Advances in Biochemistry
2017; 5(5): 102-109
http://www.sciencepublishinggroup.com/j/ab
doi: 10.11648/j.ab.20170505.14
ISSN: 2329-0870 (Print); ISSN: 2329-0862 (Online)

Review Article

An Overview of the Phytochemical Analysis of Bioactive Compounds in *Senna alata*

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To cite this article:

Funmilayo Adelowo, Oluwole Oladeji. An Overview of the Phytochemical Analysis of Bioactive Compounds in *Senna alata*. *Advances in Biochemistry*. Vol. 5, No. 5, 2017, pp. 102-109. doi: 10.11648/j.ab.20170505.14

Received: September 10, 2016; **Accepted**: January 13, 2017; **Published**: October 18, 2017

Abstract: The major problem man is facing is the growing rate of the activities of microbes. Virtually everything that surrounds man, even his environment are contaminated and polluted with these microbes. The use of medicinal plants for the treatment of bacteria and fungi that caused related diseases gave rise to the introduction of antibiotics or natural drugs. To promote the proper use of *Senna alata* as herbal medicine, their curative and therapeutic effects should be studied. Therefore, it is of great importance to determine the chemical components (phytochemicals) and the ethnobiological view of *Senna alata* extracts. This review presents updated information regarding the phytopharmacological profile of the plant.

Keywords: Antibiotics, Ethnobiological View, Herbal Medicine, Medicinal Plants, Microbes, Phytochemicals, Phytopharmacological Profile, Therapeutic Potency

1. Introduction

1.1. Description of Senna alata

Senna alata (previously named *Cassia alata*) is a medicinal plant of Leguminosae family. It has many common names such as Candle bush, Emperor Candle stick, Christmas candle, Acapulo, Ringworm bush and Calabra bush. In the Southwest of Nigeria; *Senna alata* is called 'Ewe Asunwon Oyinbo'. Wild senna (*Cassia alata*) is found in Ghana and Brazil, but it is now widely distributed in the United States of America and all over Africa, including Nigeria [1].

Senna alata is a shrub with usually an average height of between 1 and 5metres and has horizontally spread branches. Its leaves are par pinnate of between 30 to 60 cm long and consisting of 8 to 20 pairs of leaflets. Each leaflet is oblong or elliptic oblong and rounded at both ends. Its flowers are dense in auxiliary racemes, about 20 to50 cm long and 3 to 4 cm broad. The inflorescence looks like a yellow candle. The plant fruits are a thick, flattened with wings and glabrous pods. They grow well in full sun in a wide range of soils that retain moisture adequately. The species is easy to grow from the seed. They can either be sown directly or started in a nursery and distributed all over the country up to 1,500 m above sea level; they are most often cultivated for medicinal purposes [2]; The botanical classification of *Senna alata* (table 1).

The advancement of the world due to Science and Technology have helped reduced the major problem man is facing about the growing rate of the activities of microbes. Virtually everything that surrounds man, even his environment are contaminated and polluted with these microbes [3]. These have led to some infectious and contagious diseases some of which are curable, some transmissible and others deadly. In doing this, different researches have been carried out on medicinal plants in order to combat these problems. All these researches prove fruitful but despite this, there have not been a proper assessment whether it is a specific class of phytochemicals present in the plants that contributes to the observed bioactivities or the amount of phytochemicals consumed [4].

The use of medicinal plants for the treatment of bacteria and fungi that caused related diseases gave rise to the introduction of antibiotics or natural drugs [5]. The advancement in the world has led to the production of synthetic drugs. The

consistent use of these drugs have increased the development of drug resistance in man and also increase the exposure to unwanted side effects [6].

The persistent use and the growing rate of the consumption of these synthetic bactericides and fungicides by man has resulted in many side effects, such as health and environmental problems. In view of this, the Scientist have discovered that in order for man to survive these conditions, the introduction of natural antimicrobial agents that are environmental friendly and those that cannot pollute or contaminate the environment is inevitable.

Table 1. *Scientific classification of Senna alata (en.m.wihipedia.org/wiki/Senna_alata).*

Kingdom	Plantae
(unranked)	Angiosperms
(unranked)	Eudicots
(unranked)	Rosids
Order	Fabales
Family	Fabaceae
Subfamily	Caesalpinioideae
Tribe	Cassieae
Subtribe	Cassiinae
Genus	Senna
Species	*S. alata*

2. Phytochemicals Present in *Senna alata*

Senna alata is known to contain an array of bioactive components or pharmacologically active compounds known as phytochemicals. Several researches have identified different phytochemicals. There are manycompounds present in the plant (fig. 1 - 4); phenolic compounds, alkaloids, anthraquinone, tannins, steroids, flavonoids among others (table 2).

3. Phytochemical Analysis of *Senna alata*

Phytochemical screening is done to ascertain the scientific assessment of the claim of the therapeutic potency. The healing potency of these phytochemicals have taken a new dimension since there have been recent interest by the Scientists on what constitutes each medicinal plants. There have been different measures or steps taken for the analysis of these phytochemicals.

Senna alata are reported to contain a variety of secondary or bioactive compounds, known as phytochemicals. Recent studies are involved in the identification and isolation of new therapeutic compounds of medicinal importance from higher plants for specific diseases [7]. To promote the proper use of *Senna alata* as herbal medicine, their curative and therapeutic effects should be studied. Therefore, it is of great importance to determine the chemical components (phytochemicals) and the antimicrobial activities of *Senna alata* extracts.

The Methanolic, ethanolic and petroleum ether extracts of *Senna alata* leaves were collected dried, pulverized by [8]. They screened the leaves extracts for its phytochemicals, antibacterial and antifungal activities. The methanolic extract showed the highest activity than the ethanolic and petroleum ether extracts. This may be due to the effect of polarity of the solvent. The unidentified active components purified from preparative thin layer chromatography exhibited low activities against Mucor, *Rhizopus* and *Aspergillus niger* at concentration of 70µg/ml while higher activity was exhibited against all the test bacteria and fungi at 860µg/ml.

Senna alata leaf decoction has been used to treat infectious diseases in north eastern Nigeria. Timothy *et al.,* [9] screened the leaves extract for their activity against infectious diseases. In the attempt to perform this, the leaves of the plant were collected, dried and extracted using water and 95% ethanol and evaluated against five clinical isolates of pathogenic fungi for their antifungal activity. The extracts were found active against all the tested clinical fungal isolates. The extracts inhibited the growth of *Candida albicans, Microsporum canis* and *Trichophyton mentagrophyte* better than 200mgof ketoconazole used as a positive control($p<0.05$). The minimum inhibitory concentration of the water leaf extract of *Senna alata* for *Candida albicans, Aspergillus niger, Penicillium notatum, Microsporium canis* and *Trichophyton mentagrophytes* were 26.90 mg, 32.40 mg, 29.50 mg, 30.30 mg and 27.80 mg respectively, while that of ethanol leaf extract of *Senna alata* for *Candida albicans, Aspergillus niger, Penicillium notatum, Microsporium canis* and *Trichophyton mentagrophytes* were 5.60 mg, 3.50mg, 4.90 mg, 12.60 mg and 9.80 mg respectively. The plant extract was active against the organisms used, this suggested that the plant use in managing fungal diseases.

Table 2. *Some of the phytochemicals in Senna alata and their medicinal importance (phytochemicals.info).*

Phytochemicals	Application (s)
Flavonoids	Antioxidant, anti-inflammatory, anti-viral, relieve hay fever, prevent heart diseases and reduce atherosclerosis, lowers blood cholesterol, reduce oxidation of low-density cholesterol.
Alkaloids	To treat headache, cough and relieve fatigue
Saponins	Cholesterol reduction, reduce cancer risk, immunity buster, reduce bone loss, antioxidant, immune-stimulating
Tannic acid	To treat diarrhea, anti-bacteria, anti-enzymatic and astringent properties. To treat ulcers, tooth ache and wounds.
Alkaloids	Increase circulation and oxidation of fatty acid, stimulates central nervous system, respiration and blood circulation
Anthocyanin	Anticancer, anti-inflammatory, reduce cardiovascular diseases
Quercetin	Prevent obesity, antitoxic effect, anti-cancer, modulate enzyme activity
Coumarins	Anti-tumor and anti-fungicidal activity, decrease capillary permeability, increase blood flow in veins

Senna alata has been used for the treatment of *Tinea versicolor* and ringworm infections in Thailand. In order to evaluate the active ingredients and find scientific evidence for the herbal activity of *Senna alata*, Wuthi *et al.,* [10] collected

leaf samples from Thailand and were extracted by three different methods. Using a soxhlet apparatus, an 80% ethanol extract (26.4%) (A) was obtained. The extract was treated with HCl, which after further purification gave 7.3% of crude anthraquinone (B). Lyophilization of water macerates yielded 10.1% (C). In the third method, a 100-mg amount of pulverized leaves was sonicated with either 95% ethanol (D) or water (E). After filtration, the residue extraction was carried out in duplicate. All the extracts were investigated for their antifungal activities. On the basis of zone of inhibition, activities against dermatophytes and *Candida albicans 36* and 26 clinical isolates, respectively, were established by an agar diffusion method. The extracts A, B and C (20 mg, each), D and E (80 µg, each) inhibited the dermatophytes by 13.8, 9.9, 21.9, 8.2 and 7.5 mm and C. albicans by 18.8, 10.7, 14.1, 10.1 and 7.2 mm, respectively. The crude ethanol and ethanol sonicated extracts (A and D) of *S. alata* were shown to contain rhein (anthraquinone aglycone), while the lyophilized water extract (C), contained some polar compounds, which might be anthraquinone glycosides on a TLC plate.

Table 3. *The formulation of Senna alata and mode of application for medicinal purposes.*

Infection	Description or formulation	Application area
Antimicrobial	Make leaf paste of *Senna alata* by adding some lime juice	Apply on the infected skin
Antifungal	Grind some leaves of *Senna alata* with some coconut oil and make a paste	Apply externally on affected area
Ringworm	Directly apply root paste	Apply externally on affected area
Asthma	Boil *Senna alata* leaves in some water for 10 – 15 minutes to make a tea. Drink three times a day until relief	Apply internally by drinking
Aphthous Ulcers	Gargle with *Senna alata* herbal tea two to three times daily	Apply internally by drinking

In 2011, [11] evaluated the leaves of *Senna alata* for the presence of the bioactive constituents. The result obtained, showed the isolation of a new cannabinoid alkaloid (4-butylamine 10-methyl-6 hydroxy cannabinoid dronabinol). The structure was elucidated using NMR spectroscopy in combination with IR and MS spectral data. The antimicrobial studies showed that the isolated compound successfully inhibited *Pseudomonas aeruginosa, Klebsiella pneumonia, Escherichia coli, Staphylococcus aureus, Candida albicans* and *Aspergillus niger.* They discovered that the isolated compound contains antimicrobial properties and this could be useful in formulation of herbal medicine.

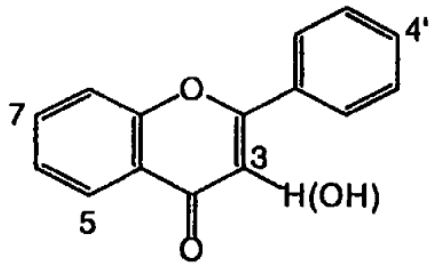

Fig. 1. *Flavone (flavonol).*

The ethanol extract of Senna alata leaves was evaluated against some dermotophytes (*Malassezia pachydermatis, Malassezia furfure,* and *Malassezia restricta, Malassezia globosa*) and gastro-intestinal bacterial pathogens (*Salmonella Typhi, Escherichiacoli, Proteusmirabilis, Pseudomonasauriginosa, Klebsiella spp*) by [12]. The antimicrobial test was carried out using well diffusion technique against pathogens and found effective against the selected pathogens. The highest zone of inhibition was observed against Klebsiella spp (27.4mm), followed by S. Typhi (26mm) and P. auriginosa (26mm), P. mirabilis (21.7mm)and E.coli (19.5mm). In case of fungi, the highest activity was observed in M. globosa (19.7mm) and M. pachydermatis (17mm). No inhibition was observed in M. furfure and M. restricta. The result suggested the antimicrobial property of Senna alata against bacterial and fungal pathogens of humans.

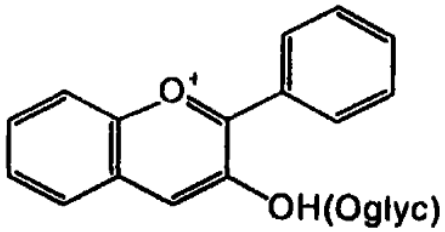

Fig. 2. *Anthocyanins (Anthocyanidins).*

In the attempt to elucidate and characterized the active ingredient of the leaf of *Senna alata*, [13], collected, extracted and purified the leaf extract using a column. The fraction was isolated and thin layer chromatographic analysis was carried out using a gradient of organic solvents with increasing polarity. A flavone 3, 5, 7, 4-tetrahydroxy flavone was isolated and the compound was characterized using UV, IR, ^{1}HNMR, ^{13}C-NMR and Mass spectrometry. From the spectral information, they predicted that the compound belonged to the flavone series and was characterized as 3, 5, 7, 4- tetrahydroxy flavone.

An antibacterial constituent was isolated from leaves of *Senna alata* by solvent extractions and chromatographic techniques by [14]. The extracts was analyzed using an Infra red spectroscopy, mass spectroscopy and nuclear magnetic resonance. The analysis showed that isolated compound was chemically 3,4 dihydroxy cinnamic acid. *In vitro* antibacterial activity of 3,4dihydroxycinnamic acid was studied against four Gram-positive and four Gram-negative bacteria using disc diffusion method. 3,4 dihydroxy cinnamic acid was found to be active against the tested bacteria.

The root and leaf of *Senna alata* was extracted with water, acetone and methanol. The extracts were investigated for the antimicrobial activity using cup plate agar diffusion and phytochemical screening was carried out. [15] discovered that all the extracts demonstrated considerable activity against

both Gram negative and Gram positive bacteria and some fungi, the organic extracts showed higher activity than the aqueous extracts. *Streptococcus pyogenes* and *Staph aureus* were the most susceptible to all the extracts followed by *Salmonella typhi* and *Escherichia coli*. The most susceptible fungi were *Cryptococcusneo formans* and *Candida albicans* while the least susceptible was *Aspergillus flavus*. The minimum inhibitory concentration of the methanol extracts ranged between 3-10 mg/ml and 25-50 mg/ml for bacteria and fungi respectively. In order to ascertain the bioactive component of the plant, preliminary phytochemical analysis was carried out. This showed the presence of tannins, saponins, glycosides, flavonoids and phenols. The results obtained show the basis for the local usage of *Senna alata* as an antimicrobial. Phytochemical result showed ethanol to be a better solvent for the extraction of the bioactive agents in *Senna alata*.

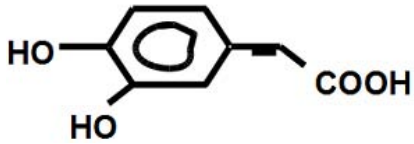

Fig. 3. *Caffeic acid.*

Senna alata and *Phyllanthus amarus* were extracted using water and ethanol. [16] evaluated the extracts for their in-vitro antimicrobial effectiveness on *Escherichia coli, Staphylococcus aureus, Salmonella typhimurium, Aspergillus niger, Aspergillus flavus* and *Candida albicans*. The extracts of the two plants were found comparatively and selectively effective on all the test organisms. The highest inhibitory zone was recorded in water extract of *Senna alata* against *Aspergillus niger* with 27.2 mm while *Salmonella typhimurium*. showed the lowest inhibitory zone of 10.1 mm. Ethanolic and water extract of *Phyllanthus amarus* recorded the best antibacterial activity against Staphylococcus aureus(20.2 mm) and E. coli (15.3 mm) while ethanol extract of P. amarus showed activity recorded for A. niger to be (18.2 mm). This confirmed that both plants are good antimicrobial agents.

In the attempt to study the comparative phytochemical screening and nutritional potentials of the flowers (petals) of Senna alata, *Senna hirsuta* and *Senna obtusifolia*, [17] screened the extract for its phytochemical and quantitative analysis. The phytochemical screening revealed the presence of some important bioactive compounds such as saponins, tannins, flavonoids, and cardiac glycosides and the absence of alkaloids in all three species. Quantitative evaluation of the petals of *S. alata, S. hirsuta* and *S. obtusifolia* revealed moisture content (%) of 12.5, 13.5, 13; Ash content (%) 6, 11, 9. Acid insoluble (%) 1.5, 2.5, 2; Sulphated ash (%) 5, 9, 5.3; protein (%) 5.1, 8.2, 4.1, Fats (%) 5, 3.5, 4.4; Fibre (%) 25, 40, 30; Carbohydrate (%) 53.7; 42, 40.7 respectively. The result proved that they contain nutrients and mineral elements, and also, bioactive compounds that may be useful in nutrition and in the synthesis of various therapeutic drugs.

In 2010, [18], collected fresh leaves of Senna alata and were extracted using four solvents; water, methanol, n-hexane and acetone. The extracts of each solvent was collected separately. The extract obtained from the solvents was compared, methanol showed high extraction when compared with other solvents. The column chromatographic of the methanolic extract showed gave large number of fractions. Column chromatographic method was used to separate the different components of the extract. The crude extract was compared with the chromatographic fractions for antibacterial activity using disc diffusion method. Among the fractions obtained from the column, only one component show antibacterial activity on *Staphylococcus aureus*. The active chromatographic fraction revealed the presence of steroids.

The leaf and stem of *Senna alata* and *Achyranthes aspera* was extracted using organic solvents namely methanol, ethanol, ethyl acetate and chloroform. The extracts obtained by [19] evaluated *Senna alata* for their antibacterial activities against *Escherichia coli, Bacillus subtilis, Vibrio cholerae, Salmonella typhi* and *Staphylococcus aureus*. The antimicrobial screening was carried out by taking 5 mg/ml of each extract and the activities were recorded by estimating zones of inhibition as produced by disc-diffusion method on Mueller-Hinton agar media. *Achyranthes aspera* extracts showed no activity on the test organisms. Senna alata exhibited antibacterial activity. They showed high inhibition against *Bacillus subtilis* and *Staph typhi,* and the corresponding MIC values of the leaf extracts were 1.25 and 1.5 mg/ml respectively. Ethanolic leaf and stem extract were active against staph aureus with minimum inhibitory concentration of 125 mg/ml.

Table 4. *The medicinal uses of Senna alata in different countries (www.google.com).*

Country	Medicinal uses
Togo	Abortifacient, laxative, for parturition, scurvy.
Brazil	For anemia, constipation, dermatitis, dyspepsia, fevers, hydropsy, liver problems, menstrual disorders, skin problems, venereal disease, as a diuretic, laxative and as a purgative.
Cuba	As a diuretic, diaphoretic, laxative, against herpes, skin infections.
Haiti	As a depurative, diaphoretic, insecticide, tonic, vulnerary, for amygdalitis, herpes, itch, measles, psoriasis, sore (throat), tonic, skin problems, prurigo, sores, wounds etc
India	As a antidote, bactericide, diuretic, fungicide, insecticide, pesticide, purgative, vermifuge, for asthma, bronchitis,constipation,dysentery,eczema,herpes,intestinalparasites,rheumatism,skindisorders,snakebite, stomach ache, venereal diseases etc
Nigeria	As a antidote, bactericide, diuretic, fungicide, insecticide, pesticide, purgative, vermifuge, for asthma, bronchitis, constipation, dysentery, eczema, herpes, intestinalparasites,rheumatism,skindisorders,snakebite,stomachache, venereal diseases etc
Malaysia	As a diuretic, insecticide, laxative, vermifuge, for hepatitis, herpes, intestinal parasites, ringworm, skin problems, snakebite, urinary infections

Senna alata leaf was dried and pulverized to fine powder and was used to obtain five extracts which contain

anthraquinone compounds in different forms i.e. anthraquinone aglycone extract, anthraquinone glycoside extract, anthraquinone aglycones from glycosidic fraction, crude ethanol extract, and anthraquinone aglycone from crude ethanol extract. [20] tested all extracts against clinical strain of dermatophytes: *Trichophyton rubrum, T. mentagrophytes, Epidermophyton floccosum,* and *Microsporum gypseum* by disc diffusion and broth dilution techniques to find out the active form for antifungal activity. Thin layer chromatography was developed to demonstrate the fingerprints of chemical constituents of each extract. This investigation showed that the highest *in-vitro* antifungal activity of anthraquinone aglycones from glycosidic fraction qualitatively and quantitatively, compared to other extracts.

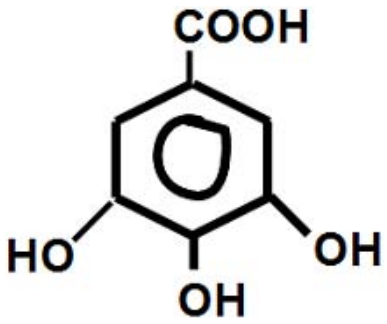

Fig. 4. *Gallic acid.*

Senna alata leaves were collected from Akure, Nigeria by [21]. They extracted the leaf sample using solvent mixture of chloroform-methanol. The biochemical constituents of extracts was analyzed by gas chromatography–mass spectrometry (GC-MS) techniques. The main constituents of the extracts were 6-Octadecenoic acid (24.99%), 2, 3-Dihydroxypropyl-9-octadecenoate (20.86%) and Octadecanoic acid (18.08%).

In 2012, the leaf of *Senna alata* was collected from Thailand by [22], and analyzed for the Total phenolic contents and antioxidant activities of aqueous and ethanolic extracts. The antioxidant activity was evaluated using the 1,1-diphenyl-2-picrylhydrazyl (DPPH) and 2,2'–azinobis(3-ethylbenzothiazoline-6-sulfonicacid(ABTS)methods. The strongest antioxidant activities of aqueous extract of *Senna alata* were 22.11± 0.324 mg gallic/g extract and 214.99 ± 17.279 mg trolox/g extract when determined by DPPH and ABTS assay, respectively. The aqueous extract showed the highest total phenolic content of 70.90 ± 1.048 mg Gallic/g extract. The authors concluded that the biological activities of these plants will be useful to develop the plant extracts for primary treatment of diseases as new therapeutic agents.

To determine the total flavonoidal content, stock solutions of the both the methanol and acetone extracts (ME: 77mg/ml; AE: 44mg/ml) were prepared with methanol to a suitable concentration for analysis. Total flavonoid content was measured according to the method previously reported by [23] with slightly modifications using standard curve generated with Rutin. Aliquots of each extract were pipette out into various test tubes and volume was made up to 0.5ml with distilled water; Sodium nitrate (5%: 0.3ml) was added to each tube and incubated for 5 min. at room temperature; Aluminum chloride solution (10%; 0.06ml) was added to the resultant solution and incubated for 5 min, at room temperature; Sodium hydroxide (1M; 0.25ml) was added and total volume was made to 1ml with distilled water. Absorbance was measured at 510nm against a reagent blank using Schimadza model 150 – 02 double beam spectrophotometer and concentration of flavonoids in the test sample was determined and expressed as mg of Rutin equivalent per gram of sample.

In 2003, Thin Layer Chromatography was used for the determination of rhein in *Senna alata*. A silica gel 60 F254 layer was used with a mixture of 90% chloroform and 10% methanol as the mobile phase. From Thin Layer Chromatography analysis, [24] discovered that the crude ethanolic (A) and ethanolic sonicated extracts (D) of *Senna alata* contained rhein (anthraquinone aglycone), and the lyophilized water extract (C) contained some polar compounds, which might be anthraquinone glycosides.

The effect of heat on the chemical constituents of *Senna alata* was carried out using sun dried leaves as reference standard. [25] observed a high concentration of the constituent in the heat-treated leaves. Spectroscopic analysis revealed the structure of the constituent as kaempferol-3-gentiobioside, a new compound in the *Senna* species. In a stability study disappearance of kaempferol-3-geniobioside was noted in the sun dried leaves while there was little or no change in the kaempferol-3-geniobioside concentration in the heat-treated leaves when incubated in an aqueous solution, suggesting a possible presence of enzymatic activities in the sun dried leaves. Therefore, heat-treatment may be a good method to stabilize kaempferol 3-gentiobioside in *Senna alata* leaves.

A soap was produced by incorporating *Senna alata* powder into a soap consisting of caustic soda and palm kernel oil to make 1.5% w/w. The soap mixture was allowed to solidify and they are cut into equal size of 65 g. The soap prepared by [26] was investigated for their activity against some skin diseases, using thirty three inmates of Ilesa prison, Nigeria. Thirty-three inmates were recruited for the study and randomly distributed into 19 treatments and 14 controls. The common skin infection in the prison are *Tinea versicolor* and *Tinea corpora.* These two skin infections were the major fungal infections found on the skin lesions at diagnosis prior to commencement of study, while *Epidermophyton floccusum* and *Cryptococcus* sp were microscopically observed to be responsible for the lesions. The herbal soap was significantly active against the lesions on 16 subjects (94.1%), comprising (11) *Tinea versicolor* and (5) *Tinea corporis*. The control did not show much activity. This showed the folkloric claims on *Senna alata* as an antimicrobial agent for treating skin infections.

The in vitro antimicrobial activity of acetone and ethanol *Senna alata* leaf extracts was investigated by [27] against *Staph aureus*, *Bacillus subtilis*, *Bacillus cereus, Bacillus stearothermophillus, E. coli, V. cholerae, S. typhi, S. dysenteriae* and *K. pneumoniae*. The extracts showed high inhibition against nearly all test microorganisms. The inhibitory effects of extracts are very close and identical in

magnitude and are comparable with that of standard antibiotics used.

The antifungal activity of *Senna alata* leaves were investigated by [28] using three different extraction methods. *Senna alata* leaf was extracted with ethanol using Soxhlet apparatus. The yield of 26.4% (A) was obtained and was treated with HCl, which was purified using column and this gave 7.3% of crude anthraquinone (B). Lyophilization of water macerates yielded 10.1% (C). Also, 100 mg of pulverized leaves was accurately weighed and sonicated with either 95% ethanol (D) or water (E). The extracts were filtered and the residue was extracted for another two times in the same way.25 ml of the solvent was added to the filtrate. All the extracts were investigated for their antifungal activities. The inhibitory zone of the extracts against dermatophytes (36 clinical isolates) and *Candida albicans* (26 clinical isolates) were established by an agar diffusion method. The extracts A, B and C (20 mg, each), D and E (80 µg, each) inhibited the dermatophytes by 13.8, 9.9, 21.9, 8.2 and 7.5 mm and *Candida albicans* by 18.8, 10.7, 14.1, 10.1 and 7.2 mm, respectively. The thin-Layer chromatographic analysis of the crude ethanol and ethanol sonicated extracts (A and D) of *Senna alata* were investigated. They showed the presence of rhein (anthraquinone aglycone), while the lyophilized water extract (C) contained some polar compounds, which might be anthraquinone glycosides.

Senna alata leaf was collected by [20] and pulverized to powder. Different extracts was obtained using ethanol. The extracts contain anthraquinone compounds in different forms i.e. anthraquinone aglycone extract, anthraquinone glycoside extract, anthraquinone aglycones from glycosidic fraction, crude ethanol extract, and anthraquinone aglycone from crude ethanol extract. All extracts were tested against clinical strain of dermatophytes: *Trichophyton rubrum, T. mentagrophytes, Epidermophyton floccosum*, and *Microsporum gypseum* by disc diffusion and broth dilution techniques. Thin layer chromatographic analysis was carried out to investigate the presence of chemical constituents of each extract. It showed that anthraquinone aglycone from glycosidic fractions have higher antifungal activity qualitatively and quantitatively when compared to other extracts.

In the attempt to investigate the healing effect of *Senna alata* on laboratory rats, [29] collected and extracted the leaf of *Senna alata* using ethanol.. 5 groups each consisting of six rats were used. A wound area of 2 x 2cm was experimentally induced at the depilated dorsal portion of the rats. Different concentrations of the leaf extracts was carried out (125, 250 and 500mg) were prepared for the treatment of the wound. In order to investigate the healing effect of the plant, the rats are grouped into three. The first three groups were treated with the ethanolic leaf extract,, the fourth group treated with spray plus (as standard drug) while the fifth group served as the control group. The wounds were measured on daily basis with two days interval till complete epithelialisation. The wound size in animals treated with the leaf extracts were significantly reduced ($p<0.05$) when compared with the negative control group. The ethanol leaf extracts of Senna alata showed significant wound healing in excision wound model compared to the negative control.

In attempt to analyze the volatile oil in *Senna alata* by gas chromatography coupled with mass spectrometry, [30], obtained the oil samples from the studied plant species by hydrodistillation using a Clevenger apparatus and then subsequently analyzed for their constituents by gas chromatography (GC) and gas chromatography coupled with mass spectrometry (GC/MS). The quantitatively significant constituents of the leaf oil of *Senna alata* (Linn.) Roxb., (Fabaceae) were 1, 8-cineole (39.8%), β-caryophyllene (19.1%) and caryophyllene oxide (12.7%). Limonene (5.2%), germacrene D (5.5%) and α-selinene (5.4%) constituted the other significant compounds present in the oil. The sunflower oil, *Helianthus annuus* L., (Asteraceae) was rich in α-pinene (16.0%), germacrene D (14.4%), sabinene (9.4%) and 14-hydroxy-α-muurolene (9.0%)().

Leaves of *Senna alata* are used to cure ringworm a fungal skin infection. They are also recommended as antibacterial, antiparasitic, antipyretic, antiinflammatory, antineoplastic, etc.

Generally leaves are marketed in dehydrated form for preparation of variety of products like, herbal tea, extracts, tinctures, herbal soaps and shampoos. To ensure the authenticity and quality of leaves of *Senna alata*, the pharmacognostic study is of utmost importance. [31] laid down the pharmacopoeia standards for the said drug. Along with unique morphological features, the drug anatomically shows glandular trichomes and papillose lower epidermis. In microscopic study of powdered drug, epidermal cells with circular outlines of papillae become diagnostic characteristic. Along with these identifying characters, physicochemical constants are also of help in detection of drug impurities. Thus all these quality standards will prove to be useful in assessment of marketed crude drug. In addition to this, the phytochemical analysis exhibits presence of major secondary metabolites which can act as the indicators of bioactivity of the drug.

The extraction of *Senna alata* leaves by [32] was carried out using Reverse phase-solid phase extraction method in order to obtain a refined extract. Higher than wild-type sensitivity to CaRP was exhibited by 16 haploid *Saccharomyces cerevisiae* mutants with defects in DNA repair and membrane transport. CaRP had a strong DPPH free radical scavenging activity with an IC_{50} concentration of 2.27 µg mL^{-1} and showed no pro-oxidant activity in yeast. To separate the compounds, HPLC was employed and the three major components present were shown to bind to DNA in vitro. The major HPLC peak was identified as kampferol-3-O-β-D-glucoside (astragalin), which showed high affinity to DNA confirmed with PLC-UV. The measurement was taken after using centrifugal ultrafiltration of astragalin-DNA mixtures. Astragalin-DNA interaction was further studied by spectroscopic methods and its interaction with DNA was evaluated using solid-state FTIR. These and computational (in silico) docking studies revealed that astragalin-DNA binding occurs through interaction with G-C base pairs, possibly by intercalation stabilized by H-bond formation.

In 2012, [33]., evaluated the cytotoxic effects of hexane extracts of *Senna alata* and *Psidium guajava* leaves in OV2008 ovarian and Kasumi-1 leukemia cancer cell lines, respectively. The cancer cells were exposed to various concentrations of either *Senna alata* (100 – 180 µg/ml) or *Psidium guajava* (100 – 500 µg/ml) leaf extract for 24 hours. Following treatment, the cells were evaluated using the 3-(4,5-Dimethylthiazol-2-yl)-2,5-diphenyltetrazolium bromide (MTT) assay to determine the cytotoxic effect of the extracts. *Senna alata* extract was also analyzed using high performance liquid chromatography (HPLC). The results obtained showed that *Senna alata* and *P. guajava* extracts produced significant ($p < 0.05$) cytotoxicity in OV2008 and Kasumi-1 cell lines, respectively. The IC_{50} concentration was160 µg/ml for *Senna alata* and 200 µg/ml for *P. guajava.* Also, the cytotoxicity exhibited by *Senna alata* might be attributable to the flavonoid, kaempferol, which was identified as a constituent of the extract. The results suggested that further chemical analysis and mechanistic investigations should be conducted on *P. guajava* and *Senna alata* extracts to validate their potential uses for anticancer therapy.

The antibacterial activity of ethanolic extract of *Senna alata* and *Tectona grandis* were investigated against *S. aureus, E. coli, S. enteritidis, P. multocida* and *P. aeuroginosa* using disc diffusion method and both dilution technique were used to evaluate the activity. [34] observed that the leaves of both plants showed high activity against all the test organisms which may be due to the presence of certain secondary metabolites present in these plants.

4. Medicinal Applications of Phytochemicals in *Senna alata*

The medicinal, therapeutic, healing effect and pharmacological applications of *Senna alata* is due to the presence of the bioactive compounds present in the plant. Scientifically, all phytochemicals are important but analytically, not all are medicinal in nature. There have been many researches on the impact of different bioactive compounds in *Senna alata* (table 3).

Nigerian researchers have identified local herbs that could be effectively used as medicine for treating infectious diseases caused by bacteria, fungi among others. *Senna alata* called ewe asunrun Oyinbo in Yoruba and ogalu in Ibo is locally used for the treatment of several infections such as ringworms, parasitic diseases. Different formulations of the plant are used for the treatment of hemorrhoids, intestinal parasite, constipation, syphilis, diabetics and inguinal hernia. The leaf was reported to be useful in treating convulsion, heart failure, abdominal pain, oedema and also in treating dermatophytosis (table 4) [7, 19, 31-33]. These phytochemicals are responsible for Pharmacological activities such as hepatoprotective, anti-inflammatory, antigenotoxic, hypolipidemic, spasmogenic and antinociceptive, antiproliferative, hypotensive, purgative, antidiabetic, estrogenic and antiestrogenic, antiulcer, antioxidant, antifungal, antishigellosis, anthelmintic, antimutagenic, antibacterial and antiplasmodial.

5. Conclusion

This study on the overview of the Phytochemical Analysis of Bioactive Compounds and ethnobiological view of *Senna alata* gives the following observations:

(i) *S. alata* was discovered to contain saponins, reducing sugars, flavonoids, terpenes, anthraquinone and glycosides. The observed antifungal and antibacterial activities on the susceptible organisms studied were due to the presence of the bioactive metabolites.

(ii) The highest concentration of phytochemicals in the extracts was obtained using solvents of high polarity; the methanolic extract manifested greater power of extraction for phytochemicals from *Senna alata* when compared to other solvents.

(iii) The results of the study suggested the great value of the species *Senna alata* for use in pharmacy and phytotherapy; therefore, it could serve as a natural source of antimicrobial substances of high importance.

Acknowledgement

The authors want to appreciate the efforts of the Head of the Department, Prof Onawumi Esther of the Department of Pure and Applied Chemistry, LAUTECH, Ogbomoso, Nigeria for her contributions during the course of the study.

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