, 2011.

[11] D. M. Selegato, A. F. Monteiro, N. C. Vieira et al., “Update: biological and chemical aspects of Senna spectabilis,” Journal of the Brazilian Chemical Society, vol. 28, no. 3, pp. 415–426, 2017.

[12] O. S. Oladeji, F. E. Adelowo, A. P. Oluyori, and D. T. Bankole, “Ethnobotanical description and biological activities of Senna alata,” Evidence-based Complementary and Alternative Medicine, vol. 2020, Article ID 2580259, 2020.

[13] A. Farid, D. Kamel, S. Abdelwahab Montaser, M. Mohamed Ahmed, M. el Amir, and A. el Amir, “Synergetic role of Senna and Fennel extracts as antioxidant, anti-inflammatory and anti-mutagenic agents in irradiated human blood lymphocytes cultures,” Journal of Radiation Research and Applied Science, vol. 13, no. 1, pp. 191–199, 2020.

[14] G. Nambrirajan, K. Karunanidhi, A. Ganesan et al., “Evaluation of antidiabetic activity of bud and flower of Avarum Senna (Cassia auriculata L.) in high fat diet and streptozocin induced diabetic rats,” Biomedicine & Pharmacotherapy, vol. 108, pp. 1495–1506, 2018.

[15] R. O. Malematja, V. P. Bagla, I. Njanje et al., “Potential hypoglycaemic and antiobesity effects of Senna italica leaf acetone extract,” Evidence-based Complementary and Alternative Medicine, vol. 2018, Article ID 5101656, 2018.

[16] T. PlantList2021, http://www.theplantlist.org/.

[17] M. Heinrich, G. Appendino, T. Efferth et al., “Best practice in research - overcoming common challenges in phytopharmaceutical research,” Journal of Ethnopharmacology, vol. 246, article 112230, 2020.

[18] E. Fernandez-Pacella, “Morfología polínica de especies del género Senna (Fabaceae) del Sureste del Iberá, Corrientes, Argentina,” Argentina. Revista de Biología Tropical, vol. 62, no. 2, pp. 769–782, 2014.

[19] D. A. Carvalho and P. E. Oliveira, “Biologia reprodutiva e polinização de Senna sylvestris (Vell.) H.S. Irwin & Barneby (Leguminosae, Caesalpinioideae),” Brazilian Journal of Botany, vol. 26, no. 3, pp. 319–328, 2003.

[20] M. Heil and D. McKey, “Protective ant-plant interactions as model systems in ecological and evolutionary research,” Annual Review of Ecology, Evolution, and Systematics, vol. 34, no. 1, pp. 425–553, 2003.

[21] S. L. Jothy, A. Torey, I. Darah et al., “Cassia spectabilis (DC) Irwin et barn: a promising traditional herb in health improvement,” Molecules, vol. 17, no. 9, pp. 10292–10305, 2012.

[22] F. O. Robbiati, L. D. Amarilla, A. M. Anton, and R. H. Fortunato, “Phenotypic variation in arid and semi-arid zones of various countries,” Plants of Africa – Fabaceae from Southeast Brazil, Caryologia, vol. 66, no. 1, pp. 1–5, 2013.

[23] A. Rice, L. Glick, S. Abadi et al., “The chromosome counts database (CCDB) – a community resource of plant chromosome numbers,” New Phytologist, vol. 206, no. 1, pp. 19–26, 2015.

[24] K. F. Resende, L. C. Davide, and G. A. Torres, “Chromosome number and meiois in populations of Senna species (Caesalpinioideae – Fabaceae) from Brazil,” International Journal of Organic Evolution, vol. 32, no. 1, pp. 128–134, 2018.

[25] K. Resende, C. Prado, L. Davide, and G. Torres, “Polyploidy and apomixis in accessions of Senna rugosa (G.Don) H.S.Irwin & Barneby,” Turkish Journal of Biology, vol. 38, no. 4, pp. 510–515, 2014.

[26] L. P. Matos, K. L. Barreto, A. S. Conceição, L. P. Queiroz, and M. J. Andrade, “Análise citogenética de 16 espécies dos gêneros Senna Mill. e Cassia L. (Leguminosae), com ênfase nas espécies Senna spectabilis e Cassia Mill. em áreas de uso medicional,” New Phytologist, vol. 32, no. 1, pp. 95–106, 2014.

[27] N. C. Vieira et al., “Polyploidy and apomixis in accessions of Senna spectabilis,” Journal of Ethnopharmacology, vol. 49, no. 1, pp. 41–58, 1995.

[28] K. Resende, C. Prado, L. Davide, and G. Torres, “Polyploidy and apomixis in accessions of Senna spectabilis,” Journal of Ethnopharmacology, vol. 49, no. 1, pp. 41–58, 1995.

[29] K. Resende, C. Prado, L. Davide, and G. Torres, “Polyploidy and apomixis in accessions of Senna spectabilis,” Journal of Ethnopharmacology, vol. 49, no. 1, pp. 41–58, 1995.

[30] K. Resende, C. Prado, L. Davide, and G. Torres, “Polyploidy and apomixis in accessions of Senna spectabilis,” Journal of Ethnopharmacology, vol. 49, no. 1, pp. 41–58, 1995.

[31] K. Resende, C. Prado, L. Davide, and G. Torres, “Polyploidy and apomixis in accessions of Senna spectabilis,” Journal of Ethnopharmacology, vol. 49, no. 1, pp. 41–58, 1995.

[32] K. Resende, C. Prado, L. Davide, and G. Torres, “Polyploidy and apomixis in accessions of Senna spectabilis,” Journal of Ethnopharmacology, vol. 49, no. 1, pp. 41–58, 1995.

[33] K. Resende, C. Prado, L. Davide, and G. Torres, “Polyploidy and apomixis in accessions of Senna spectabilis,” Journal of Ethnopharmacology, vol. 49, no. 1, pp. 41–58, 1995.

[34] K. Resende, C. Prado, L. Davide, and G. Torres, “Polyploidy and apomixis in accessions of Senna spectabilis,” Journal of Ethnopharmacology, vol. 49, no. 1, pp. 41–58, 1995.

[35] K. Resende, C. Prado, L. Davide, and G. Torres, “Polyploidy and apomixis in accessions of Senna spectabilis,” Journal of Ethnopharmacology, vol. 49, no. 1, pp. 41–58, 1995.
of Applied and Advanced Research, vol. 1, no. 3, pp. 16–24, 2016.

[52] S. Semenya, M. Potgieter, M. Tsishikhaave, S. Shava, and A. Maroyo, "Medicinal utilization of exotic plants by Bapedi traditional healers to treat human ailments in Limpopo province, South Africa," Journal of Ethnopharmacology, vol. 144, no. 3, pp. 646–655, 2012.

[53] M. Gupta, P. N. Solis, A. I. Calderón et al., "Medical ethnobotany of the Teribes of Bocas del Toro, Panama," Journal of Ethnopharmacology, vol. 96, no. 3, pp. 389–401, 2005.

[54] M. S. Amir and M. R. Joharchi, "Ethnobotanical investigation of traditional medicinal plants commercialized in the markets of Mashhad, Iran," Avicenna Journal of Phytomedicine, vol. 3, no. 3, pp. 254–271, 2013.

[55] R. Qureshi, G. R. Bhatti, and R. A. Memon, "Ethnomedical uses of herbs from northern part of Nara desert Pakistan," Pakistan Journal of Botany, vol. 42, no. 2, pp. 839–851, 2010.

[56] G. B. Hammond, I. D. Fernández, L. F. Villegas, and A. J. Vaisberg, "A survey of traditional medicinal plants from the Callejon de Huaylas, Department of Ancash, Peru," Journal of Ethnopharmacology, vol. 61, no. 1, pp. 17–30, 1998.

[57] J. Kufer, H. Förther, E. Pöll, and M. Heinrich, "Historical and modern medicinal plant uses—the example of the Ch'orti Maya and Ladinios in eastern Guatemala," Journal of Pharmacy and Pharmacology, vol. 57, no. 9, pp. 1127–1152, 2005.

[58] J. Rani, "Ethanobotanical survey and traditional uses of medicinal plants in Jind district of Haryana India," Plant Archives, vol. 19, no. 1, pp. 1241–1247, 2019.

[59] G. Yaseen, M. Ahmad, S. Shinwari et al., "Medicinal plant diversity used for livelihood of public health in deserts and arid regions of Sindh-Pakistan," Pakistan Journal of Botany, vol. 51, no. 2, pp. 2409–2419, 2019.

[60] M. J. Mishi, D. F. Otieno, and A. Weisheit, "Ethnomedicine of the Kagera region, north western Tanzania. Part 3: plants used in traditional medicine in Kikuku village, Muleba District," Journal of Ethnobiology and Ethnomedicine, vol. 8, no. 1, pp. 1–11, 2012.

[61] T. E. Tshikalange, The traditional use of medicinal plants to treat sexually transmitted diseases, University of Pretoria, 2006.

[62] N. A. Maseve, L. J. McGaw, and J. N. Eloff, "The traditional use of plants to manage candidiasis and related infections in Venda, South Africa," Journal of Ethnopharmacology, vol. 168, pp. 364–372, 2015.

[63] M. Sobeh, M. Mahmoud, R. Hasan, H. Cheng, A. el-Shazly, and M. Wink, "Senna sanguinea: antioxidant, hepatoprotective, antiapoptotic properties and phytochemical profiling of a methanol bark extract," Molecules, vol. 22, no. 9, p. 1502, 2017.

[64] L. K. Keter and P. C. Mutiso, "Ethnobotanical studies of medicinal plants used by traditional health practitioners in the management of diabetes in lower Eastern Province, Kenya," Journal of Ethnopharmacology, vol. 139, no. 1, pp. 74–80, 2012.

[65] A. Rahman and M. A. Keya, "Traditional medicinal plants used by local people at the village Sabgram under Sadar Upazila of Bogra district Bangladesh," Research in Plant Sciences, vol. 3, no. 2, pp. 31–37, 2015.

[66] Y. Fu, J. C. Yang, A. B. Cunningham et al., "A billion cups: the diversity, traditional uses, safety issues and potential of
Chinese herbal teas,” *Journal of Ethnopharmacology*, vol. 222, pp. 217–228, 2018.

[67] S. S. M. Pattnaik and L. Behera, “Traditional use of herbal medicines against rheumatism by the tribals of Bargarh district in Odisha (India) by sk senl_ mr pattnaik2 and Im behera3,” *Life Sciences Leaflets*, vol. 51, pp. 59–68, 2014.

[68] S. Ahmed and A. M. Shohael, “In silico studies of four anthraquinones of *Senna alata* L. as potential antifungal compounds,” *Pharmacology*, vol. 2, pp. 259–268, 2019.

[69] E. E. Essien, T. M. Walker, I. A. Ogunwande, A. Bansal, W. N. Setzer, and O. Ekundayo, “Volatile constituents, antimicrobial and cytotoxicity potentials of Three *Senna* Species from Nigeria,” *Journal of Essential Oil-Bearing Plants*, vol. 14, no. 6, pp. 722–730, 2011.

[70] F. Epifano, S. Fiorito, M. Locatelli, V. A. Taddeo, and S. Genovese, “Screening for novel plant sources of prenyloxyanthraquinones: *Senna alexandrina* Mill. and *Aloe vera* (L.) Burm. F,” *Natural Product Research*, vol. 29, no. 2, pp. 180–184, 2015.

[71] S. I. Ahmed, M. Q. Hayat, M. Tahir et al., “Pharmacologically active flavonoids from the anticancer, antioxidant and anti-microbial extracts of *Cassia angustifolia* Vahl,” *BMC Complementary Medicine and Therapies*, vol. 16, no. 1, p. 460, 2016.

[72] D. Arrieta-Baez, R. Roman, R. Vazquez-Duhalt, and M. Jimenez-Estrada, “Peroxidase-mediated transformation of hydroxy-9,10-anthraquinones,” *Phytochemistry*, vol. 60, no. 6, pp. 567–572, 2002.

[73] W. Francisco, M. Pivatto, A. Danuello et al., “Pyridine alkaloids from *Senna multijuga* As acetylcholinesterase inhibitors,” *Journal of Natural Products*, vol. 75, no. 3, pp. 408–413, 2012.

[74] M. A. R. Serrano, M. Pivatto, W. Francisco et al., “Acetylcholinesterase inhibitory pyridine alkaloids of the leaves of *Senna multijuga*,” *Journal of Natural Products*, vol. 73, no. 3, pp. 482–484, 2010.

[75] C. G. Vargas Rechia, M. R. Sierakowski, J. L. M. S. Ganter, and F. Reichert, “Polysaccharides from the seeds of *Senna multijuga*,” *International Journal of Biological Macromolecules*, vol. 17, no. 6, pp. 409–412, 1995.

[76] B. M. Abegaz, M. Bezabeh, G. Alemayehu, and H. Duddeck, “Anthraquinones from *Senna multiglandulosa*,” *Phytochemistry*, vol. 35, no. 2, pp. 465–468, 1994.

[77] G. Alemayehu and B. M. Abegaz, “Bianthraquinones from the seeds of *Senna multiglandulosa*,” *Phytochemistry*, vol. 41, no. 3, pp. 919–921, 1996.

[78] E. E. Essien, P. S. Thomas, R. Ascrizzi, W. N. Setzer, and G. Flamini, “*Senna occidentalis* (L.) link and *Senna hirsuta* (L.) H. S. Irwin & Barneby: constituents of fruit essential oils and antimicrobial activity,” *Natural Product Research*, vol. 33, no. 11, pp. 1637–1640, 2019.

[79] I. R. O. Maia, M. T. S. Trevisan, M. G. . V. Silva, A. Breuer, and R. W. Owen, “Characterization and quantitation of polyphenolic compounds in *Senna gardnerian* S. Georgacfrion from the northeast of Brazil,” *Natural Product Communications*, vol. 13, no. 11, article 1934578X1801301, 2018.

[80] J. A. Monteiro, J. M. Ferreira Junior, I. R. Oliveira et al., “Bioactivity and toxicity of *Senna cana* and *Senna pendula* extracts,” *Biochemistry Research International*, vol. 2018, Article ID 8074306, 2018.

[81] B. Barba, J. G. Díaz, and W. Herz, “Anthraquinones and other constituents of two *Senna* species,” *Phytochemistry*, vol. 31, no. 12, pp. 4374-4375, 1992.

[82] M. Á. Zavala-Sánchez, J. L. Rodríguez-Chávez, R. Figueroa-Brito et al., “Bioactivity of 1-octacosanol from *Senna crotalariaoides* (Fabaceae: Caesalpinioideae) to control *Spodoptera frugiperda* (Lepidoptera: Noctuidae),” *Florida Entomologist*, vol. 102, no. 4, pp. 731–737, 2019.

[83] G. Alemayehu, A. Hallu, and B. M. Abegaz, “Bianthraquinones from *Senna didymobotrya*,” *Phytochemistry*, vol. 42, no. 5, pp. 1423–1425, 1996.

[84] C. O. Ochieng, A. Shrivastava, U. Chaturvedi et al., “Effects of *Senna didymobotrya* root extract and compounds on Triton-induced hyperlipidaemic rats and differentiation of 3T3-L1 preadipocytes,” *Natural Products Journal*, vol. 3, no. 3, pp. 212–217, 2013.

[85] K. V. Rao, A. G. Damu, B. Jayaprakash, and D. Gunasekar, “Flavonol glycosides from Cassia cissi,” *Journal of Natural Products*, vol. 62, no. 2, pp. 305–306, 1999.

[86] J. G. Silva, A. A. Silva, I. D. Coutinho, C. O. Pessoa, A. J. Cavalheiro, and M. G. Silva, “Chemical profile and cytotoxic activity of leaf extracts from *Senna* spp. from northeast of Brazil,” *Journal of the Brazilian Chemical Society*, vol. 27, no. 10, pp. 1872–1880, 2016.

[87] S. S. Gololo, N. S. Mapfumari, L. S. Sethoga, M. T. Olivier, L. J. Shai, and M. A. Mogale, “Identification of phytochemical constituents within the n-hexane leaf extract of *Senna italica* (mill) using gas chromatography-mass spectrometry (GC-MS) analysis,” *Journal of Pharmaceutical Sciences and Research*, vol. 8, no. 10, pp. 1141–1143, 2016.

[88] O. M. Khalaf, M. A. Ghareeb, A. M. Saad, H. M. F. Madkour, A. K. el-Ziati, and M. S. Abdel-Aziz, “Phenolic constituents, antimicrobial, antioxidant, and anticancer activities of ethyl acetate andn-butanol extracts of *Senna italica*,” *Acta Chromatographica*, vol. 31, no. 2, pp. 138–145, 2019.

[89] H. M. Madkour, M. A. Ghareeb, M. S. Abdel-Aziz et al., “Gas chromatography-mass spectrometry analysis, antimicrobial, anticancer and antioxidant activities of n-hexane and methylene chloride extracts of *Senna italica*,” *Journal of Applied Pharmaceutical Science*, vol. 7, no. 6, pp. 023–032, 2017.

[90] M. P. Mokgotho, S. S. Gololo, P. Masoko et al., “Isolation and chemical structural characterisation of a compound with antioxidant activity from the roots of *Senna italica*,” *Evidence-based Complementary and Alternative Medicine*, vol. 2013, Article ID 519174, 2013.

[91] G. Alemayehu, B. Abegaz, G. Snatzke, and H. Duddeck, “Bianthrone from *Senna longiracemosus*,” *Phytochemistry*, vol. 32, no. 5, pp. 1273–1277, 1993.

[92] A. Branco, A. C. Pinto, R. Braz-Filho, E. F. Silva, N. F. Grynberg, and A. Echevarria, “Rubrofusarina, um policetídeo natural inibidor da topoiosomerase II α humana,” *Brazilian Journal of Pharmacognosy*, vol. 18, pp. 703–708, 2008.

[93] K. D. Klika, I. Ricarte, M. T. S. Trevisan, M. G. de Vasconcelos Silva, and R. W. Owen, "(2R,3S,4S,6S)-guibourtin-diol-(4α-8)-catechin, a biflavonoid procyanidin of the guibourtinidin group from *Senna macranthera*: its relative stereochemistry and conformation,” *Tetrahedron: Asymmetry*, vol. 26, no. 5-6, pp. 247–250, 2015.

[94] L. Pires, P. A. J. Gorin, F. Reicher, and M. R. Sierakowski, “An active hepatoprotectant obtained by sulphation of a galactomannan extracted from the endosperm of *Senna macranthera* seeds,” *Carbohydrate Polymers*, vol. 46, no. 2, pp. 165–169, 2001.

[95] I. Messana, F. Ferrari, M. S. Cavalcanti, and E. Gacs Baizt, “New naphthopyrone derivatives from *Cassia pudibunda*,” *Heterocycles*, vol. 31, no. 10, pp. 1847, 1990.
Oxidative Medicine and Cellular Longevity

[96] I. Messana, F. Ferrari, M. S. B. Cavalcanti, and G. Morace, “An anthraquinone and three naphthopyrone derivatives from Cassia pudibunda,” Phytochemistry, vol. 30, no. 2, pp. 708–710, 1991.

[97] E. M. S. de Macedo, H. J. Wiggers, M. G. V. Silva, R. Braz-Filho, A. D. Andricopulo, and C. A. Montanari, “A new bianthron glycoside as inhibitor of Trypanosoma cruzi glyceraldehyde 3-phosphate dehydrogenase activity,” Journal of the Brazilian Chemical Society, vol. 20, no. 5, pp. 947–953, 2009.

[98] J. G. Graham, H. Zhang, S. L. Pendland et al., “Antimycobacterial naphthopyrones from Senna obliqua,” Journal of Natural Products, vol. 67, no. 2, pp. 225–227, 2004.

[99] X. Pang, L. M. Wang, Y. C. Zhang et al., “New anthraquinone and eurionine analogue from the seeds of Senna obtusifolia and their inhibitory effects on human organic anion transporters 1 and 3,” Natural Product Research, vol. 33, no. 23, pp. 3409–3416, 2019.

[100] A. N. Saidu, E. O. Aina, A. Mann, and U. I. Leje, “The effect of aqueous extract of Senna occidentalis leaves on rats infected with salmonella typhi,” Australian Journal of Basic and Applied Sciences, vol. 5, no. 12, pp. 1863–1867, 2011.

[101] A. Javaid, H. Qudsia, and A. Shoaib, “Bioassays guided fractionation of Senna occidentalis for identification of natural antifungal constituents against Macrophomina phaseolina,” Planta Daninha, vol. 35, 2017.

[102] H. L. Kim, B. J. Camp, and R. D. Grigsby, “Isolation of N-methylmorpholine from the seeds of Cassia occidentalis L. (coffee Senna),” Journal of Agricultural and Food Chemistry, vol. 19, no. 1, pp. 198–199, 1971.

[103] N. Kumar, G. Singh, S. Singh, and A. Singh, “Standardization and simultaneous quantification of flavonoids and phenolic contents in Cassia occidentalis using liquid chromatography triple quadrupole mass spectrometry (LC-MS/MS),” Research Journal of Chemistry and Environment, vol. 21, no. 1, pp. 1–8, 2017.

[104] S. F. Li, Y. T. di, R. H. Luo et al., “Cycloartane triterpenoids from Cassia occidentalis,” Planta Medica, vol. 78, no. 8, pp. 821–827, 2012.

[105] S. F. Li and S. L. Li, “Cycloartane triterpenoid and its glucoside isolated from Cassia occidentalis,” Chinese Journal of Natural Medicines, vol. 15, no. 12, pp. 950–954, 2017.

[106] I. A. Ogunwande, N. O. Avoseh, G. Flaminì et al., “Essential oils from the leaves of six medicinal plants of Nigeria,” Natural Product Communications, vol. 8, no. 2, pp. 243–248, 2013.

[107] R. X. Qin, Q. Zuo, X. H. Huang et al., “A new norsesquiterpene from Cassia occidentalis and its bioactivity,” China Journal of Chinese Materia Medica, vol. 41, no. 23, pp. 4389–4392, 2016.

[108] H. Singh, P. Chahal, A. Mishra, and A. K. Mishra, “An up-to-date review on chemistry and biological activities of Senema occidentalis (L.) link family: Leguminosae,” Advances in Traditional Medicine, vol. 20, no. 3, pp. 263–278, 2020.

[109] T. E. Tshikalange, J. J. M. Meyer, and A. A. Hussein, “Antimicrobial activity, toxicity and the isolation of a bioactive compound from plants used to treat sexually transmitted diseases,” Journal of Ethnopharmacology, vol. 96, no. 3, pp. 515–519, 2005.

[110] A. M. Gamal-Eldeen, P. C. Djemgou, M. Tchuendem, B. T. Ngadjiui, P. Tane, and H. Toshifumi, “Anti-cancer and immunostimulatory activity of chromones and other constituents from Cassia petersiana,” Zeitschrift fur Naturforschung - Section C Journal of Biosciences, vol. 62, no. 5–6, pp. 331–338, 2007.

[111] J. Coetze, L. Micteka, E. Malan, and D. Ferreira, “Structure and synthesis of the first procassidin dimers based on epicatechin, and gallo- and epigallo-catechin,” Phytochemistry, vol. 53, no. 7, pp. 795–804, 2000.

[112] B. O. Ajiboye, O. A. Ojo, B. Fatoba et al., “In vitro antioxidant and enzyme inhibitory properties of the n-butanol fraction of Senema podocarpa (Guill. and Perr.) leaf,” Journal of Basic and Clinical Physiology and Pharmacology, vol. 31, no. 1, 2020.

[113] M. Malmir, E. Ferreira, R. Serrano, E. T. Gomes, M. Caniça, and O. Silva, “In vitro anti- Neisseria gonorrhoeae activity of Senema podocarpa root extracts,” Industrial Crops and Products, vol. 76, pp. 467–471, 2015.

[114] G. Genta-Jouve, L. Weinberg, V. Cocandeau, Y. Maestro, O. P. Thomas, and S. Holderith, “Revising the absolute configurations of coatlins via density functional theory calculations of electronic circular dichroism spectra,” Chirality, vol. 25, no. 3, pp. 180–184, 2013.

[115] M. Ogura, G. A. Cordell, and N. R. Farnsworth, “Quinquagulin, a new naphthopyrone from Cassia quinquangulata (Leguminosae),” Lloydia, vol. 40, no. 4, pp. 347–351, 1977.

[116] G. J. Mena-Rejóna, K. Pérez-Rivas, P. Sansorez-Peraza, T. Rios, and L. Quijano, “Racemochrysone, a dihydronaphthacenone from Senema racemosa,” Zeitschrift fur Naturforschung - Section C Journal of Biosciences, vol. 57, no. 9–10, pp. 777–779, 2002.

[117] P. Sansores-Peraza, M. Rosado-Vallado, W. Brito-Loeza, G. J. Mena-Rejón, and L. Quijano, “Cassine, an antimicrobial alkaloid from Senema racemosa,” Fitoterapia, vol. 71, no. 6, pp. 690–692, 2000.

[118] R. N. Dos Santos, M. G. D. V. Silva, and R. Braz Filho, “Constituïntes quimicos do caule de Senema reticulata Willd. (Leguminosae): chemical constituents isolated from the wood of Senema reticulata Willd,” Quimica Nova, vol. 31, no. 8, pp. 1979–1981, 2008.

[119] F. G. Barbosa, M. . C. F. de Oliveira, R. Braz-Filho, and E. R. Silva, “Anthraquinones and naphthopyrones from Senema rugosa,” Biochemical Systematics and Ecology, vol. 32, no. 3, pp. 363–365, 2004.

[120] G. Alemayehu, L. Adane, and B. M. Abegaz, “A new bianthracene C-arabinopyranoside from Senema septemtrionalis,” Natural Product Communications, vol. 5, no. 5, pp. 747–750, 2010.

[121] G. Alemayehu, B. Woldeyesus, and B. M. Abegaz, “+(+)-Florbundone 3 from the pods of Senema septemtrionalis,” Bulletin of the Chemical Society of Ethiopia, vol. 11, no. 1, pp. 25–29, 1997.

[122] K. Ingkaninan, A. P. Ijzemar, and R. Verpoorte, “Luteolin, a compound with adenosine A1Receptor-binding activity, and chromone and dihydronaphthalenone constituents from Senema siamea,” Journal of Natural Products, vol. 63, no. 3, pp. 315–317, 2000.

[123] A. P. Sakunpak, J. I. Suksaeree, C. H. Monton, and P. A. Pathompakh, “Development and quantitative determination of barakol in Senema siamea leaf extract by TLC-image analysis method,” International Journal of Pharmacy and Pharmaceutical Sciences, vol. 6, no. 3, pp. 267–270, 2014.

[124] H. Morita, S. Oshimi, Y. Hirasesawa et al., “Cassiarins a and B, novel antiplasmodial alkaloids from Cassia siamea,” Organic Letters, vol. 9, no. 18, pp. 3691–3693, 2007.
[125] S. Oshimi, Y. Tomizawa, Y. Hirasawa et al., “Chromobismamone a, a new bischromone from *Cassia siamea* and a biomimetic transformation of 5-acetyl-7-hydroxy-2-methylenochrome into cassiarin a,” *Bioorganic and Medicinal Chemistry Letters*, vol. 18, no. 13, pp. 3761–3763, 2008.

[126] S. Oshimi, J. Deguchi, Y. Hirasawa et al., “Cassiarins C-E, antiplasmodial alkaloids from the flowers of *Cassia siamea*,” *Natural Product Research*, vol. 72, no. 10, pp. 1899–1901, 2009.

[127] J. Deguchi, T. Sasaki, Y. Hirasawa et al., “Two novel tetra-cycles, cassibiphenols a and b from the flowers of *Cassia siamea*,” *Tetrahedron Letters*, vol. 55, no. 7, pp. 1362–1365, 2014.

[128] J. Koyama, I. Morita, K. Tagahara, and M. Aqil, “Bianthraquiones from *Cassia siamea*,” *Phytochemistry*, vol. 56, no. 8, pp. 849–851, 2001.

[129] D. Kumar, A. Karmase, S. Jagtap, R. Shekhara, and K. K. Bhusani, “Pancreatic lipase inhibitory activity of cassiamin a, a bianthraquinone from *Cassia siamea*,” *Natural Product Communications*, vol. 8, no. 2, pp. 195–198, 2013.

[130] O. O. Ogbole, T. E. Akinleye, T. O. C. Faleye, and A. J. Adeeniji, “Enterovirusing inhibitory activities of two Lupane triterpenoids and anthraquinones from *senna siamea* stem bark against three serotypes of echovirus,” *Acta Pharmacologica Sinica*, vol. 57, no. 3, pp. 105–115, 2019.

[131] E. O. Ajaiyeoba, J. S. Ashidi, L. C. Okpako, P. J. Houghton, and C. W. Wright, “Antiplasmoidal compounds from *Cassia siamea* stem bark extract,” *Phytotherapy Research*, vol. 22, no. 2, pp. 254–255, 2008.

[132] T. S. Lu, Y. H. Yi, S. L. Mao et al., “Studies on the anthraquinones of *Cassia siamea*,” *Yao xue xue bao = Acta Pharmaceutica Sinica*, vol. 36, no. 7, pp. 547–548, 2001.

[133] T. S. Lu, Y. H. Yi, S. L. Mao et al., “A new chromone glycoside from *Cassia siamea* Lam,” *Yaoxue Xuebao*, vol. 38, no. 2, pp. 113–115, 2003.

[134] T. S. Lu, Y. H. Yi, Z. G. Zhang, Z. Q. Zhang, and N. Hua, “A new 10-hydroxyl anthrone glycoside from *Cassia siamea* Lam,” *Chinese Chemical Letters*, vol. 13, no. 8, pp. 731–733, 2002.

[135] Q. F. Hu, B. Zhou, X. M. Gao et al., “s,” *Journal of Natural Products*, vol. 75, no. 11, pp. 1909–1914, 2012.

[136] L. Ledwani and M. Singh, “Isolation and characterization of anthraquinones from the stem bark of *Cassia species*,” *Journal of the Indian Chemical Society*, vol. 83, no. 4, pp. 383–385, 2006.

[137] Y. K. Li, B. Zhou, X. X. Wu et al., “Phenolic compounds from *Cassia siamea* and their anti-tobacco mosaic virus activity,” *Chemistry of Natural Compounds*, vol. 51, no. 1, pp. 50–53, 2015.

[138] S. Thengvai, P. Thiantongin, C. Sontimuang, C. Ovatlarnporn, and P. Puttarak, “α-glucosidase and α-amylase inhibitory activities of medicinal plants in Thai anti-diabetic recipes and bioactive compounds from *Vitex glabrata* R. Br. Stem bark,” *Journal of Herbal Medicine*, vol. 19, p. 100302, 2020.

[139] D. A. Baez, L. G. Zepeda Vallejo, and M. Jimenez-estrad, “Phytochemical studies on *Senna skinneri* and *Senna wislizeni*,” *Natural Product Letters*, vol. 13, no. 3, pp. 223–228, 1999.

[140] D. A. Baez, G. Z. Vallejo, P. C. Sanchez, M. B. Valle, R. R. Chilpa, and M. J. Estrada, “Use of the SOS-chromotest spot assay as a screening system for detecting genotoxic compounds in crude plant extracts,” *ATLA, Alternatives to Laboratory Animals*, vol. 30, no. 1, pp. 87–92, 2002.

[141] G. Alemayehu, B. Abegaz, and W. Kraus, “A 1,4-anthraquinone-dihydroanthracenone dimer from *Senna sophora*,” *Phytochemistry*, vol. 48, no. 4, pp. 699–702, 1998.

[142] A. R. Kharat, K. Kharat, M. Jadhav, and S. J. Makhija, “Anti-hyperglycemic, anti-hyperlipidemic and antioxidative evaluation of compounds from *Senna sophora* (L) Roxb in streptozotocin-induced diabetic rats,” *Natural Product Research*, vol. 33, no. 4, pp. 602–605, 2019.

[143] S. Malhotra and K. Misra, “A new anthraquinone from *Cassia sophera* Heartwood,” *Planta Medica*, vol. 46, no. 12, pp. 247–249, 1982.

[144] A. Mondal, D. Rajalingam, and T. Kumar Maity, “Anti-inflammatory effect of 0 -methylated flavonol 2-(3,4-dihydroxy-phenyl)-3,5-dihydroxy-7-methoxy-chromen-4-one obtained from *Senna sophora* Linn in rats,” *Journal of Ethnopharmacology*, vol. 147, no. 2, pp. 525–529, 2013.

[145] W. Mushtaq, Q. Ain, M. B. Siddiqui, H. Alharby, and K. R. Hakeem, “Allelochemicals change macromolecular content of some selected weeds,” *South African Journal of Botany*, vol. 130, pp. 177–184, 2020.

[146] F. O. Silva, I. R. Oliveira, M. G. V. Silva, and R. Braz-Filho, “Constituents químicos das folhas de *Senna spectabilis* (DC) Irwin & Barney var. excelsa (Schrad.) Irwin & Barney,” *Quimica Nova*, vol. 33, no. 9, pp. 1874–1876, 2010.

[147] K. T. Lim, A. Amanah, N. J. Y. Chear, Z. Zahari, Z. Zainuddin, and M. I. Adenan, “Inhibitory effects of (+)-spectalone and iso-6-spectalone from *Senna spectabilis* on the growth and ultrastructure of human-infective species *Trypanosoma brucei rhodesiense* bloodstream form,” *Experimental Parasitology*, vol. 184, pp. 57–66, 2018.

[148] K. A. B. S. da Silva, M. N. Manjavací, A. F. Paszczuk et al., “Plant derived alkaloid (−)-cassine induces anti-inflammatory and anti-hyperalgesic effects in both acute and chronic inflammatory and neuropathic pain models,” *Neuropharmacology*, vol. 62, no. 2, pp. 967–977, 2012.

[149] M. Pivatto, L. R. Baccini, A. Sharma et al., “Antimalarial activity of piperidine alkaloids from *Senna spectabilis* and semisynthetic derivatives,” *Journal of the Brazilian Chemical Society*, vol. 25, no. 10, pp. 1900–1906, 2014.

[150] F. O. Silva, M. G. V. Silva, G. S. Cerqueira et al., “Central nervous system effects of Iso-6-spectalone isolated from *Senna spectabilis* var. excelsa (schrad) in mice,” *Journal of Young Pharmacists*, vol. 3, no. 3, pp. 232–236, 2011.

[151] L. Sripong, U. Sotanaphun, S. Limrich architectural, P. Wettwayaklung, C. Chaichantiputh, and S. Pummaungura, “Cytotoxic alkaloids from the flowers of *Senna spectabilis*,” *Planta Medica*, vol. 69, no. 11, pp. 1054–1056, 2003.

[152] C. Viejas Junior, M. Pivatto, A. D. Rezende, L. Hamerski, D. H. Silva, and V. D. Bolzani, “(−)-Hydroxy-cassine: a new 2,6-dialkylpiperidin-3-ol alkaloid and other constituents isolated from flowers and fruits of *Senna spectabilis* (Fabaceae),” *Journal of the Brazilian Chemical Society*, vol. 24, no. 2, pp. 230–235, 2013.

[153] M. Valli, A. H. Betti, A. Danuello et al., “Pyridinic analog of the natural product (−)-spectalone as potential adjuvant for the treatment of central nervous system disorders,” *Bioorganic and Medicinal Chemistry Letters*, vol. 25, no. 10, pp. 2247–2250, 2015.
[154] C. Viegas Jr., V. S. Bolzani, L. S. B. Pimentel et al., “New selective acetylcholinesterase inhibitors designed from natural piperidine alkaloids,” Bioorganic and Medicinal Chemistry, vol. 13, no. 13, pp. 4184–4190, 2005.

[155] F. O. Silva, M. G. V. Silva, D. Feng, and R. M. de Freitas, “Evaluation of central nervous system effects of iso-6-cassine isolated from Senna spectabilis var. excelsa (Schrad) in mice,” Fitoterapia, vol. 82, no. 2, pp. 255–259, 2011.

[156] R. B. Lacerda, T. R. Freitas, M. M. Martins et al., “Isolation, leishmanicidal evaluation and molecular docking simulations of piperidine alkaloids from Sennga spectabilis,” Bioorganic and Medicinal Chemistry, vol. 26, no. 22, pp. 5816–5823, 2018.

[157] R. M. Pereira, G. Á. Ferreira-Silva, M. Privato et al., “Alkaloids derived from flowers of Sennga spectabilis, (–)-cassine and (–)-spacantine, have antiproliferative activity on HepG2 cells for inducing cell cycle arrest in G1/S transition through ERK inactivation and downregulation of cyclin D1 expression,” Toxicology In Vivo, vol. 31, pp. 86–92, 2016.

[158] E. Valencia, E. Valenzuela, E. Barros et al., “Estudio fitoquímico y actividad antialimentaria de Sennga stipulaceae,” Boletín de la Sociedad Chilena de Química, vol. 45, no. 2, pp. 297–301, 2000.

[159] S. A. El-Sawi and A. A. Sleem, “Flavonoids and hepatoprotective activity of leaves of Sennga Surattensis (Burm.f.) in CCl4 induced hepatotoxicity in rats,” Australian Journal of Basic and Applied Sciences, vol. 4, no. 6, pp. 1326–1334, 2010.

[160] S. J. Anu and J. Madhusudana Rao, “Oxanthrone esters from the roots of Cassia kleinii,” Phytochemistry, vol. 59, no. 4, pp. 425–427, 2002.

[161] S. J. Anu and J. M. Rao, “Oxanthrone esters from the aerial parts of Cassia kleinii,” Phytochemistry, vol. 57, no. 4, pp. 583–585, 2001.

[162] A. M. el-Halawany, M. H. Chung, N. Nakamura, C. M. Ma, T. Nishihara, and M. Hattori, “Estrogenic and anti-estrogenic activities of Cassia tora phenoic constituents,” Chemical and Pharmaceutical Bulletin, vol. 55, no. 10, pp. 1476–1482, 2007.

[163] N. Fathalla, M. Bishr, A. Nasser Singab, and O. Salama, “GC-MS and LC-MS identification of the phenolic compounds present in the ethyl acetate fraction obtained from Sennga tora L. Roxb. Seeds,” Natural Product Letters, vol. 33, no. 19, pp. 2878–2881, 2019.

[164] G. Y. Lee, D. S. Jang, Y. M. Lee, J. M. Kim, and J. S. Kim, “Naphthopyrone glucosides from the seeds of Cassia tora with inhibitory activity on advanced glycation end products (AGEs) formation,” Archives of Pharmacal Research, vol. 29, no. 7, pp. 587–590, 2006.

[165] T. Hatano, H. Uebayashi, H. Ito, S. Shiota, T. Tsuchiya, and T. Yoshida, “Phenolic constituents of cassia seeds and antibacterial effect of some naphthalenes and anthraquinones on methicillin-resistant Staphylococcus aureus,” Chemical and Pharmaceutical Bulletin, vol. 47, no. 8, pp. 1121–1127, 1999.

[166] G. Y. Lee, J. H. Kim, S. K. Choi, and Y. H. Kim, “Constituents of the seeds of Cassia tora with inhibitory activity on solubile exopoxide hydrolease,” Bioorganic and Medicinal Chemistry Letters, vol. 25, no. 22, pp. 5097–5101, 2015.

[167] H. J. Lee, J. S. Choi, J. H. Jung, and S. S. Kang, “Alaternin glucoside isomer from Cassia tora,” Phytochemistry, vol. 49, no. 5, pp. 1403–1404, 1998.

[168] Y. B. Park and S. B. Kim, “Isolation and identification of anti-tumor promoters from the seeds of Cassia tora,” Journal of Microbiology and Biotechnology, vol. 21, no. 10, pp. 1043–1048, 2011.

[169] J. M. Cherng, W. Chiang, J. H. Wang et al., “Anthraquinones of edible wild vegetable Cassia tora stimulate proliferation of human CD4+ T lymphocytes and secretion of interferon-gamma or interleukin 10,” Food Chemistry, vol. 107, no. 4, pp. 1576–1580, 2008.

[170] S. K. Hyun, H. Lee, S. S. Kang, H. Y. Chung, and J. S. Choi, “Inhibitory activities of Cassia tora and its anthraquinone constituents on angiotensin - converting enzyme,” Phytotherapy Research, vol. 23, no. 2, pp. 178–184, 2009.

[171] M. Jimenez-Coello, K. Y. Acosta-Viana, E. Guzman-Marin, C. Perez Gonzalez, and M. Salud Perez Gutierrez, “Anti-tyrpanosomal activity of (8-hydroxymethyl)-trieicosanyl acetate against infective forms of Trypanosoma cruzi,” Pharmaceutical Biology, vol. 48, no. 6, pp. 666–671, 2010.

[172] E. Guzmán, C. Pérez, M. A. Zavala, K. Y. Acosta-Viana, and S. Pérez, “Antiprotozoal activity of (8-hydroxyethyl)-trieicosanyl acetate isolated from Sennga villosa,” Phytomedicine, vol. 15, no. 10, pp. 892–895, 2008.

[173] B. Salehi, M. Shivaaprasad Shetty, N. V. Anil Kumar et al., “Veronica plants-drifting from farm to traditional healing, food application, and phytopharmacology,” Molecules, vol. 24, no. 13, pp. 2454, 2019.

[174] M. Sharifi-Rad, N. V. Anil Kumar, P. Zucca et al., “Lifestyle, oxidative stress, and antioxidants: back and forth in the pathophysiology of chronic diseases,” Frontiers in Physiology, vol. 11, p. 21, 2020.

[175] R. R. Mititelu, R. Padureanu, M. Băcănoiu et al., “Inflammatory and oxidative stress markers—Mirror tools in rheumatoid arthritis,” Biomedicine, vol. 8, no. 5, p. 125, 2020.

[176] B. Salehi, J. Sharifi-Rad, F. Cappellini et al., “The therapeutic potential of anthocyanins: current approaches based on their molecular mechanism of action,” Frontiers in Pharmacology, vol. 11, p. 20, 2020.

[177] D. Tsoukalas, P. Fragkiadaki, A. O. Docea et al., “Association of nutraceutical supplements with longer telomere length,” International Journal of Molecular Medicine, vol. 44, no. 1, pp. 218–226, 2019.

[178] B. Salehi, Sharifi-Rad, C. Capanoglu et al., “Cucurbita plants: from farm to industry,” Applied Sciences-Basel, vol. 9, no. 16, p. 3387, 2019.

[179] R. Padureanu, C. V. Albu, R. R. Mititelu et al., “Oxidative stress and inflammation interdependence in multiple sclerosis,” Journal of Clinical Medicine, vol. 8, no. 11, p. 1815, 2019.

[180] D. Calina, A. M. Buga, M. Mitroiu et al., “The treatment of cognitive, behavioural and motor impairments from brain injury and neurodegenerative diseases through cannabinoid system modulation-evidence from in vivo studies,” Journal of Clinical Medicine, vol. 9, no. 8, p. 2395, 2020.

[181] B. Salehi, C. Quispe, I. Chamkhi et al., “Pharmacological properties of chalcones: a review of preclinical including molecular mechanisms and clinical evidence,” Frontiers in Pharmacology, vol. 11, pp. 592654–592654, 2021.

[182] J. Sharifi-Rad, S. Kamiloğlu, B. Yeskalıyev et al., “Pharmacological activities of psoralidin: a comprehensive review of the molecular mechanisms of action,” Frontiers in Pharmacology, vol. 11, p. 11, 2020.
B. Salehi, A. Prakash Mishra, M. Nigam et al., "Ficus plants: state of the art from a phytochemical, pharmacological, and toxicological perspective," *Phytotherapy Research*, vol. 35, no. 3, pp. 1187–1217, 2021.

S. Thabit, H. Handoussa, M. Roxo, N. S. el Sayed, B. Cestari de Azevedo, and M. Wink, "Evaluation of antioxidant and neuroprotective activities of *Cassia fistula* (L.) using theCae-norhabditis elegansmodel," *Peel*, vol. 6, article e5159, 2018.

J. F. Campos, D. T. H. de Castro, M. J. Damiao et al., "The chemical profile of *Senna velutina* leaves and their antioxidant and cytotoxic effects," *Oxidative Medicine and Cellular Longevity*, vol. 2016, 12 pages, 2016.

S. I. Ahmed, M. Q. Hayat, M. Tahir et al., "Pharmacologically active flavonoids from the anticancer, antioxidant and antimicrobial extracts of *Cassia angustifolia Vahl*," *BMCM Complementary and Alternative Medicine*, vol. 16, no. 1, pp. 1–9, 2016.

L. Guarize, J. C. da Costa, L. B. Dutra, R. F. Mendes, I. V. A. Lima, and E. Scio, "Anti-inflammatory, laxative and intestinal motility effects of *Senna macranthera* leaves," *Natural Product Research*, vol. 26, no. 4, pp. 331–343, 2012.

G. A. Silva, J. A. Monteiro, E. B. Ferreira et al., "Total phenolic content, antioxidant and antinociceptive activities of four species of *Senna* mill. from Northeast Brazil," *International Journal of Pharmacy and Pharmaceutical Sciences*, vol. 6, pp. 199–202, 2014.

B. Ita and G. Ndukwu, "Antioxidant activity of *Senna alata* root extracts," *Journal of Natural Products and Resources*, vol. 3, no. 1, pp. 94–96, 2017.

A. Phaiaphan and B. Baharin, "Ultrasound-assisted extraction produce better antibacterial and antioxidant activities of *Senna siamea* (Lam.) leaf extracts than solvent extraction," *Malaysian Journal of Microbiology*, vol. 15, pp. 34–43, 2019.

A. Q. Laghari, S. Memon, A. Nelofar, and A. H. Laghari, “Extraction, identification and Antioxidative properties of the flavonoid-rich fractions from leaves and flowers of *Cassia angustifolia*,” *American Journal of Analytical Chemistry*, vol. 2, no. 8, pp. 871–878, 2011.

B. Sagnia, D. Fedeli, R. Casetti, C. Montesano, G. Falciioni, and V. Colizzi, "Antioxidant and anti-inflammatory activities of extracts from *Cassia alata*, *Eleusine indica*, *Eremomastax speciosa*, *Carica papaya* and *Polyscias fulva* medicinal plants collected in Cameroon," *PLoS One*, vol. 9, no. 8, article e103999, 2014.

M. Navarro, I. Moreira, E. Arnaez et al., "Proanthocyanidin characterization, antioxidant and cytotoxic activities of three plants commonly used in traditional medicine in Costa Rica: *Petiveria alliacea* L., *Phyllanthus niruri* L. and *Senna reticulata* Willd.," *Plants*, vol. 6, no. 4, pp. 50, 2017.

Y. W. Mak, L. O. Chuah, R. Ahmad, and R. Bhat, "Antioxidant and antibacterial activities of hibiscus (*Hibiscus rosa-sinensis* L.) and *Cassia* (*Cassia bicapsularis* L.) flower extracts," *Journal of King Saud University-Science*, vol. 25, no. 4, pp. 275–282, 2013.

U. Channa, A. M. Shah, S. Bhatti, A. A. Memon, A. B. Ghanghro, and M. N. Memon, "Phytochemical analysis and antibacterial properties of *Cassia Sena alata*," *Rawal Medical Journal*, vol. 45, no. 1, pp. 223–226, 2020.

I. I. Madubunyi and O. J. Ode, "In vitro and in vivo antioxidant potential of the methanolic extract of *Cassia singueana* Delile (*Fabaceae*) lock leaves," *Comparative Clinical Pathology*, vol. 21, no. 6, pp. 1565–1569, 2012.

O. Ottu, S. Atawodi, and E. Onyike, "Antioxidant, hepatoprotective and hypolipidemic effects of methanolic root extract of *Cassia singueana* in rats following acute and chronic carbon tetrachloride intoxication," *Asian Pacific Journal of Tropical Medicine*, vol. 6, no. 8, pp. 609–615, 2013.

M. N. Abubacker, R. Ramanathan, and T. S. Kumar, "In vitro antifungal activity of *Cassia alata* Linn. Flower extract," *Natural Product Radiance*, vol. 7, no. 1, pp. 6–9, 2008.

S. Mohideen, E. Sasikala, and P. Aruhaj, "Pharmacognosy of *Cassia alata* Linn–leaves," *Ancient Science of Life*, vol. 24, no. 4, pp. 192–198, 2005.

R. Borges-Argáez, C. I. Canche-Chay, L. M. Peña-Rodríguez, S. Saíd-Fernández, and G. M. Molina-Salinas, “Antimicrobial activity of *Dispyros anisandra*,” *Fitoterapia*, vol. 78, no. 5, pp. 370–372, 2007.

A. T. de Castro, A. P. Castro, M. S. Silva et al., "In vitro evaluation of the schistosomicidal effect of the extracts, fractions and major 3-hydroxy-2,6-dialkyl-substituted piperidine alkanoids from the flowers of *Senna spectabilis* (*Fabaceae*)," *Bioorganic & Medicinal Chemistry Letters*, vol. 26, no. 17, pp. 4197–4204, 2016.

T. Hennebelle, B. Weniger, H. Joseph, S. Sahpaz, and F. Bailleul, "*Senna alata*," *Fitoterapia*, vol. 80, no. 7, pp. 385–393, 2009.

A. Gounjobi and M. Abiala, "Antimicrobial activity of *Senna alata* and *Phyllanthus amarus*," *Global journal of pharmacology*, vol. 7, no. 2, pp. 198–202, 2013.

A. A. Makinde, J. O. Igoli, L. Ta’Ama, S. J. Shaibu, and A. Garba, "Antimicrobial activity of *Cassia alata*," *African Journal of Biotechnology*, vol. 6, no. 13, 2007.

G. Ehiowemwengu, J. Inetianbor, and J. Yakubu, "Antimicrobial qualities of *Senna alata*," *IbOS Journal of Pharmacy and Biological Sciences*, vol. 9, no. 2, pp. 47–52, 2014.

W. F. Sule, I. O. Okonko, S. Omo-Ogun et al., "Phytochemical properties and in-vitro antifungal activity of *Senna alata* Linn. Crude stem bark extract," *Journal of Medicinal Plant Research*, vol. 5, no. 2, pp. 176–183, 2011.

S. Y. Timothy, C. H. Waizis, R. G. Adati, and I. D. Maspalma, "Antifungal activity of aqueous and ethanolic leaf extracts of *Cassia alata* Linn.," *Journal of Applied Pharmaceutical Science*, vol. 2, no. 7, p. 182, 2012.

M. Wuhi-udomiert, P. Kupitayanant, and W. Gritsanapan, "In vitro evaluation of antifungal activity of arhaquinoine derivatives of *Senna alata*," *Journal of Health Research*, vol. 24, no. 3, pp. 117–122, 2010.

S. Phongpaichit, N. Pujenjob, V. Rukachaisirikul, and M. Ongsakul, "Antimicrobial activity of *Cassia fistula* L. and *Cassia tora* L.," *Songklanakarin Journal of Science and Technology*, vol. 26, no. 5, pp. 741–748, 2004.

J. Sharifi-Rad, C. Quise, A. Rahavian et al., “Bioactive compounds as potential agents for sexually transmitted diseases management: a review to explore molecular mechanisms of action,” *Frontiers in Pharmacology*, vol. 12, no. 1886, 2021.

S. Albayrak, A. Aksoy, O. Sagdic, and S. Albayrak, "Antioxidant and antimicrobial activities of different extracts of some medicinal herbs consumed as tea and spices in Turkey," *Journal of Food Biochemistry*, vol. 36, no. 5, pp. 547–554, 2012.

S. Jain, R. A. Sharma, R. Jain, and C. Mittal, "Antimicrobial screening of *Cassia occidentalis* Lin vivo and in vitro," *Phytotherapy Research*, vol. 12, no. 3, pp. 200–204, 1998.
[213] O. O. Ogbole, J. A. Adeniji, and E. O. Ajaiyeoba, “Anthraxquionones and triterpenoids from Senna siamea (Fabaceae) Lam inhibit poliovirus activity,” *African Journal of Microbiology Research*, vol. 8, no. 31, pp. 2955–2963, 2014.

[214] O. O. Ogbole, J. A. Adeniji, E. O. Ajaiyeoba, and D. F. Adu, “Anti-polio virus activity of medicinal plants selected from the Nigerian ethno-medicine,” *Academic Journals*, vol. 12, no. 24, pp. 3878–3883, 2013.

[215] M. Shaheen, M. Borsanyiova, S. Mostafa, S. Bopeegasus, and N. El-Esnawy, “Antiviral activity of Cassia alata extracts against cardiac coxsackievirus B3 infections in vitro and in vivo,” *Tropical Journal of Pharmaceutical Research*, vol. 8, no. 2, pp. 117–125, 2009.

[216] W. Woradulayapinij, N. Soonthornchareonnont, and C. Wiwat, “In vitro HIV type 1 reverse transcriptase inhibitory activities of Thai medicinal plants and *Canna indica* L. rhizomes,” *Journal of Ethnopharmacology*, vol. 101, no. 1-3, pp. 84–89, 2005.

[217] WHO, *Schistosomiasis*, World Health Organization, 2020.

[218] G. M. de Albuquerque Melo, M. C. R. Silva, T. P. Guimarães et al., “Leishmanicidal activity of the crude extract, fractions and major piperidine alkaloids from the flowers of *Senna spectabilis*,” *Phytotherapy*, vol. 21, no. 3, pp. 277–281, 2014.

[219] E. E. Caamal-Fuentes, M. Graniel-Sabido, G. J. Mena-Rejón, and R. E. Moo-Puc, “Anti-giardia activity and acute toxicity of a methanol extract of *Senna racemosa* bark,” *Journal of Ethnopharmacology*, vol. 193, pp. 604–606, 2016.

[220] R. E. Moo-Puc, G. J. Mena-Rejón, L. Quijano, and R. Cedillo-Rivera, “Antiprotozoal activity of *Senna racemosa*,” *Journal of Ethnopharmacology*, vol. 112, no. 2, pp. 415–416, 2007.

[221] T. Equale, D. Tadesse, and M. Giday, “In Vitro anthelmintic activity of crude extracts of five medicinal plants against *egg-hatching* and larval development of *Haemonchus contortus*,” *Journal of Ethnopharmacology*, vol. 137, no. 1, pp. 108–113, 2011.

[222] I. M. Villaseñor, A. P. Canlas, M. P. Pascua, M. N. Sabando, and L. A. Soliven, “Bioactivity studies on *Cassia alata* Linn. Leaf extracts,” *Phytotherapy Research*, vol. 16, no. S1, pp. 93–96, 2002.

[223] M. T. Chomnawang, S. Surassmo, V. S. Nukoolkarn, and W. Gritsanapan, “Antimicrobial and weed inhibitory activities of *Senna spectabilis* extracts against plant pathogens,” *International Journal of Agricultural Technology*, vol. 14, no. 7 Special Issue, pp. 1445–1454, 2018.

[224] M. T. Chomnawang et al., “Antimicrobial effects of Thai medicinal plants against acne-inducing bacteria,” *Journal of Ethnopharmacology*, vol. 101, no. 1-3, pp. 330–333, 2005.

[225] G. P. Mcnicol, “The effect of a standardised *senna* preparation on the human bowel,” *Journal of Pharmacy and Pharmacology*, vol. 10, no. 1, pp. 499–506, 2011.

[226] V. I. Thamlikitkul, N. Bunyapraphatsara, T. Dechatwongse et al., “Randomized controlled trial of *Cassia alata* Linn. For constipation,” *Journal of the Medical Association of Thailand*, vol. 73, no. 4, pp. 217–222, 1990.

[227] O. Kinnunen, W. Winblad, P. Koistinen, and I. Salokannel, “Safety and efficacy of a bulk laxative containing *Senna versus* lactulose in the treatment of chronic constipation in geriatric patients,” *Pharmacology*, vol. 47, no. 1, pp. 253–255, 1993.

[228] S. Damodaran and S. Venkataraman, “A study on the therapeutic efficacy of *Cassia alata*, Linn. Leaf extract against *Ptyiasis versicolor*,” *Journal of Ethnopharmacology*, vol. 42, no. 1, pp. 19–23, 1994.

[229] P. Ramesh, K. S. Kumar, M. R. Rajagopal, P. Balachandran, and P. K. Warrier, “Managing morphine-induced constipation: a controlled comparison of an Ayurvedic formulation and *Senna*,” *Journal of Pain and Symptom Management*, vol. 16, no. 4, pp. 240–244, 1998.

[230] B. A. van Gorkom, A. Karrenbeld, A. J. Limburg, and J. H. Kleibeuker, “The effect of sennosides on colonic mucosal histology and bowel preparation,” *Zeitschrift für Gastroenterologie*, vol. 36, no. 1, pp. 13–18, 1998.

[231] J. Phuttsiset, C. Kietpeerakool, N. Jampathong et al., “Effects of *Cassia alata* Linn on bowel function recovery following surgery for gynecological cancer: a randomized controlled trial,” *Complementary Therapies in Medicine*, vol. 47, article 102222, 2019.

[232] K. A. Santos-Jasso, J. L. Arredondo-García, J. Maza-Vallejos, and P. Lezama-del Valle, “Effectiveness of *senna* vs. polyethylene glycol as laxative therapy in children with constipation related to anorectal malformation,” *Journal of Pediatric Surgery*, vol. 52, no. 1, pp. 84–88, 2017.

[233] C. Feudtner, J. Freedman, T. Kang, J. W. Womer, D. Dai, and J. Faerber, “Comparative effectiveness of *Senna* to prevent problematic constipation in pediatric oncology patients receiving opioids: a multicenter study of clinically detailed administrative data,” *Journal of Pain and Symptom Management*, vol. 48, no. 2, pp. 272–280, 2014.

[234] B. Ergül, L. Filik, E. Koçak, Z. Doğan, and M. Sarıkaya, “Efficacy and safety of gum chewing in adjunct to high-dose *Senna* for bowel cleansing before colonoscopy: a single-blind randomized controlled trial,” *Saudi Journal of Gastroenterology*, vol. 20, no. 6, pp. 356–359, 2014.

[235] M. Patel, M. O. Schimpf, D. M. O’Sullivan, and C. A. LaSala, “The use of *Senna* with docusate for postoperative constipation after pelvic reconstructive surgery: a randomized, double-blind, placebo-controlled trial,” *American Journal of Obstetrics and Gynecology*, vol. 202, no. 5, pp. 479.e1–479.e5, 2010.

[236] J. Raposo and P. Velho, “Prolonged ingestion of *senna*: weight loss, cyclic edema, dyspepsia and heptatoneuromyopathy,” *Medicina Interná*, vol. 17, no. 2, pp. 81–84, 2010.

[237] S. Kositchaiwat, W. Suwanthanman, R. Suvikapornkulk, V. Tiewthanom, P. Rerkpanatkul, and C. Tinkornrusmee, “Comparative study of two bowel preparation regimens for colonoscopy: Senna tablets vs sodium phosphate solution,” *World Journal of Gastroenterology*, vol. 12, no. 34, pp. 5536–5539, 2006.

[238] S.-H. Cho, T. H. Kim, N. H. Lee, H. S. Son, I. J. Cho, and T. Y. Ha, “Effects of *Cassia tora* fiber supplement on serum lipids in Korean diabetic patients,” *Journal of Medicinal Food*, vol. 8, no. 3, pp. 311–318, 2005.

[239] F. Radaelli, G. Meucci, V. Terruzzi et al., “Efficacy and acceptability of high dose *Senna* compared with standard polyethylene glycol solution for colon cleansing prior to colonoscopy: preliminary results of a randomized, investigator-blind trial,” *Gastrointestinal Endoscopy*, vol. 61, no. 5, p. AB119, 2005.

[240] B. A. van Gorkom, A. Karrenbeld, T. van der Sluis, J. Koudstaal, E. G. E. de Vries, and J. H. Kleibeuker, “Influence of a highly purified *senna* extract on colonic epithelium,” *Digestion*, vol. 61, no. 2, pp. 113–120, 2000.
C. Cirillo and R. Capasso, “Chinese herbal medicine (Ma Zi Ren wan) for functional constipation: study protocol for a prospective, double-blinded, double-dummy, randomized controlled trial,” Trials, vol. 14, no. 1, p. 366, 2013.

L. L. Zhong, C. W. Cheng, W. Kun et al., “Efficacy of MaZiRenWan, a Chinese herbal medicine, in patients with functional constipation in a randomized controlled trial,” Clinical Gastroenterology and Hepatology, vol. 17, no. 7, pp. 1303–1310.e18, 2019.

U. Beuers, U. Spengler, and G. R. Pape, “Hepatitis after chronic abuse of senna,” Lancet, vol. 337, no. 8737, pp. 372-373, 1991.

B. Vanderperren, M. Rizzo, L. Angenot, V. Haufroid, M. Jadoul, and P. Hantson, “Acute liver failure with renal impairment related to the abuse of Senna anthraquinone glycosides,” Annals of Pharmacotherapy, vol. 39, no. 7-8, pp. 1353–1357, 2005.

S. Soyuncu, Y. Cete, and A. E. Nokay, “Portal vein thrombosis related to Cassia angustifolia,” Clinical Toxicology, vol. 46, no. 8, pp. 774–777, 2008.

J. Sharifi-Rad, C. F. Rodrigues, Z. Stojanović-Radić et al., “Probiotics: versatile bioactive components in promoting human health,” Medicina, vol. 56, no. 9, p. 433, 2020.

M. T. Islam, C. Quispe, M. Martorell et al., “Dietary supplements, vitamins and minerals as potential interventions against viruses: perspectives for COVID-19,” International Journal for Vitamin and Nutrition Research, pp. 1–18, 2021.

P. Mitrut, A. O. Docea, A. M. Kamal et al., “Colon cancer and inflammatory bowel disease,” Colorectal Cancer - from Pathogenesis to Treatment, L. Rodrigo, Ed., pp. 185–199, 2016.

O. M. Zlatian, M. V. Comănescu, A. F. Rosu et al., “Histochcmical and immunohistochemical evidence of tumor heterogeneity in colorectal cancer,” Romanian Journal of Morphology and Embryology, vol. 56, no. 1, pp. 175–181, 2015.

N. Mascolo, R. Capasso, and F. Capasso, “Senna. A safe and effective drug,” Phytotherapy Research, vol. 12, no. S1, pp. S143–S145, 1998.

C. Cirillo and R. Capasso, “Constipation and botanical medicines: an overview,” Phytotherapy Research, vol. 29, no. 10, pp. 1488–1493, 2015.

X. Wang and J. Yin, “Complementary and alternative therapies for chronic constipation,” Evidence-based Complementary and Alternative Medicine, vol. 2015, Article ID 396396, 2015.

F. Capasso and T. S. Gaginella, Laxative. A Practical Guide, Springer-Verlag Italia, Milan, 1997.

J. Labenz, G. Hopmann, F. Leverkus, and G. Börsch, “Bowel cleansing prior to colonoscopy: A prospective, randomized, blind comparative study,” Medizinische Klinik, vol. 85, no. 10, pp. 581–585, 1990.

S. B. Park and Y. S. Kim, “Simultaneous separation of three isomeric sennosides from senna leaf (Cassia acutifolia) using counter-current chromatography,” Journal of Separation Science, vol. 38, no. 20, pp. 3502–3507, 2015.

https://www.cbsnews.com/news/norway-covid-19-vaccine-elderly-deaths-no-link/.

A. Vilanova-Sanchez, A. C. Gasior, N. Toocheck et al., “Are Senna based laxatives safe when used as long term treatment for constipation in children?,” Journal of Pediatric Surgery, vol. 53, no. 4, pp. 722–727, 2018.

J. O. Greenhalf and H. S. Leonard, “Laxatives in the treatment of constipation in pregnant and breast-feeding mothers,” Practitioner, vol. 210, no. 256, pp. 259–263, 1973.

C. M. Prather, “Pregnancy-related constipation,” Current Gastroenterology Reports, vol. 6, no. 5, pp. 402–404, 2004.

J. M. Gattuso and M. A. Kamm, “Adverse effects of drugs used in the management of constipation and diarrhoea,” Drug Safety, vol. 10, no. 1, pp. 47–65, 1994.

N. Ács, F. Bánhidy, E. H. Puhó, and A. E. Czeiez, “No association between severe constipation with related drug treatment in pregnant women and congenital abnormalities in their offspring: a population-based case-control study,” Congenital Anomalies, vol. 50, no. 1, pp. 15–20, 2010.

S. O. Müller, I. Eckert, W. K. Lutz, and H. Stopper, “Genotoxicity of the laxative drug components emodin, aloe-emodin and danthron in mammalian cells: topoisomerase II mediated?,” Mutation Research, vol. 371, no. 3-4, pp. 165–173, 1996.

W. F. Baldwin, “Clinical study of Senna administration to nursing mothers: assessment of effects on infant bowel habits,” Canadian Medical Association Journal, vol. 89, no. 11, pp. 566–568, 1963.

P. Faber and A. Sтренге-Несе, “Relevance of rhein excretion into breast milk,” Pharmacology, vol. 36, no. 1, pp. 212–220, 1988.

F. Capasso, T. S. Gaginella, G. Grandolini, and A. A. Izzo, Phytotherapy: A Quick Reference to Herbal Medicine, Springer-Verlag, Heidelberg, Germany, 2003.

G. H. Ritsema and G. Eilers, “Potassium supplements prevent serious hypokalaemia in colon cleansing,” Clinical Radiology, vol. 49, no. 12, pp. 874–876, 1994.

V. H. Waldhäusl, “Laxative-induced hypokalemie myopathy. A case history,” Wiener Klinische Wochenschrift, vol. 92, no. 3, pp. 101–103, 1980.

M. T. Wang, I. H. Li, W. J. Lee, T. Y. Huang, H. B. Leu, and A. L. F. Chan, “Exportation to sennoside-digoxin interaction and risk of digoxin toxicity: a population-based nested case-control study,” European Journal of Heart Failure, vol. 13, no. 11, pp. 1238–1243, 2011.

Y. Cao, Y. He, C. Wei et al., “Aquaporin alterations profile revealed different actions of Senna, Sennosides, and Sennoside a in diarrhea-rats,” International Journal of Molecular Sciences, vol. 19, no. 10, p. 3210, 2018.

N. Mascolo, E. Mereto, F. Borrelli et al., “Does senna extract promote growth of aberrant crypt foci and malignant tumors in rat colon?,” Digestive Diseases and Sciences, vol. 44, no. 11, pp. 2226–2230, 1999.

A. Lyden-Sokolowski, A. Nilsson, and P. Sjöberg, “Two-year carcinogenicity study with sennosides in the rat: emphasis on gastro-intestinal alterations,” Pharmacology, vol. 47, no. 1, pp. 209–215, 1993.

E. Mereto, M. Ghia, and G. Brambilla, “Evaluation of the potential carcinogenic activity of Senna and cascara glycosides for the rat colon,” Cancer Letters, vol. 101, no. 1, pp. 79–83, 1996.