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A Review on ethnobotanical uses, biological activities and phytochemical aspects of *Acacia senegal* (L.) Willd. and *Acacia seyal* Delile. (Fabaceae)

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Abstract

The genus *Acacia* is a group of tropical plants species used in folk medicine due to virtue of its many therapeutic properties. In this document, we review the Ethnopharmacology, biological and phytochemical activities of the two major plant species used. Although, several researchers has been done, *Acacia senegal* (L.) Willd. and *Acacia seyal* Delile. are among the species of the genus for which phytochemical study is limited, few bioactive compounds and properties described. Based on these current traditional uses, it is necessary to carry out more biochemical and pharmaceutical assays in order to identify the precise ingredient that supports the recommendation in traditional medicine. The characterization of the active compound that plays a role for treating human diseases (infection, cancer, etc.) represents a key step in phytochemical research of new compounds. Moreover, this information about the active compound will help the clinician/pharmacist to define a rational and combined use with the synthetic molecules for which resistance mechanisms are currently reported in clinical cases.

Keywords: *Acacia Senegal; Acacia seyal; Antimicrobial;* Biological activity; Phytochemistry; Tradional medicine

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Introduction

Traditional medical practices vary from country to country and region to region, and are influenced by several factors including culture, history, attitudes and personal philosophy [1]. The renewed interest over the centuries and the transmission of experience from generation to generation are proof of the safety and effectiveness of this medicine. The lack of health care centers in remote areas, often linked to the high cost of conventional medicines, means that 80% of people in African countries use traditional medicine for their primary health needs [2]. Nowadays, developing countries such as Burkina Faso are adopting policies to promote traditional recipes through collaboration between health practitioners and traditional healers. Today, infectious diseases are the leading cause of death in the world and antibiotic resistance has become a global concern [3]. The emergence and spreading of pathogens that present resistance to many if not for all clinically used antibiotics has led WHO to classify them as a human health priority [4-6]. Therefore, researchers are increasingly turning to medicinal plants in search of new approaches to develop new effective drugs against microbial infections. The screening of potential antimicrobial activity of active molecules from medicinal plants is of concern [7]. Some recent reviews point on the possible use of natural products to combat multidrug resistant bacteria (for an example see. Interestingly, *Acacia senegal* (L.) Willd. and *Acacia seyal* (Del.), of the *Fabaceae-Mimosoideae* family, are well known in traditional medicine and often used in combination with other plants to combat microbial infections [12-14]. The available knowledge on these plants was searched using the keywords *Acacia senegal* (L.) Willd. and *Acacia seyal* Del. in the databases 'Google scholar', 'NCBI', 'Springer Link', Free Scientific Publications' and' Web of Science'. Their properties are of a major interest in the research and development of new active molecules targeting multidrug resistant pathogens or the identification of adjuvant that can restore the antibiotic activity in resistant bacteria. This review summarizes the current knowledge regarding these two plants and presents some perspectives for a future study and application about their antimicrobial properties to combat antibiotic resistance.

Taxonomy of *Fabaceae*

Leguminosae Fabaceae previously identified and described by Adanson and de Jussieu are subdivided into three sub-families including *Caesalpinioideae, Mimosoideae and Papilionoideae* [15-17]. With about 765 genera and more than 19500 species, *Fabaceae*, constitute the third most important plant family [18,19]. The species in this family are well distributed in all tropical and warm temperate regions of the world. Recent data indicated that the Legume Phylogeny Working Group has subdivided the *Fabaceae* into six sub-families instead of three, namely *Cercidoideae* (12 genera, 335 species), *Detarioideae* (84 genera, 335 species), *Detarioideae* (84 genera, 335 species) and *Cercidoideae* (84 genera, 760 species), *Duparquetioideae* (1 genus, 1 species), *Dialioideae* (17 genera, 85 species), *Caesalpinioideae* (148 genera, 4400 species; includes genera of the *Mimosoideae*) and *Papilionoideae* with 503 genera, and 14,000 species [20,21]. *Acacia* genus belongs to the subfamily of *Mimosoideae* and is the second most important genus in the *Fabaceae* family, with about 1350 species currently recognized. The highest concentrations of *Acacia* sp. are found in Australia (955 species), with high numbers also in America (about 185 species), Africa (144 species) and Asia (89 species**)** [22, 23]. This family represents an important source of molecules that are involved in the treatment of various diseases.

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Botanical description

Acacia senegal (L.): Willd. *Acacia senegal* is commonly known as white gum tree, with *Acacia verek* Guill. & Perott and *Mimosa senegal* L. as synonymes and vernacular names, *gon pèelega* (Moore) and Gommier of Senegal (French). It's a Sahelian and Sudano-Sahelian species, belonging to the *Fabaceae-Mimosoideae* family [24]. It's distributed in Senegal to Cameroon and Sudan. *A. senegal* occurs naturally in arid, semi-arid and subtropical regions, and is drought-resistant [25]. It's also presents in tropical, Southern Africa and India. It is a phanerophytes, a thorny shrub tree of 2-6 or even 12 meters high with very branched and ascending branches [26]. The trunk is about 30 cm in diameter and the bark is light grey with a red slice marbled with white [27]. The leaves are green-grey, alternating and bipinnate, measuring 3.5-8 cm long with grapes of cream color small flowers. Seeds are greenish brown [26]. Pubescent then hairless pods measuring about 7 cm long x 2 cm wide represent the fruits. In Africa, flowering takes place at the foliage before the first rains but also sometimes at the end of the rainy season, especially from July to September. *A. senegal* is one of the species used to create the great African green wall. *A. senegal* is used to fertilize soils, as firewood, local construction and fence posts and the gum Arabic produced is traded internationally [28-30].

Acacia seyal (Delile.): *Acacia seyal* also called *Gon-ponsego* (Mooré); Gommier, Mimosa épineux (French) is phanerophyte, a thorny tree 6 to 17 m high with smooth and green bark [24]. The twigs are greenish and the leaves are alternating and bipinnate, from 3 to 10 cm long with 3-7 pairs of pinnules. The fruits are represented by narrow pods and contain 6 to 10 seeds that are brown when they are ripened. Flowering and fruiting usually take place in the second half of the dry season, before foliage. It is a species that is Sahelo-Saharan and Sudano-Sahelian. It's found in low slopes and low ground and generally near rivers. This species has spread from Senegal to Cameroon, Egypt and Somalia [31].

Ethnobotanical uses (parts, traditional uses, nutritional value) of *A. Senegal* and *A. seyal*.

Different parts of the plant species are used dry or in liquid form after maceration or decoction for general treatment of bacterial, viral, parasitic infections or used to treat symptoms in gastroenterology, dermatology, hematology, rheumatology and inflammation (Table 1 and 2). Locally applications can be performed for ophthalmological or dermatological problems.

Table 1: Different uses and methods of extract preparation of *A. senegal* in different African countries.

Medical uses	Plant parts	Forms	Plant association	Medication administration	Country	References
Respiratory infections, Flue, sinusitis	Bark Gum	Decoction Powder		Oral	Burkina Faso	[14,32]
Toothaches	Young leaves, Thorns	Powder	*Diospyros mespiliformis* Hochst. Ex A. DC.	Inhalation gargles		[33]
Stomac ulcer Colic	Bark Stems Gum	Powder Decoction		Oral	Senegal	[34]

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Malaria fever	Gum	water		Oral		[35]
Malaria	Bark Stem	Decoction		Bath Oral	Mali	[36]
Hemorrhoids STIs	Roots	decoction	*Guiera senegalensis* J. F. Gmel	Oral		[37]
Liver deseases	Roots	Decoction	*Stereospermum kunthianum* Cham. *Ficus thonningii* Blume		Niger	[38]
Laxative Cirrhosis Hepatitis	Roots	Powder		Oral		[39]
wounds	Bark	Decoction		Oral		[40]
Malaria	Stems Bark	Decoction		Oral	Nigeria	[41]
Stomach aches Purgative STIs Diarrhea Stomach aches	Roots Bark	Decoction		Oral	Kenya	[42]
Wounds	Gum	Paste		Topical		[43]
Bleedings	Gum	Paste	*Commiphora myrra* (T. Nees) Engl	Oral		
Stomach aches	Bark	Macerate		Oral		[44]
Laxatives	Bark Seeds	Macerate		Oral		[45]
Food suplement	Leaves	eaten by livestock		Oral		[46]
Stomach aches	Bark	Decoction		Oral		[46]
Against Evil spirits	Seeds	Crushed		Oral	Ethiopia	[47]
Eyes injuries Back pain	Fresh gum	Decoction		Oral		[48]

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Constipation Stomach aches						
Eyes injuries	Bark	Drops		Local		[49]
Mumps	Leaves	Topic		Oral		
Fertility	Roots	Topic		Oral		
Diarrhoea Mouth inflammation	Roots			Oral	Angola	[50]
Abscesses and boils Cough	Roots	Decoction		Local	Tanzania	[51,52]
Haemorrhagic Diarrhea	Barks and roots	Decoction		Oral		[53]
Headaches	Roots	Powder		Smoked	Uganda	[54]
Delivery pain in animals	Bark	Maceration		Oral		[55]
Pospartum pain in animals	Bark and roots	Maceration		Oral		
Diarrhea Ulcers	Gum	Powder		Oral	Sudan	[56,57]
diabetes, Kidney failure	Fruits	Powder		Oral		
Stomach ulcers and aches Abdominal pain	Stem bark	Decoction		Oral	Mauritania	[58]
Eyes drop	Gum	eyewash		Local	Morocco	[59]
Lung disases Stomach aches Liver diseases		Powder		Oral		
Anti-inflammatory				External use		

Table 2: Different uses and methods of extract preparation of *A. seyal* in different African countries.

Medical use	**Plant parts**	**Forms**	**Plant association**	**Medication administration**	**Country**	**Refs**
Dysentery Gastrointestinal pain	Bark and roots	Decoction		Oral	Burkina Faso	[60]

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Leprosis	Root bark	Infusion		Oral		
Nervous sensory Digestive disorders	Bark gum	Decoction		Crushing Instillation Oral bashing		[61]
Toothaches	Bark and leaves	Decoction		Oral		[33]
STIs Bleeding	Bark stems Trunks twigs	Decoction Powder	*Mytragyna inermis* (Willd.) Kuntze. *Gossypium sp*	Oral		[12]
Keratitis Eyes aches	Bark stems	chew	Salt	Instillation		[34]
Dysentery	Bark	Powder	Honey	Oral	Senegal	[62]
Snake bites	Bark stems	Infusion		Oral and local		[63]
Purgative Fortifying STIs	bark, stem trunk, or twig	Decoction		Oral		[13,14]
Leprosy	bark, stem trunk, or twig	Decoction		Oral		
Headaches			Liquid butter,	Local wash		
Eye diseases	Leaves		*Leptadenia hastata* (Perr.) Decne *Ziziphus mucronata* Willd.			
Bilious fever and jaunice Urinary infections	Roots	Decoction	*Combretum glutinosum* Perr. Ex DC. And milk	Local wash Oral		
Leprosy	Red bark of trunk			Oral		[64]
Wound injuries	Leaves	Decoction	Milk	local	Niger	[65]
Malaria Spleen dilatation fever	Bark	Powder	Milk Millet	Oral		[65]

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Asthenia Avitaminosis Sickle cell disease	Roots	Maceration	*Securidaca longipedunculata* Fresen., *Pergularia tomentosa* L., *Stereospermum kunthianum* Cham., *Feretia apodanthera* Del., *Annona senegalensis* Pers., *Securinega virosa* (Roxb.ex willd.) Baill, *Ziziphus mauritiana* Lam., *Boscia senegalensis* (Pers.) Lam, *Cassia sieberiana* DC.	Oral with millet milk porridge		[66]
Arthritis Inflammation Liver desaese	Bark	Decoction		Oral		[67,68]
Epilepsy	Bark	Maceration		Oral	Mauritanie	[58]
Pneumonia	Bark Stem Trunk twig	Decoction		Oral	Kenya	[69]
Malaria	Roots	Decoction		Oral		[70]
Joint pain	Bark stems leaves	boiled	*Strychnos henningsii Pvetta crassipes* (K. Schum.)	Oral		[71]
Intestinal parasites	Roots			Oral	Ethiopia	[49]
Jaunice	Leaves			Oral		
Chest pain	Roots	crushed		Oral		[47])
Diarrhoea	Roots	Maceration		Oral	Uganda	[55]
Viral skin necrosis nodules	Bark leaves	Maceration		Oral		
Bleeding and leaves	Bark	Decoction		external	Sudan	[72]
Leprosy						
Arthritis Rheumatisms Rheumatoid fever	Wood			smoked		[73]

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Inflammation and stomach aches	Leaves					
Laxative	Stem bark	Decoction		Oral	Mauritania	[58]
Painful period	Roots seeds	Decoction	*Pennisetum americanum* (L.) Leeke *Capsicum annuum* (L.)[Cult.] *Zanthoxylum zanthoxyloides* (Lam.) Zepem.&Timler	Oral	Togo	[74]
Appendicitis	Roots	Decoction		Oral	Benin	[75]
Conjonctivitis trachoma	Gum	Maceration		Oral	Mali	[76]
Conjonctivitis trachoma	Leafed stem Bark of trunk	Decoction		Oral		
Purgative Syphilis Leprosy Headaches Chest pain	Bark of trunk and leafed	Decoction		Oral		
fistula	Leaves	Powder	Honey	local	Rwanda	[77]
dysentery	Bark and roots	crushed	Water	Oral	Djibouti	[78]
Post-abortion care Stmach aches	Bark	Maceration		Oral		
Infected wounds	Seed	Powder		Local	Algeria, Egypt, Morocco	[79]
Fever Dysmenorrhea Eye infections	Seed	Decoction		Oral local		[79]
Stomach ulcers Rheumatisms	Leaves bark	Decoction		Oral local		[79]
Rheumatisms Infecions post delivery	Wood	Fumigation		Oral	Algeria, Egypt, Morocco	[59,80]
Rheumatisms Respiratory tract infection	Gum			Oral		
Gastric ulcer	Leaves			Oral		

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	bark					
Livestock	Pod			Oral		

Phytochemistry, pharmacology and toxicological studies on the plants extracts

The *Fabaceae* family is an important source of biologically active molecules. However, few species have been examined specifically for these substances; in fact, the secondary metabolites of only a small proportion of *Acacia* species have been examined in detail [81]. *Acacia senegal* and *Acacia seyal* are among the few that have been studied.

Acacia senegal

The data contained in Table 3 summarize the biological activities and molecules or groups of molecules that have been informed by the different authors about *Acacia senegal* (L) Willd. and their supposed involvement in biological activities. The dichloromethane extract from the root wood of *A. senegal* showed good activity against two bacterial species, *E. coli* and *S. aureus* while the ethanolic extract, dichloromethane and ethyl acetate showed significant antifungal activity against *C. albicans*. From the wood of the root, ten molecules were isolated, including eicosanyl 3-Oferuloyl-quinate, isolated from nature for the first time. The molecules of 3α-hydroxyeuph-25-ene and α-amyrin were isolated for the first time from this species [82]. The α-amyrin and its derivatives have presented various biological activities e.g. anti-HIV and anti-acyl coenzyme A: cholesterol acyltransferase (ACAT) activities [83]. Other authors have reported the antifungal activity of β-sitosterol isolated from the methanolic fraction of *M. azedarach* leaves against *Ascochyta rabiei* [84]. A recent study demonstrated by bio-autographic analysis that extracts of *A. senegal* leaves (Acetone, chloroform, ethanol and petroleum ether) possesses antioxidant derivatives (DPPH) and an antibacterial activity against *Pseudomonas aeruginosa*. Analysis revealed antibacterial activity of four fractions of acetone extract, four fractions of chloroform extract, two fractions of ethanolic extracts and four fractions of petroleum-ether extracts. The phytochemical compounds present in the extracts are glycosides, alkaloids and flavonoids. In addition, ethanolic extract was the richest in secondary metabolites and the antibacterial and oxidative activity observed is believed to be related to the presence of its compound groups [85]. However, to date, no molecules have been isolated and identified from the various fractions and certified to be responsible for the activity. Furthermore, methanol and ethanol extracts from the trunk bark of *A. senegal* showed antibacterial activity against *K. pneumoniae*, *Proteus vulgaris*, *Salmonella typhi*, *Salmonella dysenteriae* and *E. coli*. According to the authors, the tannins and saponins contained in the extracts are responsible for the observed activity. In addition, toxicity studies of ethanolic extract from stem bark revealed any significant toxicity against *Artemia salina* [86]. According to some authors, the hexanic fraction of *A. senegal* stem bark is active against respiratory pathogenic bacteria including *Klebsiella pneumonia* and *Streptococcus pneumoniae* [87]. Two flavonoids, namely Vicenin [Apigenin-6,8-bis-C-bis-C-b-D-glucopyranoside] and Quercetin-3-O-rutinoside (Rutin) are most commonly found in the genus *Acacia* [81]. Vicenin *et al*. isolated these flavonoids from *Ocimum sanctum* and showed an antibacterial effect against *Escherichia coli* and *Proteus* with inhibition zone diameters of 18.84 and 17.16 mm respectively [88]. Several authors have reported the antibacterial effect of rutin against *Escherichia coli*, *Proteus vulgaris*, *Shigella sonnei*, *Klebsiella* sp., *Pseudomonas aeruginosa* and *Bacillus subtilis* [89-91]. In addition, the combination of rutin with other flavonoids has shown strong antibacterial

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activity against *Bacillus cereus* and *Salmonella enteritidis* [92]. Ethanolic extract from the leaves of *A. senegal* has decreased the activity of the sucrose enzyme and appears to facilitate the control of carbohydrate hydrolysis and therefore reduces postprandial increases in blood glucose levels in diabetics [93]. Ethyl acetate extract from the bark of the stem of *A. senegal* significantly reduced blood glucose, serum TC, serum TTG, serum LDL, serum urea and creatinine levels, and increased serum HDL levels in alloxane-induced diabetic albino rats [94]. Neutral sugar gums (rhamnose, arabinose and galactose), acids (glucuronic acid and 4-methoxyglucuronic acid), calcium, magnesium, potassium and sodium have been identified [26].

Table 3: Summary of known molecules from *Acacia senegal* (L) Willd.

Organs	Extraction Solvent (s)	Biological Activity	Familly/Molecules	Active molecules isolated	Refs
Leaves	Ethanol	Diabète (reduce the increase in blood sugar levels)			[97]
	80% ethanol	Antioxidant (DPPH) Good cytotoxic activity against Hep G2 Cell line	Phenolic compounds		[93]
	Acetone	Antioxydant/ Antibacterial (*Pseudomonas aeruginosa*)	Carbohydrates, phenol, glycosides, Quinones /anthraquinones, alkaloids, anthocyanins and leuco anthocyanins, volatile oils		[85]
	Chloroform	Antioxidant/ Antibacterial (*Pseudomonas aeruginosa*)	Glycosides, saponins/glycosides, alkaloids, flavonoids		
	Ethanol	Antioxidant/ Antibacterial (*Pseudomonas aeruginosa*)	Carbohydrates, Amino acid and protein, phenols, sterols and steroids, alkaloids, flavonoids, anthocyanins and leucoanthocyanins, volatile oils		
	Petroleum ether	Antioxidant/ Antibacterial (*Pseudomonas aeruginosa*)	Leucoanthocyanin, Glycoside		
Stem Root (heart Wood)	Ethanol, DCM and Ethyl acetate	Antibacterial (*E. coli* and *S. aureus*).	Steroids, triterpenoids, quinic acid diester, cyclohexitol	Ceryl cerotate, Eicosanoic acid, Tetracosanol, Docosanoic acid, 3α-	[82]

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		Antifongical *C. albicans*		Hydroxyeuph-25-ene, α-Amyrin, Stigmasterol, ß-Sitosterol, Betulin-3-O-stearate, Eicosanyl 3-O-feruloyl-quinate, ß-Sitosterol-ß-D-glucoside, D-Pinitol	
Stem Bark	Ethanol, Methanol	No significant toxicity against *Artemia salina*.	Saponin, tannin and Sterols		[86]
		Antibacterial (*K. pneumoniae; P. vulgaris, S. typhi, S. dysenteriae, E. coli*)			
	Ethyl acetate	Diabète	Flavonoids		[94]
	Methanolic	Anthelminthic activity (*Fasciola gigantica*)			[95]
Pods	Ethanol Aqueous	No Antioxidant activity and Enzymatic inhibition			[56]
	Ethanol Aqueous	All extract exhibit high toxicity on Brine shrimp			
	70 % ethanol	Neurotoxicity Hepatotoxicity			[96]
Seeds	70% ethanol	antiatherosclerotic cardioprotective			[98]
	70 % ethanol	Neurotoxicity Hepatotoxicity			[96])

However, the study did not pay any attention to the relationship between activity and the chemical compounds produced by the gum. Methanolic extract from the bark of the stem showed 100% mortality against adult *Fasciola gigantica* worms in vitro at concentrations of 1000, 500 and 250 ppm after 6, 12 and 24 hours respectively [95]. A recent study evaluated the efficiency of Acacia senegal extracts against in improving DEHP-induced liver and brain toxicity. Sprague Dawley rats in which acute hepatotoxicity and neurotoxicity was induced by Di-2- Ethylhexyl phthalate (DEHP), received as oral treatment ethanolic extract at 70% of *A. senegal* pods for 28 days under several conditions. The results showed that the extract of *A. senegal* has an ameliorative effect by restoring the activities of antioxidant enzymes to normal by reducing the level of LPO in both tissues. Also, the extract improved the levels of cerebral amino acids, monoamines and their metabolites [96].

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Acacia seyal

Table 4 also summarizes the molecules or groups of molecules identified from *Acacia seyal* (Del.). Ethanolic extracts (leaves, root bark and trunk) and dichloromethane from *Acacia seyal* showed interesting activity against *Klebsiella pneumoniae* [99]. Previous work on other species of the same genus (*Acacia nilotica* (L.) Willd ex Del., *Acacia sieberiana* DC.) has shown good antibacterial activity against *Escherichia coli* and *Klebsiella pneumoniae* [99]. Many authors have reported of acacia genus, many biologically active compounds e.g. ethyl gallate, octasanol, β-amyrin, α-betulin and flavonoids [100, 101]**.** Concerning *A. seyal*, we have few information on the phytochemical composition of the different parts. However, the authors attribute the activity found by the species to the presence of similar compounds. The methanolic extract from the bark showed good antibacterial activity. Four compounds were isolated (epicatechin, catechin, digallic catechin and β-sitosterol) and tested for their activities. The author indicated that the activity of the isolated compounds was less interesting compared to totum [102]. This shows a synergy of activity between the compounds. In addition, different teams have reported the activity of β-sitosterol on inhibiting the growth of *S. aureus* and *E. coli* [103, 104]. Methanolic extract from the leaves of A. seyal reduced the incidence of green mold (*Penicillium digitatum*) by 56.1% on fruits inoculated per injury. The extract of *A. seyal* revealed a high content of gallic acid, salicylic acid, *p*- coumaric acid, caffeic acid, 3,4 dihydroxy benzoic acid, ferulic acid [105]. Isolated p- coumaric acid from *Nauclea pobeguinii* (Pobeg.) Merr. did not activate against bacteria tested (*E. coli, E. aerogenes, K. pneumoniae, P. aeruginosa, P. stuartii*) at a concentration of 256 µg/mL [106]. In other hand, researchers have reported that caffeic and p-coumaric acid cause membrane damage of 44% and 59%, respectively, in Gram-positive bacteria, *Oenococcus oeni* [107]. Also, p-cumaric and ferulic acids have shown synergistic activity with amikacin against *E. coli, E. aerogenes* and *S. aureus* [108]. Ethyl gallate has shown antibacterial activity and synergistically when combined with tetracycline and fusidic acid against specific resistant and methicillin-sensitive strains of *Staphylococcus aureus* [109]. Ethanolic extracts (leaves, bark) and dichloromethane extract from the bark of *Acacia seyal* showed an activity higher than 85% with respect to the enzyme acetylcholinesterase. Alkaloids are known to have many pharmacological properties, including inhibition of acetylcholinesterase enzyme activity and the author associate the activity with alkaloids [99]. A recent study showed that methanolic extract from the bark of *A. seyal* showed 100% mortality against *Biomphalaria Pfeifferi* at different doses used [110]. The root extract of *A. seyal* has demonstrated antimicrobial activity against fungal and bacterial pathogens [111]. The cytotoxic study of the hydroethanolic extract of the stem bark of *A. seyal* to reduce the protein content of Bcl-xL and Bcl-2 which in turn promotes the intrinsic induction of apoptosis. In addition, the phytochemical analysis of this extract shows that it is rich in pro-apoptotic components such as flavonoids [112]. The structure of the gum of *A. senegal* (L.) and *A. seyal* has recently been revised by methylation analysis and nuclear magnetic resonance (NMR) spectroscopy. It has been found that *A. seyal* gum is more strongly branched than *A. senegal* and is composed of galactopyranosyl bound to 1,3. Galacturonic acid was recently identified for the first time in *A. seyal* [113] (Figure 1-5).

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Tableau 4: Summary of known bioactive molecules from *Acacia seyal* (Del.).

Organs	Extraction Solvent (s)	Biological Activity	Familly/Molecules	Active molecules isolated	References
Leaves	Ethanol Dichlorométhane Ethyl acetate	Inhibition of acetylcholinesterase Anti-inflammatory	nd		[99,114]
		Antibacterial			
	Methanol, acetone, water	Antifungal (*Penicillium digitatum*)	Phenolic compounds	gallic acid, salicylic acid, p-coumaric acid, caffeic acid, 3,4 dihydroxy benzoic acid and ferulic acid	[105,111]
Leaves **Roots**		*E. carotovora*, *P. syringae pv*, *Syringae*, *R. solanacearum*, *S. epidermidis*, *X. campestris pv. Mangiferae indicae*			
Stem Root	Dichloromethane	Antiinflammatory (Inhibition of prostaglandin synthesis)			[99,114]
	Ethyl acetate	Antibacterial			
Stem Bark	méthanol, chloroform water	anti-trichomonal activity			[115]
	Ethanol, Dichloromethane Ethyl acetate	Inhibition of acetylcholinesterase, Antimycobacterial (*M. aurum A +)*			[99,116]
	70% Ethanol	Anti-cancer			[102]
	Ethanol	Antimicrobial *Staphylococcus*	Flavonoids, saponins,		[117]

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		aureus and *Candida albicans* Antioxydant (DPPH)	terpenoids, steroids, alkaloids, phenols and tannins.		
	(Wood) Aqueous, ethyl acetate, chloroform	Antibacterial *Staphylococcus aureus, Escherichia coli and Salmonella*			[118]
	Gum Arabic		Complex of polysaccharides containing calcium, magnesium, potassium salts, protein, gallic, ellagic and chlorogenic acids		[113]
	n-hexane Ethanol	Anticonvulsant	Flavonoids, saponins, terpenoids, steroids, alkaloids, coumarin and tannins.		[119]
	Methanol	Molluscicidal Activity (*Biomphalaria pfeifferi*)			[110]
Fruits	methanol, chloroform water	anti-trichomonal activity			[115]

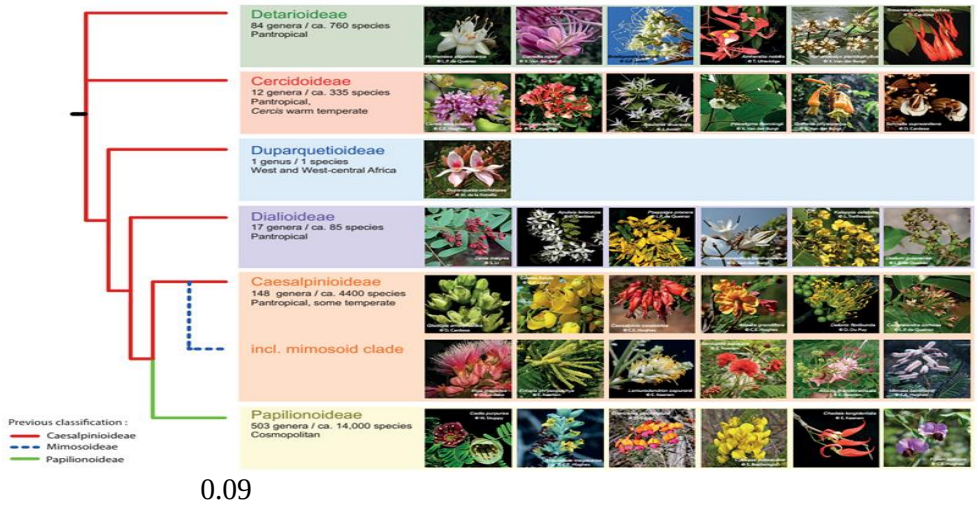

Figure 1: Phylogeny and Classification of *Fabaceae* [20].

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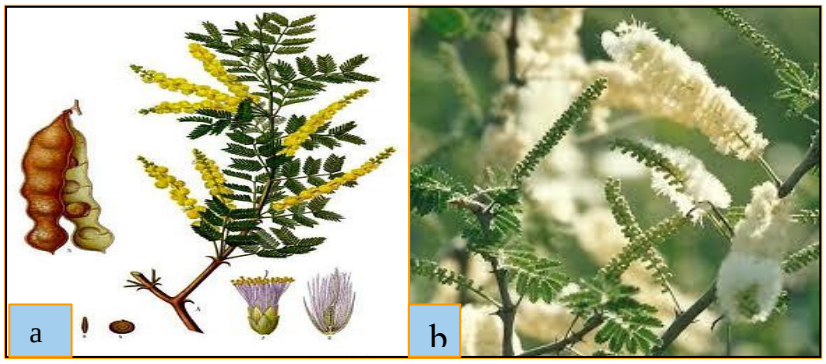

Figure 2: (a) fruit, inflorescence, (b) leaves of *Acacia senegal* (L.) Willd. [Marco Schmidt, (CC BY-NC-SA)].

Figure 3 : (a) leaves, (b) inflorescence of *Acacia seyal* (Delile.) [P. Poilecot].

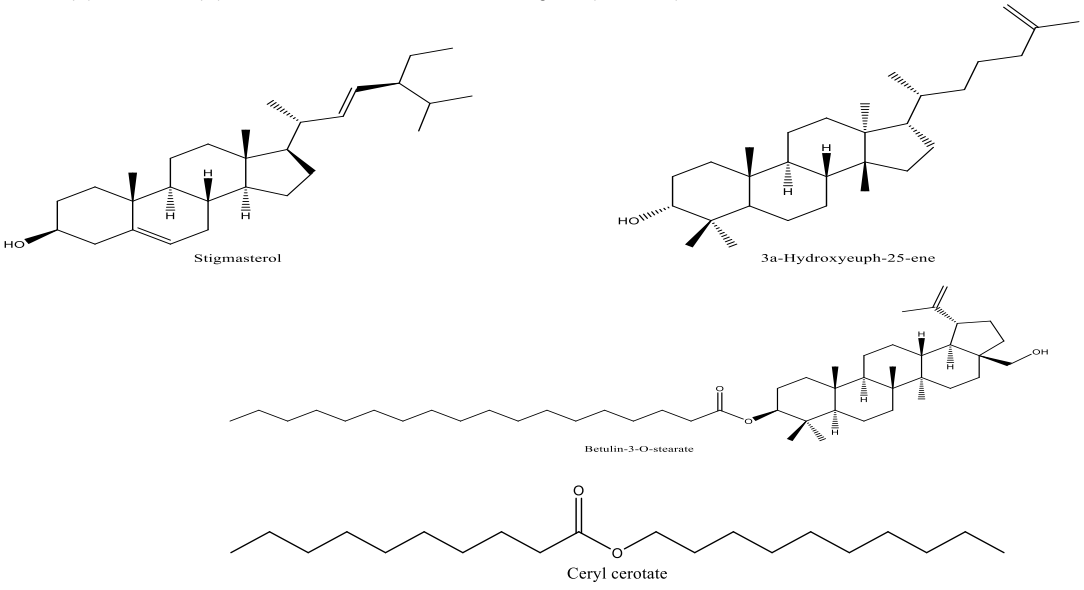

Figure 4: Some molecular structure from *Acacia senegal* (L.) Willd.

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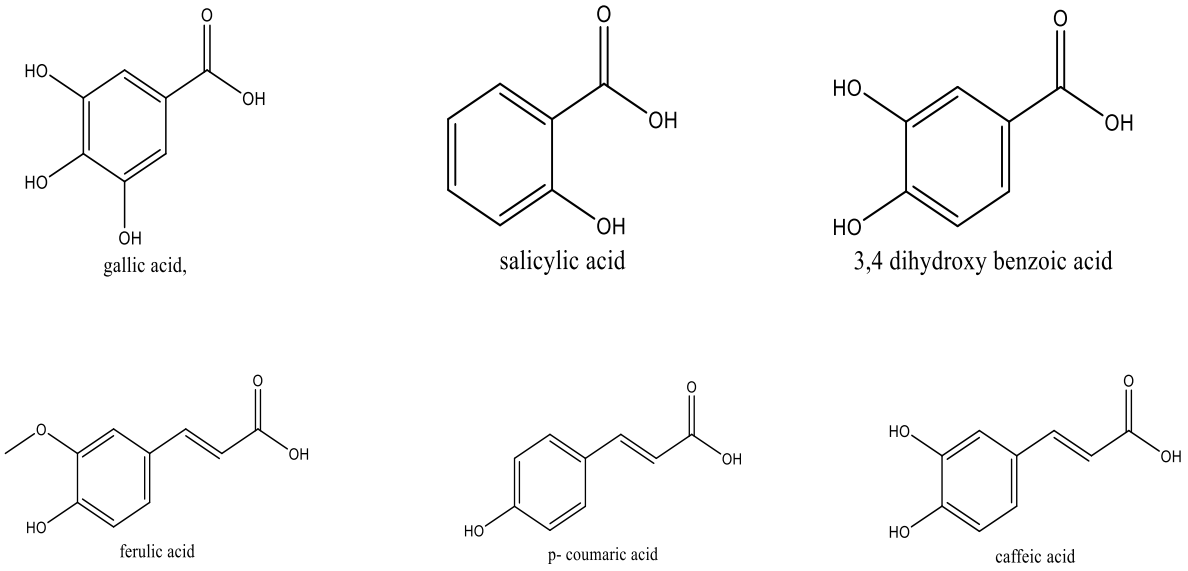

Figure 5: Some molecular structure from *Acacia seyal* (Del.).

Conclusion

This literature review provides an opportunity to learn about the therapeutic potentialities of *Acacia senegal* (L.) Willd. and *Acacia seyal* (Delile.). Although phytochemical knowledge of both species is limited, it appears to be a rich source of various active compounds with a wide range of pharmacological and therapeutic properties. For traditional use, it has become more common for several plants to be used in combination to treat a disease. This shows that the synergy of activity is well known to traditional healers. Among the diseases traditionally managed by *A. senegal* and *A. seyal*, infectious diseases occupy a prominent place. The pharmacological activity is objectively based on empirical experience and with the recent development of tools/methods based on Omics technologies (e.g. genomic, proteomic, transcriptomic, membranomic, etc.), it is important to measure the effects of these natural compounds on the physiology and metabolism of selected targeted cells (cancer cells, parasites, bacteria). Interestingly, this panel of research will be used to characterize the antimicrobial potential of *Acacia* species found in Burkina Faso. With the rise of resistant infections, natural extracts could be assayed in combination with usual antibiotics on multi-resistant bacterial strains (MDR) to formulate future combined therapeutic strategies. To this aim, different approaches could be envisaged in this way. For instance, today a main resistance mechanism is associated with the lack of internal concentration of active antibiotics close to its target [120]. It will be interesting to test the capability of Acacia extracts to permeabilize the bacterial membrane and improve the activity of antibiotics in resistant bacterial strains as previously reported for some other natural products [106, 121, 122]. Alternatively, it will be interesting to use the purified extracts in order to impair the activity of efflux pumps present in multidrug resistant bacteria that expel the antibiotic before it blocks the target [123, 124]. This mode of action has been reported for different natural compounds

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that block or inhibits the antibiotic flux across the pump channel [125-127]. These different perspectives are especially attractive taking into account the methods recently reported that allow measuring the drug transport across bacterial membrane [120]. Another approach can be to research some compound having new activity against bacterial physiology [128, 129]. To conclude, the *Acacia* represents an attractive source for future development of antimicrobial compounds that could be identified and characterized using the new tools available in biochemical, physicochemical and biological domains.

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Authors' contributions

RDM, HMK and AH had collected all data reported. RDM wrote the paper. AH and ADR supervised the study. All authors read and approved the final manuscript.

Availability of data and materials

Data can be requested from the corresponding author.

Ethics approval and consent to participate

All participants were asked for their free prior informed consent.

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