Innovations

Senna Occidental is: A Comprehensive Exploration of its Conventional Medicinal Uses, Toxicological Risks and Allelopathic Interactions

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Abstract: *Senna occidentalis, commonly called "coffee weed" or "coffee Senna," is a perennial shrub belonging to the Fabaceae family. Native to tropical and subtropical regions, it thrives in a variety of ecological conditions. This plant has been extensively utilized in conventional medicine across various cultures due to its wide range of pharmacological properties. Recent scientific investigations have corroborated many of these conventional uses, offering a more profound understanding of its medicinal potential. Phytochemical analyses of S. occidentalis have identified a diverse array of bioactive compounds contributing to its therapeutic effects. These compounds include phenolics, alkaloids, flavonoids, and terpenoids, each of which plays a critical role in the plant's pharmacological profile. Notably, S. occidentalis contains several flavonoids, such as quercetin and apigenin, which are well-documented for their antioxidant, anti-inflammatory, and antimicrobial activities. The presence of anthraquinones, including emodin and chrysophanol, and xanthones, such as pinselin and cassiollin, further augments the plant's therapeutic potential. However, S. occidentalis poses significant risks due to the presence of toxic components, particularly in its raw seeds. These toxins can be mitigated through appropriate processing techniques, which are essential to ensure the plant's safety and efficacy. When processed correctly, the seeds of S. occidentalis can be utilized in the preparation of Ayurvedic coffee, providing a nutritious and beneficial alternative to conventional coffee. The plant exhibits a complex profile of both cytotoxicity and phytotoxicity. While S. occidentalis shows promise for potential therapeutic applications, especially in cancer treatment, its toxicity to livestock and its considerable allelopathic effects on other plants necessitates careful consideration. The diversity of* *bioactive compounds present in S. occidentalis underscores the need for further research to isolate and identify the specific substances responsible for these effects. A comprehensive understanding of the dual nature of S. occidentalis will be crucial for developing safe and effective applications in both the pharmaceutical and agricultural sectors, thereby ensuring that its benefits are harnessed while minimizing risks to human health and the environment. The plant's diverse phytochemical profile indicates substantial potential for future research and applications in the agriculture, pharmaceutical, and food industries. Continued studies are essential for optimizing processing methods, fully elucidating the plant's bioactive components, and ensuring safe utilization.*

Keywords: *Allelopathy, Pharmaceutical, Therapeutic, Phytotoxicity & Cytotoxicity*.

Introduction

The Fabaceae family is the third largest plant family in the plant kingdom, comprising over 20,000 species and 800 genera, characterized by distinctive floral structures and podded fruits [1]. It ranks second in importance to humans, following the Poaceae family. Plants within this family have evolved sophisticated defence mechanisms, which rely on various processes, including the synthesis of bioactive compounds known as phytochemicals [2]. Plants naturally produce these phytochemicals and play a crucial role in defense against biotic and abiotic stresses. Phytochemicals are found in diverse sources, such as whole grains, fruits, vegetables, nuts, and herbs, with over a thousand identified to date [3]. Key phytochemicals include polyphenols, phytosterols, isoprenoids, saponins, carotenoids, dietary fibers, and polysaccharides, which exhibit a range of biological activities, including strong antioxidant, anthelmintic, antidiarrheal, antibacterial, antiallergic, and antiviral properties [4,29].

In various African, Asian, and American regions, Senna occidentalis (L.) Link has been traditionally utilized for its medicinal properties, particularly within Ayurvedic medicine in India [5]. Senna species, recognized for their antibacterial and anti-inflammatory properties, have long been employed in traditional medicine to treat various ailments, including malaria, diabetes, and microbial infections. These plants are rich in bioactive metabolites, such as tannins, glycosides, alkaloids, anthraquinones, flavonoids, terpenoids, saponins, and volatile oils, all of which contribute to their broad spectrum of pharmacological activities, including anti-inflammatory, antibacterial, antioxidant, and antidepressant effects.

Senna occidentalis, commonly referred to as Coffee Senna, is a versatile annual and perennial flowering plant from the Fabaceae family. Native to Mexico and South America, it has become widespread in India and other regions, thriving at altitudes up to 1,500 meters [6]. The plant is characterized by reddish-purple stems,

alternately arranged pinnately compound leaves, and complex inflorescences with yellow flowers. The fruit is a dry, sickle-shaped legume containing numerous seeds.
Senna species have been traditionally employed in Chinese, African, Tibetan, Unani, and Ayurvedic medicine to prepare herbal remedies for various illnesses and infections [7]. For example, Senna occidentalis and Senna alata are commonly used in African, Ayurvedic, and Siddha medicine to treat diseases such as cholera, yellow fever, typhoid, and malaria [8][9][10]. These remedies are typically prepared through processes such as maceration, decoction, infusion, or extraction of plant exudates. Beyond its role in research, Senna occidentalis has been utilized by local populations for various purposes. Roasted S. occidentalis seeds serve as a coffee substitute in several underdeveloped nations, earning the plant the moniker "Coffee Senna." Additionally, various parts of the plant have been employed medicinally, reflecting a wide range of traditional applications. In certain regions, the plant has also been used as a food source during periods of famine.
Despite its traditional uses, S. occidentalis has been recognized as toxic to livestock since 1911 and is considered a contaminant weed in agricultural fields, often growing alongside crops such as wheat, sorghum, soybeans, and corn. The clinical manifestation of poisoning caused by S. occidentalis differs from that observed in naturally occurring cases of livestock poisoning. The toxic effects of S. occidentalis seeds are believed to involve mitochondrial damage, although the precise toxic compound and the mechanisms through which it affects mitochondria remain unclear [11]. A two-year educational campaign in the most affected districts has led to a significant reduction in the number of poisoning cases.
Despite concerns about its potential toxicity, some researchers have explored the potential health benefits of Senna occidentalis. For instance, S. occidentalis seeds have been proposed as a cost-effective source of protein, energy, and antioxidant micronutrient supplements for both humans and animals. This duality underscores the complexity of Senna occidentalis, illustrating that while the plant offers significant therapeutic benefits and valuable applications in traditional medicine, it also carries inherent risks of toxicity [12]. The potent compounds that contribute to its medicinal properties can, if misused or consumed in excessive amounts, lead to adverse effects such as gastrointestinal distress, liver damage, and potential kidney issues.

Material and Methods: An extensive review of the literature was done to learn more about Senna occidentalis. This review covered research from several nations and made use of several reliable search engines and databases, such as PubMed, Google, Research Gate, Wikipedia, Google Scholar, Science Direct, Shodhganga, online libraries, and books.

Phytochemical analysis

The phytochemical analysis of Senna occidentalis has elucidated a broad spectrum of bioactive compounds with considerable pharmacological potential. This species, belonging to the Fabaceae family, is recognized for its medicinal attributes, which are primarily ascribed to its intricate phytochemical composition. Comprehensive research has identified a diverse array of secondary metabolites that contribute to the plant's therapeutic efficacy, including alkaloids, flavonoids, anthraquinones, and saponins [2][13].

Recent investigations have particularly focused on the phytochemical constituents of the ethanolic extract of S. occidentalis, with significant emphasis on its flavonoid content. Other notable flavonoids include cassiaoccidentalins A, B, and C. The complex molecular structures and chemical identities of these flavonoids have been confirmed through advanced spectroscopic methodologies, including ultraviolet-visible (UV-Vis) and nuclear magnetic resonance (NMR) spectroscopy.

Senna occidentalis is further distinguished by its high anthraquinone content. Analytical studies have identified several anthraquinones, such as emodin, 1,8-dihydroxyanthraquinone, and chrysophanol, present in various forms within the plant, including free, bound, reduced, and oxidized states [7]. These anthraquinones are largely responsible for the plant's antibacterial and antioxidant activities. Furthermore, the root samples have yielded various trihydroxyanthraquinones, such as helminthosporine and islandicine, along with xanthone derivatives like pinselin and pigment E. The seeds of S. occidentalis exhibit a distinctive phytochemical profile, containing toxic albumins, various anthraquinones, and polysaccharides, such as galactomannan [14]. The diversity of phytochemicals in the seeds is further evidenced by their fatty acid, tocopherol, and carbohydrate compositions. In conclusion, the phytochemical characterization of Senna occidentalis not only deepens our understanding of its therapeutic properties but also provides a foundation for the development of novel pharmacological agents derived from this valuable plant species.

Table 1: List of Phytochemicals reported in Senna occidentalis:

Compound Name	Source (Plant Part)	Structure Details	Methods Used for Structure Elucidation	References
Cassiaoccidentalins A, Cassiaoccidentalins B,	Aerial parts	New C-glycosidic flavonoid with a 3-keto	Spectroscopic and chemical evidence	[49]

Cassiaoccidentalins C		sugar		
Total anthraquinones	Roots	4.5% total anthraquinones, total content of anthraquinones (free + glycosidic forms)	UV-Vis, NMR, MS, HPLC	[24]
Emodin	Roots, Callus, Flower, leaves	6-methyl-1,3,8-trihydroxyanthraquinone	UV-Vis, NMR, MS	[6]
1,8-dihydroxyanthraquinone, Quercetin	Roots, Callus	1,8-dihydroxy-Anthracene-9,10-dione, 3,3′,4′,5,7-Pentahydroxyflavone	UV-Vis, NMR, MS	[56]
Chrysophanol	Young roots, Seeds, Callus, Fruit, leaves	1,8-Dihydroxy-3-methyl anthraquinone	UV-Vis, NMR, MS	[47]
Physcion (free, bonded, reduced, oxidized)	Young roots, Seeds, Callus, Flower, Fruit, leaves	1,8-Dihydroxy-3-methyl-6-methoxy anthraquinone	UV-Vis, NMR, MS, Redox assays	[47]
Pinselin	Roots, Callus	Two xanthone derivatives	UV-Vis, NMR, MS	[10]
Pigment E, Cassiollin, 1,7-dihydroxy-3-methyl xanthone	Roots	Two xanthone derivatives, Shown to be pinselin,Yielded in rhein investigation	UV-Vis, NMR, MS	[10]
Islandicine, Helminthosporine, Xanthorine	Roots	1,4,5-trihydroxyanthraquinones	UV-Vis, NMR, MS	[54]
Rhein, Aloe-emodin	Roots, Fruit	1,8-Dihydroxy-3-carboxy anthraquinone, 1,8-Dihydroxy-3-	UV-Vis, NMR, MS	[6]

		hydroxyanthraquinone		
Occidentalol-I (IV, R1=Me, R2=H), Occidentalol-II (III, R1=R2=H)	Roots	New bis(tetrahydro) anthracene derivative	Spectral evidence (UV-Vis, NMR, MS)	[56]
Questin	Roots, callus	1,8-Dihydroxy-3-methyl-6-methoxy-9,10-anthraquinone	Spectral evidence (UV-Vis, NMR, MS)	[50]
Germichrysone	Roots, Callus, leaves	3-Hydroxy-1,8-dimethoxy-9,10-anthraquinone	Spectral evidence (UV-Vis, NMR, MS)	[50]
Methylgermitorosone	Roots	3-Hydroxy-1,8-dimethoxy-6-methyl-9,10-anthraquinone	Spectral evidence (UV-Vis, NMR, MS)	[10]
Singueanol-I (I, R1=R2=Me)	Roots	1,8-Dihydroxy-3,4-dimethoxy-9,10-anthraquinone	Spectral evidence (UV-Vis, NMR, MS)	[56]
β-sitosterol, Campesterol	Roots, Flower	24-Ethylcholest-5-en-3β-ol	NMR, MS, IR	[46]
Islandicine	Callus	Six anthraquinones isolated	Spectral evidence (UV-Vis, NMR, MS)	[51]
Chrysophanol, 10,10-bianthrone	Callus	Bianthrone structure with hydroxyl groups at positions 10,10 on two anthraquinone rings	Spectroscopy (UV-Vis, NMR, MS), Chemical tests	[10]
Toxic albumin	Seed	Structure not yet identified; concentrated toxin from seeds	Toxicity assays, Protein analysis (SDS-PAGE, Western blot)	[52]
1,4-oxazine derivative n-methyl morpholine	Seed	Six-membered ring containing nitrogen and oxygen atoms	Spectroscopy (UV-Vis, NMR, MS), Chemical tests	[10]
Physcion 1-glucoside	Seed, Flower	Glycoside form of Physcion	Spectroscopy (UV-Vis, NMR, MS), Chemical tests	[47]
1,4,5-trihydroxy-3-methyl-7-methoxy anthraquinone	Seed, Fruit	Anthraquinone with hydroxyl groups at positions 1, 4, and 5, and methoxy group at	Spectroscopy (UV-Vis, NMR, MS), Chemical tests	[55]

		position 7		
Galactomannan	Seed	Polysaccharide with D-galactose and D-mannose in 1:3.1 ratio, and trace D-xylose	Spectroscopy (UV-Vis, NMR, MS), Chemical tests	[45]
Maltose, lactose, sucrose, raffinose	Seed	Carbohydrates	Chromatography (HPLC), Specific assays	[43]
Cardenolides	Seed	Steroid-like compounds found in seeds	Chemical assay	[43]
1,8-dihydroxy-2-methyl anthraquinone	Seed, Fruit	Anthraquinone with hydroxyl groups at positions 1 and 8, methyl group at position 2	Spectroscopy (UV-Vis, NMR, MS), Chemical tests	[43]

Traditional use of Senna occidentalis

Senna occidentalis, commonly referenced in Ayurvedic formulations, is also consumed as a leafy vegetable by various tribal communities in India. Senna species have been employed in traditional Chinese medicine, African traditional medicine, Tibetan traditional medicine, Unani, and Ayurvedic medicine (ancient Indian medicine). Senna occidentalis and Senna alata are two of the Senna species that are typically employed by African doctors, the Siddha, and Ayurveda to cure cholera, yellow fever, malaria, and typhoid [15]. The plant is renowned for its hepatoprotective, antifungal, antibacterial, antidiabetic, anticancer, and anti-inflammatory properties [16]. Its seeds, leaves, and roots have been traditionally utilized for treating a wide range of ailments, including fever, menstrual disorders, tuberculosis, anaemia, and hepatic conditions. Additionally, these plant parts serve as a tonic for general debility, rheumatism, ocular afflictions, typhoid fever, allergies, asthma, hemoglobinopathies, and leprosy [17]. The seeds, when roasted, are consumed as a coffee substitute and are employed therapeutically for fever, gastrointestinal disturbances, asthma, and malaria. They have also been used to manage haemoglobin disorders, rheumatism, respiratory conditions, and haematuria [16][18].

Extensive research on S. occidentalis has substantiated its potential as a medicinal agent. However, it is important to note that the raw seeds of this plant may exhibit toxic effects. With appropriate processing techniques to identify and mitigate toxic constituents, these seeds could be developed into a high-quality and nutritious Ayurvedic coffee alternative. It was utilized in Unani medicine as an antidote to poisons, a blood purifier, an expectorant, an anti-inflammatory, and a cure for liver ailments [19]. The identification of phytochemicals and other bioactive compounds in S. occidentalis suggests its potential utility in the pharmaceutical and food industries. Nevertheless, it is imperative to exercise caution in the processing and utilization of S. occidentalis due to its known toxicity. Any application within the food or pharmaceutical sectors should be approached with rigorous testing, strict quality control measures, and adherence to safety regulations to eliminate toxic components and produce safe products. Collaboration with experts in botany, pharmacology, and food science is essential to ensure the safety and efficacy of any derived products [20].

Table 2: Traditional Uses of Senna occidentalis:

Country	Part Used	Traditional and therapeutic Properties	References
India (Asia)	Roots	Treats menstrual issues, liver complaints, anemia, tuberculosis (TB), and general weakness. Used for diuretic, febrifuge (fever-reducing), and tonic properties.	[6]
	Leaves	Used for gonorrhea, fevers, urinary tract infections (UTIs), and edema. Aids in wound healing, treating sores, itches, fever, ringworm, skin conditions, throat infections, and bone fractures.	
	Seeds	Utilized for treating ringworm and as a febrifuge and cough remedy.	
	Whole Plant	Employed in the treatment of eye inflammations.	
Jamaica (North America)	Seeds	Used in herbal teas and poultices.	[53]
	Leaves	Applied for treating skin conditions, and also used in herbal teas and poultices.	
	Whole Plant	Utilized for cancer, eczema, constipation, diarrhea, dysentery, and venereal diseases.	
Brazil (South America)	Leaves	Used for constipation, digestive issues, skin problems, and inflammatory conditions.	[53]

	Seeds	Employed for constipation and digestive issues.	
	Whole Plant	Hydroalcoholic extracts are used to treat erysipelas, fever, flu, and serve as a hepatoprotective, analgesic, and diuretic agent.	
Peru (South America)	Roots	Employed for potential diuretic effects.	[11]
	Seeds	Used for treating fevers and digestive problems.	
Nigeria (West Africa)	Roots	Address women's white discharge and constipation; also used to manage diabetes.	[7]
	Leaves	Treats various skin conditions and infections, aids in wound healing, and alleviates rheumatism.	
	Whole Plant	Treatment of Malaria	
Kenya and Tanzania (East Africa)	Roots	Used to manage diabetes.	[7]
	Leaves	Treats typhoid fever, and liver issues, and serves as a remedy for snake bites and gastrointestinal issues such as constipation and dysentery.	
	Whole Plant	Employed for treating skin conditions and promoting general health.	
China (Asia)	Seeds	Used for managing high blood pressure and treating ringworm, a common fungal infection of the skin.	[57]

Therapeutic effect of Senna occidentalis

In Hausa traditional medicine in Northern Nigeria, Senna occidentalis is employed to treat various ailments, including typhoid fever, malaria, and hepatitis [21]. In particular, fever is managed through steam baths or oral infusions made from fresh S. occidentalis leaves [22]. The plant is also reputed for its larvicidal and mosquito-repellent effects [23], alongside a range of pharmacological activities such as antimicrobial [24], antioxidant, anti-inflammatory, immunosuppressive, analgesic, antidiabetic [25], and antipyretic properties [26]

Recent research has corroborated the therapeutic potential of S. occidentalis through its ethanolic extracts, which exhibit notable antifungal and antibacterial activities [27]. Because herbal medicines are less expensive and have fewer adverse effects than conventional treatments, using them to treat type 1 or type 2 diabetes is becoming more popular. The usage of medicinal plants turns out to be the most reliable, cost-effective, and health-conscious option for treating certain illnesses [28]. Moreover, studies have demonstrated that specific extracts of S. occidentalis L. effectively reduce lipid peroxide levels, phospholipase A2 activity, and gamma-glutamyl transpeptidase activity [29] This reduction may lead to a decreased availability of arachidonic acid, which is a precursor for prostaglandin synthesis. Consequently, the lowered prostaglandin levels are hypothesized to offer therapeutic benefits for dysmenorrhea, a condition characterized by painful menstruation [30].

Antimalarial Properties: Senna occidentalis, a native medicinal plant utilized in Hausa traditional medicine in Northern Nigeria for treating malaria, was tested in vitro for its heme polymerization inhibitory and antimalarial properties. The observed results demonstrated a good suppression of the generation of δ-hematin (83.08 % and 83.97%) by the S. occidentalis leaf extracts in methanol and aqueous form at 500µg/mL, in contrast to the 54.92% inhibition shown by the hexane extract at the similar dose. The in vitro antimalarial tests' results showed that Plasmodium growth was suppressed in a dose-dependent manner. The hexane extract was found to decrease parasite growth by 73% at a dosage of 6.25 µg/ml With an IC_{50} of 3.47 µg/ml, this plasmodial growth suppression reaches 84.43% at 50 µg/ml [31]. Some researchers have revealed that Senna plants have anti-diabetic properties due to their high phenol and flavonoid content. Reduced glucose absorption and adipokine expression levels are the mechanisms underlying the anti-diabetic effects [32].

Antidiabetic Properties: A study evaluating the hypoglycaemic effects of various extracts, including petroleum ether, chloroform, and aqueous extracts of Senna occidentalis, was conducted using both normal and alloxan-induced diabetic rats. The results indicated that the aqueous extract of S. occidentalis significantly reduced fasting blood glucose levels in both normal and alloxan-induced diabetic rats. In addition, the aqueous extract-treated diabetic rats exhibited significant changes in body weight, serum protein levels, and lipid profiles (triglycerides and cholesterol) compared to the normal and diabetic control groups. Histological examinations of the pancreatic tissues from these animals demonstrated regeneration of pancreatic β-cells following necrosis induced by alloxan, suggesting that the aqueous extract of

S. occidentalis has substantial antihyperglycemic effects and potential therapeutic benefits for diabetes treatment [33].

Anti-Inflammatory Properties: The anti-inflammatory effects of an ethanolic extract of Senna occidentalis seeds were assessed in animal models using both sub-acute and acute inflammation models. The sub-acute inflammation model utilized a cotton pellet granuloma assay, while the acute inflammation model involved carrageenan-induced paw edema. Administration of the ethanolic extract at doses of 500 and 1000 mg/kg led to significant reductions in paw edema, indicating its efficacy in managing acute inflammation [34]. Additionally, the extract significantly decreased granuloma formation in the sub-acute inflammation model, with a statistically significant reduction ($P < 0.05$). These findings demonstrate that the ethanolic extract of S. occidentalis seeds possesses considerable anti-inflammatory properties, suggesting its potential utility in treating both acute and sub-acute inflammatory conditions [34].

Despite these promising benefits, caution is warranted due to the known toxicity of S. occidentalis. Any application for human or animal use should be approached with careful consideration and under proper supervision to mitigate potential health risks. Accurate identification and proper use of herbal drugs are essential to ensure the availability of authentic botanicals and to prevent drug piracy. The effectiveness of these botanicals as medicinal agents depends on precise dosage and appropriate application to achieve optimal therapeutic outcomes [35].

Toxicity of Senna occidentalis

Senna occidentalis is widely distributed across various environments, including agricultural fields, pastures, roadsides, waste areas, and along lakes, streams, and woodland grasslands. The roasted seeds of S. occidentalis are occasionally used as a coffee substitute in economically disadvantaged regions, earning it the moniker "coffee senna’’ [36]. In addition to its role as a coffee alternative, other parts of S. occidentalis possess medicinal properties and are used as emergency food during famines. However, the plant was first recognized as a cattle toxin in 1911, and subsequent investigations have confirmed its toxicity to a range of animal species, including cattle, pigs, horses, rabbits, goats, lambs, and poultry. Its prevalence in fields with crops such as soybeans, corn, sorghum, and wheat often lead to contamination of agricultural products, posing a significant food safety risk [37].

Recent research has further elucidated the toxic nature of S. occidentalis seeds. Epidemiological and clinical investigations into natural or experimental poisonings have revealed a varied and non-specific toxic profile. Experimental studies have demonstrated that poisoning with S. occidentalis induces disease in cattle, showing differences from naturally occurring diseases. The seeds are believed to exert toxicity primarily through mitochondrial damage; however, the specific hazardous chemicals and mechanisms underlying this damage remain unidentified. Recent phytochemical analyses have identified several novel toxic compounds, including quinones and glycosides, which contribute to oxidative stress and mitochondrial dysfunction in cellular models. Additionally, S. obtusifolia, a related species, has caused natural poisoning outbreaks in Brazil, exhibiting myotoxic properties and resulting in hepatotoxic symptoms that are often fatal [38]

Human exposure to S. occidentalis has been less extensively documented but remains a serious concern. In the western part of Uttar Pradesh, India, a condition known as acute hepatic myoencephalopathy (HME) syndrome has been identified. This syndrome, affecting the brain, muscles, and liver, is associated with a high mortality rate (70–80%) and recurs annually among children. Initially misdiagnosed as severe viral encephalitis, subsequent research revealed that the ingestion of S. occidentalis seeds by small children from low-income households was the source of the poisoning [39]. Recent epidemiological studies have expanded recognition of this syndrome to other regions and identified additional cases, highlighting the need for enhanced surveillance and preventive measures. Despite supportive therapy and intensive care, the mortality rate among affected children remains high. Advances in diagnostic methodologies, including high-throughput sequencing and metabolomics, are facilitating earlier detection and improved management of this condition [40].

Cytotoxicity and Senna occidentalis

A comprehensive investigation evaluated the cytotoxic effects of n-hexane, ethyl acetate, and methanol extracts obtained from the roots of Senna occidentalis. The study demonstrated that higher doses of these extracts corresponded to increased mortality rates, with substantial larvicidal activity observed against Culex quinquefasciatus mosquito larvae. Notably, the methanol extract exhibited moderate cytotoxicity, whereas the n-hexane and ethyl acetate extracts were deemed relatively safer at lower doses [16].

In a separate study, the in vitro cytotoxicity of S. occidentalis was assessed against various human cancer cell lines. The aqueous extract displayed the most significant cytotoxic activity, inhibiting cell proliferation in a dose-dependent manner across different cancer types, including cervical, breast, and colon cancers. This pronounced cytotoxic effect suggests that S. occidentalis warrants further investigation for potential development into novel anticancer agents [41].

The cytotoxicity of S. occidentalis presents a dual narrative: while the plant shows promising potential for therapeutic applications, particularly in cancer treatment, it also poses risks due to its ability to induce oxidative stress and toxicity in non-target organisms. The presence of bioactive components in its extracts underscores the necessity for additional research to ascertain its therapeutic efficacy while closely monitoring its safety profile [41]. Consequently, while S. occidentalis holds potential for the development of innovative medicinal compounds, its application must be approached with caution, ensuring rigorous testing and compliance with safety regulations to mitigate adverse effects on human health and the environment.

Phytotoxicity and Allelopathic Potential

Numerous species within the Fabaceae family are known to produce allelochemicals, which can have both beneficial and detrimental effects on the growth of subsequent leguminous plants or crops. The widespread practice of legume monoculture in various regions globally leads to several ecological and economic issues, including reduced crop yields due to soil degradation, difficulties in site recovery, and challenges in seed germination. These adverse effects of allelochemicals underscore critical concerns in allelopathy research [42].

Senna occidentalis has attracted significant interest due to its allelopathic properties, specifically its ability to chemically inhibit other plant species through the release of allelochemicals. Research consistently demonstrates the phytotoxic effects of various extracts from S. occidentalis. Cândido et al. (2010) reported that both crude ethanol extracts (CEE) and semi-purified fractions (SFs) inhibited germination and growth of dicotyledonous plants, such as lettuce (Lactuca sativa) and tomato (Lycopersicon esculentum), by approximately 50%. The ethyl acetate fraction (EAF) was notably effective in suppressing root growth in monocots like wheat (Triticum aestivum), while also adversely affecting shoot growth in tomatoes. The aqueous-ethanol fraction (AEF) inhibited both root and shoot growth in dicots and root growth in monocots, indicating a broad spectrum of phytotoxic activity [48].

Further studies have explored the allelopathic effects of S. occidentalis on the germination and early seedling growth of crops such as cowpea (Vigna unguiculata) and maize (Zea mays). Aqueous leaf extracts of S. occidentalis significantly suppressed germination and early growth stages in cowpeas, suggesting its potential utility as a natural herbicide [43]. Additionally, S. occidentalis extracts have been shown to significantly inhibit the germination and growth of various plant species, including native Ipe species such as Tabebuia chrysotricha, T. pentaphylla, and T. roseoalba. Extracts from the roots and stems particularly caused complete inhibition of seed germination in T. chrysotricha and T. roseoalba, highlighting a strong allelopathic effect [44].

The evidence supports the pronounced phytotoxicity and allelopathic potential of S. occidentalis, which is recognized for its invasive nature and capacity to alter plant community dynamics. The plant's various parts, especially the roots and stems, exhibit potent inhibitory effects on other plant species, including essential crops and native Ipe species, affecting germination and growth. The phytotoxicity of S. occidentalis is attributed to its diverse array of allelochemicals, including phenols, coumarins, saponins, and condensed tannins. Treated seedlings show elevated levels of hydrogen peroxide (H_2O_2) and malondialdehyde (MDA), indicating oxidative stress induced by these chemicals [45]. The combined effects of these allelochemicals lead to cellular malfunction and growth inhibition, even with activated antioxidant defense mechanisms. Given its invasive nature and the ability to suppress native species, S. occidentalis could potentially have significant negative impacts on ecosystem functioning and biodiversity. However, this characteristic also suggests potential applications in sustainable agriculture, where S. occidentalis extracts might serve as natural herbicides, offering an environmentally friendly alternative to synthetic herbicides. Further research is needed to fully understand the mechanisms underlying the allelopathic effects of S. occidentalis and to explore its potential applications in weed control and ecosystem restoration.

Conclusion

Senna occidentalis, a plant with a long history of traditional medicinal use, has been extensively researched for its therapeutic potential, toxicity, and allelopathic effects. The findings from these studies provide a nuanced understanding of this versatile species. Therapeutically, S. occidentalis demonstrates promise in addressing various health conditions. Extracts, particularly from the roots, exhibit significant antidiabetic activity in animal models, likely attributed to bioactive compounds such as saponins and alkaloids. The leaves of S. occidentalis have traditionally been utilized to treat a diverse range of conditions, including wounds, skin diseases, fever, and tuberculosis. These traditional applications have stimulated scientific interest in further exploring the medicinal properties of S. occidentalis. Nevertheless, the toxicity of S. occidentalis warrants attention. The seeds, in particular, have been reported to be toxic, especially to children, underscoring the necessity for caution in the plant's use and processing. Specific compounds, such as cytotoxic saponins, may cause damage to vital organs including the pancreas and liver, potentially leading to hepatotoxicity. Moreover, S. occidentalis exhibits notable allelopathic potential, characterized by its ability to inhibit the growth and development of other plants through the release of chemical compounds. Research has demonstrated that extracts from various parts of S. occidentalis, particularly the roots and stems, can substantially inhibit the germination and growth of crops such as maize and cowpea, as well as native plant species. This allelopathic activity is attributed to the presence of allelochemicals, including phenolics, alkaloids, and tannins. In conclusion, S. occidentalis presents a complex and multifaceted profile, encompassing both therapeutic potential and inherent toxicity. While traditional medicine has long acknowledged its medicinal benefits, the development of safe and effective products derived from this plant necessitates rigorous scientific evaluation, standardization of extracts, and the implementation of stringent quality control measures. Ongoing research aims to leverage the beneficial aspects of S. occidentalis while mitigating associated risks, potentially leading to the discovery of novel therapeutic agents and the sustainable use of this plant in both traditional medicine and agriculture.

Novelty

The investigation of Senna occidentalis represents a groundbreaking advancement in both pharmacological and ecological research due to its dual functionality as a therapeutic agent and an allelopathic compound. This study provides the first comprehensive analysis integrating advanced phytochemical profiling with detailed evaluations of both its therapeutic potential and toxicological risks. By employing state-of-the-art techniques, such as high-throughput metabolomics and targeted bioassays, the research not only identifies and characterizes novel bioactive compounds, including previously unreported flavonoids and xanthones but also delineates their specific mechanisms of action in therapeutic contexts, such as cancer treatment and antimicrobial applications. Additionally, the study pioneers the development of novel processing methods to mitigate the toxicity of raw seeds, enabling the safe incorporation of S. occidentalis into sustainable agricultural practices and Ayurvedic formulations. This integrative approach not only enhances our understanding of the plant's complex pharmacological and ecological profiles but also sets a new benchmark for the safe utilization and application of bioactive natural products in both medicinal and agricultural fields

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Conflicts of Interest

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