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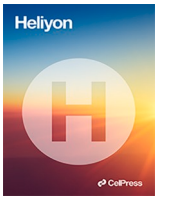

Review article

Traditional uses, phytochemicals, and biological properties of *Saba senegalensis*

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ABSTRACT

The fruit of *Saba senegalensis* is respectively known among local folks in Ghana, Senegal, and Burkina Faso as *ɛsononantin*, *maad* and *weda*. The plant has been used traditionally, ethnobotanically, and medicinally in most West African countries. The phytochemicals that have been discovered in various extracts of *S. senegalensis* parts include alkaloids, coumarins, anthracene glycosides, anthocyanosides, anthocyanins, coumarins, flavonoids, saponins, saponin glycosides, sterols, condensed tannins, tannins, triterpenes, and triterpenoids. Presently, isolation and characterisation of phytochemicals from various parts of *S. senegalensis* has not been fully explored since scientists have isolated only two steroidal alkaloids from the stem of the plant namely Irehine and Homoandrost-9-ene-17β,17aβ-diol-3β-(methylamino)-17aα-methyl-12-one. The phytochemicals have shown biological properties such as anti-oxidant, anti-inflammatory, anthelmintic, anti-microbial, analgesic, larvicidal, ovicidal, myostimulant, hypotensive, anti-diabetic, anti-lipid peroxidation and anti-mycobacterial effects. Additionally, isolation and characterisation of medicinally beneficial phytochemicals from various parts of the plant, namely latex, leaf, stem, flower, root, fruit, and bark should be comprehensively investigated. Thus, this current review summarises the traditional uses, phytochemicals, and biological properties of various parts of the plant.

1. Introduction

Description of the genus *Saba* (Pichon) in the Apocynaceae family was first conducted in 1849. The genus is considered native to mainland Africa, Comoros, and Madagascar [1,2]. However, the wider distribution of three species of this genus in Sub-Saharan Africa [namely *Saba comorensis* (Bojer ex ADC.) Pichon, *S. senegalensis* (ADC.) Pichon and *S. thompsonii* (AChev.) Pichon] has been reported [3] The *S. senegalensis* seems to be popular among the three above-mentioned species and has been appreciably studied by scientists. As a wild fruit-bearing plant, *S. senegalensis* is mainly dispersed around African banks of rivers and open woodland [4]. The fruit of this shrub-like liana plant is respectively known among local folks in Ghana, Senegal, and Burkina Faso as *ɛsononantin*, *maad* and *weda* [5].

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It is a climber with lance-shaped leaves that taper to the apex and can potentially reach a height of 40 m long with diameter below 15 cm [4]. Ethnobotanically, *S. senegalensis* has been used for medicine, food, and other economically viable purposes [6]. In terms of value addition, the local folks of Ghana usually mash the ripened sweet-sour yellowish pulp of the fruit and use it to prepare Tuozaafi and porridge, whilst the Burkinabe and Senegalese normally produce juice and jam from the fruit. Also, inner materials that envelope the fruit pulp and shell are respectively used to substitute tamarind and lemon in fruit drinks as well as chewing gum [7]. Traditionally, parts of *S. senegalensis* such as leaves, fruit, stem, roots, and latex have been used to treat various ailments [6]. Notable among these traditional uses are the treatment of blindness, burning, constipation, chronic headaches, food poisoning, parasitic infections, pulmonary disorders, leprosy, and scleroderma [6,8]. Besides, Belemlilga and co-experimenters affirmed the traditional use of *S. senegalensis* for helminths treatment when they showed that an aqueous decoction of the plant could kill adult worms (*Haemonchus contortus*, at LC_{50} of 6790 μg/ml) [9]. A growing body of literature has reported various biological activities of *S. senegalensis*. Scientists in Burkina Faso showed that the aqueous extract of *S. senegalensis* could potently treat inflammatory diseases, particularly through analgesia, anti-oxidation (at IC_{50} of 18.4 μg/ml) and anti-inflammation in mice [10]. Likewise, the leaves of *S. senegalensis* demonstrated strong anti-oxidant (at IC_{50} of 1.74 μg/ml), analgesic and anti-inflammatory effects in mice [11]. Besides, polar fractions of *S. senegalensis* has been explored for the treatment of diabetes mellitus, wherein scientists have demonstrated that butanol and ethyl acetate extracts of the woody liana substantially inhibited alpha-amylase with respective IC_{50} of 410 and 1450 μg/ml [12]. Further, leaves of *S. senegalensis* (aqueous extract) displayed anti-hypertension and myostimulant potentials in rabbits [13]. Various bioactive phytochemicals have been extracted from parts of *S. senegalensis*. These include but are not limited to alkaloids, anthocyanosides, anthracene-glycosides, carotenoids, coumarins, flavonoids, glycosides, phenols, tannins, triterpenes, triterpenoids, saponins and sterols [10–12,14,15]. Altogether, ethnobotanical use and extracted phytochemicals demonstrate the excellent potential of *S. senegalensis* to promoting health. Notwithstanding, secondary metabolites that have been identified in various parts of the plants have not been compiled in a review article. Therefore, this review discusses the ethnobotanical uses, proximate compositions, phytochemicals, biological activities, and toxicities of *S. senegalensis*.

2. Ethnobotanical uses

2.1. Botany

The botany of *S. senegalensis* has been reviewed in existing literature [6]. In brief, the plant has been found to freely grow in the tropics. As a member of Apocynaceae family, *S. senegalensis* is a liana and is largely woody with the potential to grow beyond 40 m high (Fig. 1a), amidst the bark being scaly dark-gray and produces white latex [6]. Usually, the plant climbs and grows through support of other plant species, wherein the colour and shape of leaves are respectively dark-green and elliptically shaped (Fig. 1b). *S. senegalensis* produces large and bumpy and ovoid-shaped fruits (Fig. 1c). When it is cut opened, the seeds can be seen to be coated with marginally semi-transparent yellow and fibrous pulps (Fig. 1d) [6].

2.2. Utilisation of S. senegalensis as food

There are several culinary applications for *S. senegalensis*, which is often known as the African cherry or wild custard apple. Importantly, the pulp of *S. senegalensis* is a healthy food for human consumption because of its nutritional composition [16]. The fruit of *S. senegalensis* has been used in many ways across African cultures. It is often eaten raw or used to make juices, jams, and sweets [6]. In addition to this, Diabagate and colleagues produced jam and syrup from fruit of the African cherry [17]. Also, *S. senegalensis* pulp, palm oil and spices were combined to form sweet and tangy sauce known as "*sabara*," a popular meal in Nigeria [5]. Likewise, condiments and sauces have been prepared from leaves of the plants into appetizer which tasted salty or sweet [6]. Besides, certain foods are prepared in Burkina Faso with an acidifier, which are usually prepared from dried hulls through grinding, mixing with water and sieving [5]. Additionally, *S. senegalensis* is commonly pounded into a powder and dried in Cameroon for use as a flavouring in a variety of recipes, namely stews, marinades, and soups [6,14]. Further, *S. senegalensis* seeds are very frequently roasted and processed into a powder that may are used as a spice or added to soups and stews to improve their flavour [7]. In another study, it was observed that

Fig. 1. (a) Tree with unripe fruit, (b) leaves, (c) ripe fruit, and (d) cross-sectioned fruit with pulpy seeds of *Saba senegalensis*.

Table 1
Proximate composition of *Saba senegalensis*.

Country	Community	Moisture %	Ash %	Fat %	Carbohydrate %	Fibre%	Protein%	Energy (kcal/kg)	method	references
Cote devoir	Boromo	84.55 ± 0.23	0.42 ± 0.02	1.15 ± 0.02	13.28 ± 0.11		0.57 ± 0.02	657.5	AOAC (1990)	[5]
	Hounde	82.09 ± 0.17	1.04 ± 0.01	1.25 ± 0.08	14.81 ± 0.10		0.79 ± 0.15	736.5		
	Nouna	88.03 ± 0.02	0.25 ± 0.01	0.88 ± 0.05	10.45 ± 0.07		0.37 ± 0.00	512		
	Ouagqdougou	80.94 ± 0.04	1.02 ± 0.06	1.17 ± 0.06	16.23 ± 0.59		0.63 ± 0.03	779.7		
	Ouahigouya	82.45 ± 0.01	0.52 ± 0.04	1.31 ± 0.03	15.09 ± 0.90		0.60 ± 0.00	745.5		
	Po	81.76 ± 0.20	0.58 ± 0.01	1.17 ± 0.03	15.88 ± 0.15		0.58 ± 0.4	763.7		
	Sapone'	82.75 ± 0.03	0.31 ± 0.02	1.16 ± 0.02	15.20 ± 0.19		0.56 ± 0.02	734.8		
Senegal	Youtou	75.16 ± 1.06	1.29 ± 0.07	1.66 ± 0.51			0.22 ± 0.03		dehydration (method NF V 03–707)	[40]
	Bayla	74.77 ± 0.84	1.15 ± 0.06	0.96 ± 0.30			0.22 ± 0.02		Soxhlet (method NFV 03–905 standard)	
	Niamone	74.34 ± 0.93	1.52 ± 0.01	1.10 ± 0.26			0.22 ± 0.02		Kjeldhal's method (NF 03–050 standard)	
	Salemata	75.34 ± 0.27	1.45 ± 0.20	1.33 ± 0.20			0.24 ± 0.01			
	Bandafasse	74.24 ± 0.43	1.44 ± 0.21	1.16 ± 0.05			0.21 ± 0.02			
Ghana	Nyankpala		2.80 ± 0.00	8.92 ± 0.00	74.23 ± 0.00	13.25 ± 0.00	0.53 ± 0.00		AOAC, 1990	[41]
Cote d'Ivoire		85.27 ± 0.37	0.58 ± 0.01	0.81 ± 0.02		0.18 ± 0.02	0.32 ± 0.01		(AOAC 1990)	[42]

S. senegalensis can be transformed into puree for subsequent conversion into other products such as concentrated bases, syrups, marmalades, and nectars [6]. Despite the nutritional importance of plants, scientists have not comprehensively explored its health benefits.

2.3. Traditionally medicinal uses of S. senegalensis

Traditionally, herbal medicine practitioners have utilised *S. senegalensis* for a very long time, especially among the West African countries. Sarr and colleagues [6] had reviewed the traditional uses of the plant and reported that the local folks use the *S. senegalensis* to treat conditions that include but not limited to anaemia, anorexia, gonorrhoea, cough, wounds, colic disorder, stomachache, tuberculosis, haemostatic disorder, emetic syndrome, pulmonary disease, sterility, and scurvy. However, other scientists have reported some traditionally medicinal uses of the plants which are different from what have been reported by Sarr and co-authors. In another study, the authors observed that the raw fruits of *S. senegalensis* were utilised as appetite suppressant, which suggests the potential use of the fruit for treatment of obesity [18]. Also, the stem and climber of the *S. senegalensis* were used to prepare tea for treatment of stomach cancer [19]. Through ethnobotanical study, Tuo et al. discovered that the leaves of *S. senegalensis* is traditionally used to treat diarrhoea in humans [20]. Besides, tonic, stimulant, anti-scorbutic and anorectic effects of the ripe fruits has been reported, whilst the roots have been exploited to treat female fertility [21]. Stomach aches and vomiting along with tuberculosis and coughs are respectively treated with the macerated leaves and latex of the plant, whilst its tendrils are used for baby care [21]. Further, an ethnobotanical survey indicated that traditional healers in Mali explored the aqueous extracts of the fruit and root of *S. senegalensis* for wound healing [22]. From existing literature, it is obvious that the *S. senegalensis* is consumed by West African local folks in the form of teas, decoctions, or poultices for medical reasons, wherein the plant's leaves, stem bark, and roots are frequently used. Although *S. senegalensis* is a well-liked option for natural therapies, little is known about the active ingredients in the various parts of the plants. Thus, scientists should isolate and characterise the active compounds that are responsible for the reported medicinal effects of the plant.

2.4. Proximate composition of S. senegalensis fruit

Quantitative estimation of food and food substances such as dietary fibre, crude protein, moisture total carbohydrates and fats is known as proximate analysis [23]. Thus, proximate composition is a crucial standard which is used to ascertain the nutritional values

Fig. 2. Vitamins and minerals identified in the fruit of *Saba senegalensis*.

and quality of edible medicinal plants [24]. Available literature suggests that the proximate composition of *S. senegalensis* fruit has been widely studied by other scientists. Table 1 shows the proximate analysis of distinct parameters from different countries and different communities from some nations. The parameters that have been studied in terms of proximate analysis include moisture, ash, fat, fibre, protein, carbohydrate, and energy. Notwithstanding, the existing literature suggests that scientists have not determined all the parameters for *S. senegalensis* fruit pulp. Hence, scientists can explore this area especially when the pulp is considered as the principal edible part of the plant. Another observation from Table 1 is that even though all the authors worked on the fruit pulp but yield different results which may be due to differences in geographical origin, genotypic distinctions, environmental factors, maturity of the fruit pulp and ecological factors [25,26]. Besides, recent literature has reported the presence of essential amino acids such as valine, tryptophan, threonine, phenylalanine, methionine, leucine, isoleucine, and lysine [27] in fruit pulp of the plant. Of note, the proximate analysis of the other parts of the plant is yet to be studied.

2.5. Vitamins and mineral contents of S. senegalensis fruit

As vital micronutrients of foods, vitamins and minerals participate in most of the metabolic processes of humans at molecular level. The vitamin and mineral contents of the fruit of *S. senegalensis* have been studied [5,8,16,17,28–30] wherein vitamin C, beta-carotene and potassium have been respectively discovered to be the main vitamins and mineral in the fruit. Fig. 2 shows the vitamins and minerals that have been identified in the fruit of *S. senegalensis*. Of note, the vitamins and minerals in the other parts of the plant have not been well-studied.

2.6. Anti-nutritional profile of S. senegalensis fruit

Uptake of food or utilisation of nutrients can be reduced by the presence of biological components in foods, which are known as anti-nutritional factors (ANFs), wherein they contribute to impaired functions of gastro-intestines and performance of metabolism [31] as well as decrease bioavailability of nutrients [32]. Available literature has identified ANFs in edible plants to be amylase inhibitor, goitrogens, gossypol, lectins, phytic acid, protease inhibitors, saponins and tannins [32]. The ANFs of *S. senegalensis* fruit pulp has been studied [16,17,30,33], wherein the pulp mainly contained oxalic acids, phytates, tannins and saponins. Given the obvious presence of ANFs in *S. senegalensis* fruit, it is importance that scientists explore available methods (such as acid-alkali treatment, boiling, cooking, dehulling, fermentation, roasting, soaking, sonication, and toasting) [34] to remove ANFs before consumption to harness its potential health benefits. At present, the ANFs of the pod and seeds of *S. senegalensis* have not been studied.

2.7. Phytochemicals present in various parts of S. senegalensis

Available literature suggests that various parts of *S. senegalensis* such as fruit pulp, leaf, stem, bark, twig, flower, seed, tendril, and root have been explored for their ethnobotanical and therapeutical benefits [35]. Extensive literature search showed that scientists have not extensively identified and isolated the phytochemicals presents in the above-mentioned parts of the plants. Herein, the

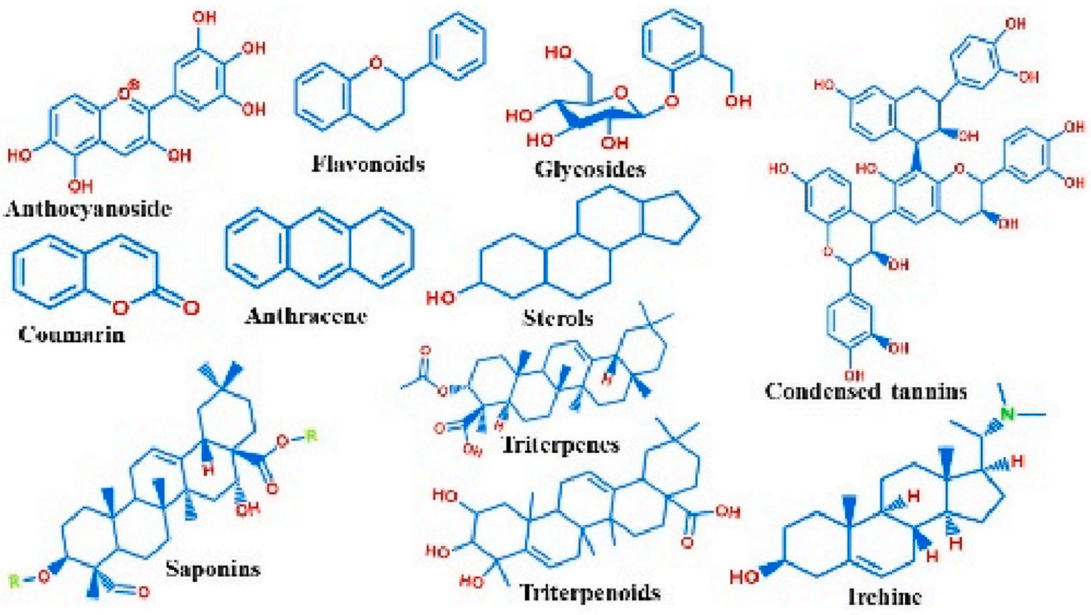

Fig. 3. General structure of some phytochemicals and structure of irehine, a pregnane steroidal alkaloid.

Table 2
Biological properties of various parts of *Saba senegalensis*.

Parts of *S. senegalensis*	Biological property	Method	Result	Country of study	References
Fruit pulp	Anti-oxidant	Scavenging of DPPH free radical	The fruit pulp had increased anti-oxidant activity with IC_{50} of 39.98 mg/ml	Cote d'Ivoire	[26]
		Scavenging of DPPH free radical Ferric reducing anti-oxidant power (FRAP)	The fruit pulp displayed high anti-radical activity of DPPH (73.62 %) and increased mean FRAP value of 29.52 mg EAA/100 g FP	Burkina Faso	[21]
		Scavenging of DPPH free radical	The fruit extract (125.00 μg/ml) showed the highest anti-oxidant activity with percentage scavenging activity of 30.66 %	Mali	[35]
Stem with leaf		Scavenging of DPPH free radical	Anti-oxidant activity of the aqueous extract was discovered through inhibition of DPPH radical with IC_{50} of 18.4 μg/ml	Burkina Faso	[10]
	Anti-inflammatory	In vivo anti-oedematous effect using carrageenan assay in NMRI mice with aqueous extract of *S. senegalensis* stem with leaves being 100, 200 and 300 mg/kg. In vitro 5-lipoxygenase inhibitory assay	The aqueous extracts decreased oedema maximally after fifth hour of carrageenan injection and achieved 93.26 % inhibition of lipoxygenase		
	Analgesic	Acetic acid induced writhing method in NMRI mice using the same extracts at 100, 200 and 300 mg/kg	The aqueous extract exhibited analgesic effect by reducing NMRI mice abdominal writhing		
	Anti-lipid peroxidation	Anti-lipid peroxidation assay	The aqueous extract inhibition lipid peroxidation by 79.22 %		
Leaf	Anthelmintic	In vitro anthelmintic assay using *Haemonchus contortus* with concentrations of aqueous extract being 0.10, 1.00, 3.00, 10.00 and 15.00 mg/ml	At concentration of 15.00 mg/ml, the aqueous extract of leaves showed 93.63 % inhibition and LC_{50} on adult worms of 6.79 mg/ml	Burkina Faso	[9]
	Ovicidal/ Larvicidal	In vitro anthelmintic assay using *Heligmosomoides bakeri*, In vitro ovicidal activity, In vitro larvicidal activity using different concentrations of the extracts (100, 625, 1250, 2500 and 3750 μg/ml)	Both aqueous decoction and hydroethanolic macerate of the leaves extracts and fractions demonstrated increased ovicidal and larvicidal properties with respective E_{max} and LC_{50} of 95.60 % and 390.00 μg/ml along with 100.00 % and 900.00 μg/mL	Burkina Faso	[44]
	Myostimulant	In vivo using rabbit through the method of rabbit intestinal fragment and intra-peritoneal injection of thiopental (1 g/kg body weight) before measurement of arterial blood pressure	Aqueous extract (0.21–0.81 mg/ml) of the leaves exhibited myostimulatory effect by increasing the amplitude of rabbit intestinal rhythmic contractions by 130.00–244.29 %.	Cote d'Ivoire	[13]
	Hypotensive		The same aqueous extract (ED50 = 6, 11 mg/kg body weight) of the plant decreased the rabbits' arterial blood pressure from 7(4 %) to 18 (33 %)		
	Anti-oxidant	Scavenging of DPPH free radical with ethyl acetate and butanolic fractions of *S. senegalensis* leaves	The butanolic fraction (IC_{50} = 0.94 mg/ml) showed increased anti-oxidant activity compared to ethyl acetate fraction (2.89 mg/ml)	Senegal	[12]
	Anti-diabetic	In vitro alpha-amylase inhibitory assaying with ethyl acetate and butanolic fractions of *S. senegalensis* leaves	Anti-diabetic effect was evaluated through alpha-amylase inhibition, wherein the result showed that the butanolic fraction (IC_{50} = 0.41 mg/ml) demonstrated obvious inhibition of alpha amylase compared to ethyl acetate fraction (IC_{50} = 1.45 mg/ml)		
		In vivo treatment of *Mus musculus* mice with glucose 3 g/kg body weight to induce hyperglycaemia before oral administration of aqueous extract of *S. senegalensis* leaves at doses of 150, 200 and 250 mg/kg	The aqueous extract exhibited blood glucose lowering activity within a range of 48.60–81.84 % after 1 h of treatment.	Cote d'Ivoire	[52]
	Anti-mycobacterial	Anti-mycobacterial activity of the aqueous, dichloromethane and ethanolic extracts of *S. senegalensis* leaves was investigated with *Mycobacterium tuberculosis* H37Rv (ATCC 27294 strain)	The ethanolic extract of the leaves obviously prevented the growth of H37Rv strain with minimal inhibitory concentration (MIC) of 125 μg/ml	Mali	[53]
	Anti-oxidant	Scavenging of DPPH free radical with aqueous, hydroethanolic and ethyl acetate fractions of *S. senegalensis* leaves at doses of 200, 400 and 600 mg/kg	The aqueous fraction demonstrated better anti-oxidant activity with respective IC_{50} and reducing power being 1.74 μg/ml and 59.53 ET/g Sample	Burkina Faso	[11]
	Anti-inflammatory	In vivo anti-oedematous effect using carrageenan assay in NMRI mice with the above-mentioned fractions and doses	Aqueous fraction showed respective increasing oedematous inhibition		

(*continued on next page*)

Table 2 (*continued*)

Parts of *S. senegalensis*	Biological property	Method	Result	Country of study	References
			percentages of 30.81, 62.27 and 72.71 % at doses of 200, 400 and 600 mg/kg		
	Analgesic	Acetic acid induced writhing method in NMRI mice	Hydroethanolic fraction demonstrated better pain reduction with maximal inhibition of 77.28 % at 400 mg/kg		
	Anti-oxidant	Hydrogen peroxide scavenging activity FRAP	The aqueous (IC_{50} = 69.57 μg/ml) and hydroethanolic (IC_{50} = 35.61 μg/ml) extracts of the leaves demonstrated moderate and good anti-oxidant activity respectively	Mali	[54]
	Anti-inflammatory	In vitro cyclooxygenase and protein denaturation inhibition tests	Hydroethanolic extract of *S. senegalensis* leaves inhibited cyclooxygenase activity with IC_{50} lower than 30 μg/ml		

phytochemicals that have been reported in this study were identified in the extracts of the various parts of the plant. Generally, the presence of phytochemicals such as alkaloids, coumarins, anthracene glycosides, anthocyanosides, anthocyanins, coumarins, flavonoids, saponins, saponin glycosides, sterols, condensed tannins, tannins, triterpenes, and triterpenoids (Fig. 3) have been identified in the extracts of *S. Senegalensis* fruit pulp, leaves, stem, and root.

2.7.1. Fruit pulp

Of all the various parts of the plant, the fruit has been widely studied in terms of identifying its bioactive phytochemicals. Based on existing literature [8,9,29], it can be concluded that the fruits contain diverse phytochemicals. Earlier work had shown the presence of polyphenols (mainly composed of flavonoids and anthocyanins) in the methanol and acetone extracts of *S. senegalensis* fruit pulp [36]. Likewise, Kini and colleagues revealed the presence of triterpenes and anthraquinones in the fruit pulp of *S. senegalensis* [37]. In another study, Yao and co-experimenters affirmed the presence of polyphenols, particularly flavonoids and tannins in ethanolic solution of the fruit pulp [33]. However, other scientists did not detect alkaloids, saponins, tannins and coumarins, but revealed the presence of flavonoids, anthocyanins, and steroid terpenes in the fruit pulp of *S. senegalensis* [38]. Besides, Kouakoua and co-authors [29] observed higher presence of beta-carotene and polyphenols (specifically flavonoids) in fruit pulp of *S. senegalensis* in comparison with banana, papaya, and pineapple. The presence of beta-carotene and phenols in fruit pulp of the plants was also affirmed by Diabagate and colleagues [16]. Also, the presence of beta-carotene and lycopene were detected in the pulp of *S. senegalensis* after the scientists [21] treated the sample with acetone/hexane (70/30). In the same study, the authors discovered that ethanolic extract of the fruit pulp contained alkaloids, saponins, terpenes, tannins, flavonoids, and polyphenols [21]. In summary, fruit pulp of *S. senegalensis* mainly contain beta-carotene and polyphenols, amid inconsistency in the reported phytochemicals of the plants. The above-mentioned discrepancy may be attributed to sample storage and climatic conditions, as well as extract preparative methods, ripening time and solvents that were employed for the sample preparations [21,39–42].

2.7.2. Leaf

Leaves of plants are endowed with various phytochemicals which are responsible for the medicinal values of such natural products [43]. Extensive literature search revealed that a few studies have been conducted on identification of the phytochemicals in the leaves of *S. senegalensis*. A study conducted by Mamadou and co-workers [13] revealed that an aqueous extract of *S. senegalensis* leaves composed of polyphenols (flavonoids), saponoside, sterols and tannins with quinonic compounds and alkaloids being absent. Also, Belemlilga and colleagues reported the presence of steroid, triterpene glycoside and saponins in aqueous *S. senegalensis* leaf extract [9]. Besides, Belemlilga et al. [44] sought to identify the phytochemicals in *S. senegalensis* leaves extracts, which was prepared with hydroethanol and distilled water as solvents. The authors observed that the presence of coumarins and derivatives, anthocyanosides, polyoses (in hydroethanolic macerate only), flavonoids, organoselenium, saponins, reducing compounds tannins, steroid and triterpenic glucosides in the above-mentioned extracts [44]. Using solvents such as dichloromethane and ethyl acetate, the scientists characterised the phytochemicals with thin-layer chromatography, wherein the results showed that the leaves' extracts composed of flavonoids, saponins, sterols, triterpenes, and tannins [44]. Additionally, Mireku-Gyimah and co-workers discovered the presence of alkaloids, condensed tannins, saponin glycosides and triterpenoid [14]. Further, aqueous extract of *S. senegalensis* leaves comprising phytochemicals such as anthocyanosides, coumarins, flavonoids, saponins, sterols, tannins, and triterpenes has been reported [45]. Inferably, the few existing literature suggests that the *S. senegalensis* leaves may comprise diverse phytochemicals, which should be comprehensively investigated through isolation and purification of bioactive compounds.

2.7.3. Stem, root, and seed

The extraction of phytochemicals in medicinal plants' stem barks, roots and seeds is well-known studied by scientists [46]. With regards to *S senegalensis*, there is paucity of literature on the phytochemicals present in the parts. Notwithstanding, Mireku-Gyimah and colleagues identified phytochemicals such as alkaloids, anthracene glycosides, saponin glycosides and triterpenoids in the stem and root of *S. senegalensis* [14]. Of note, the phytochemicals of the seeds have not been presently investigated. The same authors isolated two steroidal alkaloids from the stem of *S. senegalensis*, which were characterised through 1-dimensional (D) and 2D nuclear magnetic

resonance to be Irehine (Fig. 3) and Homoandrost-9-ene-17β,17aβ-diol-3β-(methylamino)-17aα-methyl-12-one [47] (structure not shown). However, the biological effect of these two steroidal alkaloids have not been investigated as indicated by available literature.

3. Biological properties of *S. Senegalensis*

Bioactive compounds in medicinal plants have generally been shown to possess various biological properties such as anti-cancer, anti-malarial, anti-inflammatory, anti-oxidant, anti-microbial, anti-viral and anti-diabetic activities [48,49]. Many biological properties of *S. senegalensis* have been reported by scientists, wherein these have been summarised in Table 2. It is possible that *S. senegalensis* from different countries may have diverse biological properties because geographical locations have been found to cause variations in the accumulation of phytochemicals [50]. The variations in IC_{50} values for anti-oxidant, anti-diabetic and anti-inflammatory effects of various parts of the plant (Table 2) suggest possible influence of countries of origin. Nonetheless, the influence of geographical locations on the biological properties of *S. senegalensis* has not been explored. This current review has identified the biological properties of *S. senegalensis* to include anti-oxidant, anti-inflammatory, anthelmintic, anti-microbial, analgesic, larvicidal, ovicidal, myostimulant, hypotensive, anti-diabetic, anti-lipid peroxidation and anti-mycobacterial. More importantly, adverse effects of the various parts of *S. senegalensis* have not been reported in the clinical settings.

4. Clinical therapeutic effect of *S. senegalensis*

In general, the phytochemicals in the medicinal plants have been revealed to be responsible for their therapeutic effects on human beings. In this regard, the roots of *S. senegalensis* have been used to effectively treat disorders of neuropsychiatry in Burkinabe individuals residing within the Hauts Bassins region through treatment of hallucination or loss of consciousness [51]. Another study has reported the potential of unripe *S. senegalensis* fruit to treat obesity among folks in hunter Nomad communities through suppression of appetite [18]. In terms of cosmetic application, extract of *S. senegalensis* has been developed to soften skin or mucous membranes coupled with cutaneous inflammation treatment [52]. Collectively, there is paucity of data on the clinical therapeutic effect of *S. senegalensis*, hence further investigations are urgently needed in this regard.

5. Toxicity and interactions studies

Toxicological investigations of drug candidates are very important since they provide preliminary level of safety after various routes of exposure of such compounds [53]. This implies that a potential drug-like molecule can only be developed into a drug and used by humans when it has been confirmed to be safe and viable. Apart from seed ingestion that can lead to intestinal obstruction and abdominal pain [54,55], no obvious toxicity of other parts of *S. senegalensis* has been reported based on available literature. In an acute toxicity study [13] of aqueous *S. senegalensis* leaf extract, batches (1, 2 and 3) of *M. musculus* mice (weighing between 20 and 30 g) were orally administered with 2000, 3000 and 5000 mg/kg body weight respectively. The authors discovered that the aqueous extract did not cause any obvious toxicity since no death of mice was observed even at the maximum dose (5000 mg/kg body weight) with the LD_{50} being above 5000 mg/kg body weight. Another acute toxicity study was conducted the same authors [56] in *M. musculus* mice, wherein they orally administered increasing doses (ranged from 100 to 5000 mg/kg body weight) of aqueous extract of *S. senegalensis* leaves to the mice. Likewise, the same above finding was discovered by the authors. Extensive literature search shows that the acute, sub-acute and chronic toxicological studies of various parts of the plant have not been comprehensively conducted by scientists. Also, the drug-drug interactions of the phytochemicals of *S. senegalensis* have not yet been investigated.

6. Limitations of the study

Although this narrative review was flexible, it facilitated rigorous synthesis of knowledge on the traditional uses, phytochemicals, and biological properties of *S. senegalensis*, which may be useful for medicinal chemists and other scientists. Notwithstanding, the findings of review are limited because of non-reproducibility, which may be due to influence of authors on the selection of literature that was used for this review coupled with the sampling, screening, and analysis of the literature. Despite that we tried to include all literature on *S. senegalensis*, language barrier may affect findings of this review since articles written in French and other languages without English translation were omitted.

7. Conclusions

This mini review provides a summary of ethnobotanical and traditional uses, along with proximate composition, phytochemicals, and biological properties of *S. senegalensis*, an edible liana plant that has been mostly exploited by indigenes in West African countries because of its various medicinal properties. Various phytochemicals have been accordingly identified in the extracts of *S. senegalensis* parts, namely fruit pulp, leaves, stem, and root. These phytochemicals include alkaloids, coumarins, anthracene glycosides, anthocyanosides, anthocyanins, coumarins, flavonoids, saponins, saponin glycosides, sterols, condensed tannins, tannins, triterpenes, and triterpenoids. According to the existing literature, *S. senegalensis* has shown potential biological properties such as anti-oxidant, anti-inflammatory, anthelmintic, anti-microbial, analgesic, larvicidal, ovicidal, myostimulant, hypotensive, anti-diabetic, anti-lipid peroxidation, and anti-mycobacterial effects. However, further investigations are required on both preclinical and clinical phases. These investigations should focus on the isolation, characterisation, and potential pharmacological effects of phytochemicals from various

parts of the plant, as well as sub-acute and chronic toxicity. Additionally, it is necessary to study the solubility and bioavailability of enhancing nanocarriers of isolated phytochemicals.

Data source and availability statement

This narrative review was conducted to include a noncomprehensive and non-exhaustive sample of the literature on this topic. Literature was searched from databases such as PubMed, Scopus, Web of Science, ScienceDirect and Google Scholar. The literature that was used for this review has been duly cited in the article and is available.

Additional information

No additional information is available for this paper.

CRediT authorship contribution statement

Auphedeous Yinme Dang-i: Writing – original draft, Conceptualization. **Isaac Otu Atta:** Software, Data curation. **Osman Haadi Mbaadawu:** Writing – original draft, Validation, Data curation. **Shakira Ibrahim:** Writing – original draft, Methodology, Data curation. **James Abugri:** Writing – review & editing, Supervision. **Michael Adu-Frimpong:** Writing – review & editing, Writing – original draft, Conceptualization.

Declaration of competing interest

The authors have declared that they do not have any personal relationships or competing financial interests that could have appeared to influence the findings of this review.

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