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Medicinal attributes of *Acacia nilotica* Linn. - A comprehensive review on ethnopharmacological claims

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Abstract

Herbal medicine is still the mainstay of about 70-80% of world population, mainly in the developing countries, for primary health care because of better cultural acceptability, better compatibility with human body with lesser side effects. *Acacia nilotica* is also a popular ornamental avenue tree in India. This review aimed at revealing brief account of plant part used, mode of administration, the animal model, description of Pharmacological activity and results concluded for the same.

Key-Words: *Acacia nilotica*, Antimicrobial, Antioxidant, Antispasmodial, Molluscicidal, Antihypertensive, Analgesic & Antiinflammatory activity

Introduction

The World Health Organization (WHO) has listed more than 21,000 plants, which are used for many medicinal purposes around the world (1). They observed that about 74% of 119 plant-derived pharmaceutical medicines are used in modern medicine. It also estimates that 4 billion people (80 percent of the world population) presently use herbal medicine for health care (2).

Over hundreds of years, herbal medicines derived from medicinal plants minerals and organic matter is still the mainstay of about 75–80% of the world's population for health care marketed and gaining popularity in developed and developing countries (3). Herbs have medicinal property due to presence of different active principles like alkaloids, volatile essential oils, glycosides, resins, oleoresins, steroids, tannins, terpenes and phenols (4). In the last few years there is an exponential growth in the field of herbal medicine because of their natural origin, easy availability, efficacy, safety and less side effects with efficient to cure age-related disorders like memory loss, osteoporosis, immune disorders, etc. for which no modern medicine is available. (5,6).

Medicinal plant researchers pursued with several goals like the development of low cost therapeutic compounds and the discovery of prototypic drugs (7). *Acacia nilotica* (L.) Willd. ex Del. is also known as Gum Arabic tree, Babul, Egyptian thorn, or Prickly Acacia is multipurpose nitrogen fixing tree legume. It occurs from sea level to over 2000m and withstand at extreme temperature (>50° C) and air dryness but sensitive to frost when it is young (8). It is widely spread in subtropical and tropical Africa from Egypt to Mauritania southwards to South Africa, and in Asia eastwards to Pakistan and India (9, 10).

Taxonomical classification

Kingdom	:	Plantae
Subkingdom	:	Tracheobionta
Super division	:	Spermatophyta
Division	:	Magnoliophyta
Class	:	Magnoliopsida
Subclass	:	Rosidae
Order	:	Fabales
Family	:	Fabaceae
Genus	:	*Acacia*
Species	:	*nilotica*

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Origin and distribution

The species is widespread in Africa and Asia, and occurs in Australia and Kenya. Indian gum Arabic tree is found in well watered Sahelian and Sudanian savannas to the southern Arabian Peninsula, East Africa and in the Gambia, the Sudan, Togo, Ghana, and Nigeria. It is widely cultivated in the Indian subcontinent, and also found on lateritic soil in the Himalayan foothills in India

Plant description

Acacia nilotica is a single stemmed plant, grows to 15-18 m in height and 2-3 m in diameter. Pods and Seeds: Pods are 7-15 cm long, green and tomentose (when immature) or greenish black (when mature), indehiscent, deeply constricted between the seed giving a necklace appearance. Seeds are 8-12 per pod, compressed, ovoid, dark brown shining with hard testa (11). Leaves: The leaves are bipinnate, pinnate 3-10 pairs, 1.3- 3.8 cm long, leaflets 10-20 pairs, and 2-5mm long (12). Flowers: Flowers are globular heads, 1.2-1.5 cm in diameter of a bright golden yellow colour, develop either in axillary or whorly pattern on peduncles 2-3 cm long located at the end of branches (8). Stem: Stems are usually dark to black coloured, deep longitudinal fissured, grey-pinkish slash, exuding a reddish low quality gum (13). Bark: The bark a tinge of orange and/or green (young tree), but older trees have dark, rough bark and tend to lose their thorns (14). Thorns: Thorns are thin, straight, light grey exist in axillary pairs (usually 3-12), 5-7.5 cm long in young trees. Root: Root is generally of brown colour in older and whitish in younger regions. Gum: The gum varies in colour from very pale yellowish brown to dark reddish brown depending on the quantity of tannins in the sample. The lighter, more highly valued gums are soluble in water and very viscous; the tannins in the darker gum reduce the solubility. The gum has a moisture content of about 13% and is slightly dextrorotary (15).

Growth pattern and germination

Acacia nilotica is a tropical species found throughout India and occurs from sea-level to over 2000 m altitude. Prickly Acacia germinates in rainfall in the wet season. But some seeds may still germinate up to 15 years after seed drop. Seedlings grow rapidly near water but more slowly in open grasslands. It grows in average annual temperatures range from 15–28°C, being frost sensitive when young and withstanding daily maximum temperatures of 50°C. (16) The mean maximum temperature of the hottest month is 25–42ºC and the mean minimum temperature of the coldest month 6–23°C. Babul plant prefers dry conditions, with an annual rainfall of (100–) 250–1500(–2300) mm. This subspecies is commonly found on soils with high clay content, but may grow on deep sandy loam in areas of higher rainfall. It commonly grows close to waterways on seasonally flooded river flats and tolerates salinity well (17).

Trees can flower and fruit two to three years after germination, but after high rainfall it is more quickly, usually between March and June (18). Pods are formed between July and December. Most leaf fall between June and November and seed pods drop during October to January (19). Seeds are very simple. Inner integument degenerates completely and the testa is formed by the outer integument (20, 21). Meharia (2005) has observed that *A. nilotica* is more productive than *A. tortilis* after slat treatment. It grows well in two types of soils i.e. riverian alluvial soil and black cotton soil (22).

Major chemical constituents

Acacia species contains secondary metabolites (Figure 1) including amines and alkaloids, cyanogenic glycosides, cyclitols, fatty acids and seed oils, fluoroacetate, gums, nonprotein amino acids, terpenes (including essential oils, diterpenes, phytosterol and triterpene genins and saponins), hydrolyzable tannins, flavonoids and condensed tannins (23). The plant is richer source of cystine, methionine, threonine, lysine, tryptophan, Potassium, phosphorus, magnesium, iron and manganese (24). The plant chemical compounds like diester, pentacosane dioic acid dihexadecyl ester and is alcohol, heptacosane 1, 2, 3-triol (25). Seeds: It contain high percentage of phenolic constituents consisting of m-digallic acid, gallic acid, protocatechuic and ellagic acids, leucocyanidin, m-digallic dimer 3,4,5,7-tetrahydroxy flavan-3-ol, oligomer 3,4,7- trihydroxy flavan 3,4-diol and 3,4,5,7-tetrahydroxy flavan-3-ol and (-) epicatechol. The mature seed also contains crude protein, crude fibre, crude fat, carbohydrates, potassium, phosphorus, magnesium, iron and manganese occurred in high concentrations and it is richer source of cystine, methionine, threonine, lysine and tryptophan. Fruit also contains mucilage and saponins (26, 27). Pods: It contains gallic acid & its Me-este-n-digallic acid and condensed tannins. Leaf: It contain apigenin, 6-8-bis-D-glucoside, rutin, 8% digestive protein (12.4% crude protein). Relative levels of tannin in different parts of plant is, deseeded pods (50%), pods (5.4%), leaves (7.6%), bark (13.5%) and twigs (15.8%) (28). Bark: It contains tannin (12-20%), terpenoids, saponins and glycosides, Phlobetannin, gallic acid, protocatechuic acid pyrocatechol, (+) – catechin, (-) epigallocatechin-5,7-digallate (29). Its extract contains total phenolic content ranging from 9.2 to 16.5 g/100 g (30). Root: It

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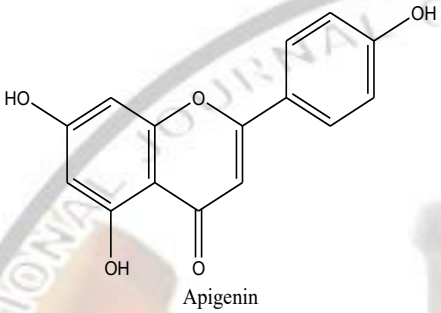
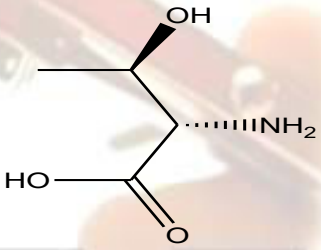
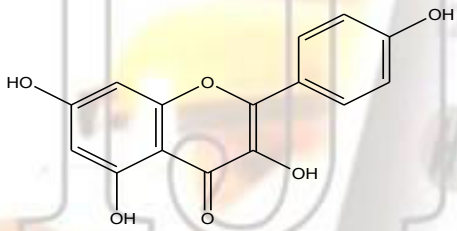
contains octaconsanol, betulin, B-amyrin and B-sitosterol. Gum: It is composed of galactoaraban which gives on hydrolysis L-arabinose, D-galactose, L-rhamnose, D-glucuronic acid and 4-O-methyl- D-glucuronic acid.



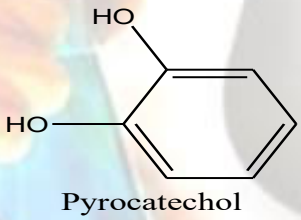
Apigenin



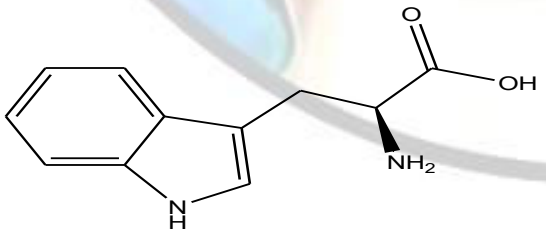
Threonine



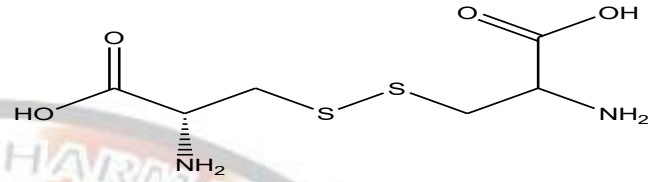
Kaempferol



Pyrocatechol

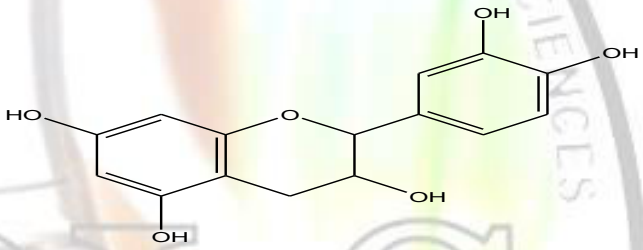


Tryptophan

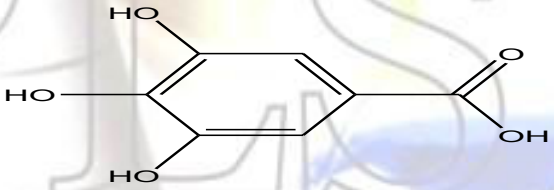


Cystine

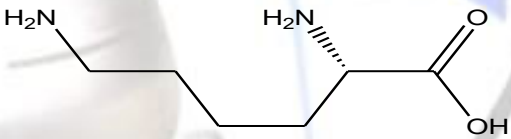
Cyanidin



Catechin



Gallic acid



Lysine

Fig. 1: Phytochemicals in *Acacia nilotica* Linn.

Traditional claims

Acacia nilotica is a pioneer species, relatively high in bioactive secondary compound and are important for a variety of functions is economically used as a source of tannins, gums, timber, fuel and fodder (31, 32). Babul plant is therapeutic used as Anti-cancer, anti tumours, Antiscorbutic, Astringent, anti-oxidant, Natriuretic, Antispasmodial, Diuretic, Intestinal pains and diarrhea, Nerve stimulant, Cold, Congestion, Coughs, Dysenter,

Fever, Hemorrhages, Leucorrhea, Ophthalmia and Sclerosis (33). Seed: seeds have antimalarial, antidiabetic, antihypertensive and antispasmodic activities. Leaves & Pod: The leaves and pods are an excellent fodder with antiinflammatory properties, rich in protein. The pods have molluscicidal and algicidal properties. Bark: It is used in the treatment of hemorrhages, cold, diarrhea, tuberculosis and leprosy. Root: it is used as an aphrodisiac and the flowers for treating syphilis lesions. Gum: Gum obtains from the tree is pharmaceutically used as suspending and emulsifying agent and in preparation of many formulations. Its resins repel insects and water (34).

Ethnopharmacological claims

Antimicrobial Activity: G. O. Solomon-Wisdom et al (2010) has investigated *in vitro* antimicrobial activity of the crude ethanolic leaf extract of *Acacia nilotica* linn against *Campylobacter coli* isolated from goats. The highest zone of inhibition was observed with the 70 mg/ml concentration (35). Banso A (2009) has studied the antimicrobial activity of ethanolic extracts of the stem bark against *Streptococcus viridans*, *Staphylococcus aureus*, *Escherichia coli*, *Bacillus subtilis* and *Shigella sonnei* using the agar diffusion method and found the minimum inhibitory concentration of the stem bark extract of the plant ranged between 35 and 50 mg/ml while the minimum bactericidal concentration ranged between 35 and 60 mg/ml (25). Khan R et al (2009) has explored the antimicrobial activities of the crude ethanolic extracts of five plants against multidrug resistant (MDR) strains of *Escherichia coli, Klebsiella pneumoniae* and *Candida albicans and* ATCC strains of *Streptococcus mutans, and different stains of microorganism* and *A. nilotica has* minimum Inhibitory Concentration range 9.75-313Âµg/ml (36). Mashram N et al (2009) has observed the anti microbial activity of *Acacia nilotica,* against *S. aureus, B. subtilis* and *E. coli.* The leaf and bark extracts showed zone of inhibition between 7.5-16 and 8-15.5 mm respectively and most active against *E. coli* (37).

Antibacterial Activity: B. Mahesh et al (2008) has observed antibacterial activity study of methanolic extracts of *Acacia nilotica,* showed highest antibacterial activity *against B. subtilis.* and *Staphylococcus aureus* with inhibition zone 15±0.66mm and leaf extract showed highest activity against *Bacillus subtilis* with inhibition zone 20±1.20mm (38). Mohan Lal Saini et al (2008) examined comparative antimicrobial studies of *Acacia* species and *A. nilotica* exhibited highest activity against three bacterial (*Escherichia coli, Staphylococcus aureus* and *Salmonella typhi*) and two fungal strain (*Candida albicans* and *Aspergillus niger*) (33).

Antifungal activity and Antiviral activity: *Acacia nilotica* species can be regarded as promising resources for antibacterial drugs due to its highly active nature. B. Mahesh et al (2008) have showed antifungal activity of methanolic extracts and aqueous extract of *A. nilotica* with percentage inhibition ranging from 34.27± 1.45 to 93.35±1.99 (38,39). Dried fruits of *Acacia nilotica* are active against *C. albicans* and used to treat oral candidiasis (Candice V. W., et.al. 2009). Methanolic extract of the plant is active against two animal viruses: Newcastle Disease and Fowl pox Viruses (40).

Antibiotic activity: The plant extract showed potent antibiotic activity against four bacterial species: gram positive; *Bacillus subtilis*, *Staphylococcus albus*, *Streptococcus faecalis*; gram negative, *Escherichia coli* and two fungal species: *Candida albicans* and *Aspergillus flavus* examine by using paper disc diffusion method (41).

Antimalarial activity: The root extracts of *A. nilotica* was active against *Plasmodium berghei* and *Plasmodium falciparum* in mice (42). *In vitro* Antimalarial activity against CQ sensitive (3D7) and CQ-resistant (Dd2 and INDO) strains of *P. falciparum* in culture using the fluorescence-based SYBR. *A. nilotica* was reported with significant activity and IC50 was found as 13µg/mL (43). Crude methanolic extracts of root of *Acacia nilotica* Del. demonstrated significant activity against chloroquine sensitive strain of *Plasmodium berghei* in mice. (Ali A., 2010). Ethyl acetate extract of *Acacia nilotica* have highest antiplasmodial activity *in vitro* against *Plasmodium falciparum* 3D (chloroquine sensitive) and Dd2 (chloroquine resistant and pyrimethamine sensitive) organisms (43).

Anti-Diarrhea Activity: *Acacia nilotica* has been reported to be very useful in treating diarrhea and cough in human (44). The powdered bark of the plant with little salt is used for treating acute diarrhea (45). Methanol and chloroform extracts exhibit activity against *Escherichia coli* by using the agar-well diffusion assay method having Minimum Inhibitory Concentration as 50ìg/ml. (46). Abdulkarim A et al (2005) reported antidiarrhoeal activity of ethyl acetate fraction *A. nilotica* in castor oil-induced model. It reduces the number of unformed faeces and decreased the intestinal transit of charcoal (47).

Antioxidant Activity: *Acacia* species are rich source of polyphenolic compounds, known to have strong antioxidant properties that help in prevention and therapy of various oxidative stress related diseases

including cardiovascular, neurodegenerative and cancer (48). Methanolic extract of the plant containing keampherol which is responsible for antioxidant activity of the plant (49). *Acacia nilotica* showed anti-denaturation percentage inhibition of 97% at 1µg/ml, whereas the standard drug (Diclofenac sodium) showed a percentage inhibition of 66%. *Acacia nilotica* reduces this oxidative stress due to production of reactive oxygen species (ROS) (50). *In vitro* antioxidant activities of ethyl acetate extract/fractions of plant were studied in rat tissue homogenate and it was also found that the antioxidative activity increased with increasing extract/fractions concentration (48). Methanolic extract of plant have anti-oxidant activity which was found to be 9.88µg/ml, (51). Different extracts of bark of *Acacia nilotica* linn exhibited inhibition of oxidation of linoleic acid 44–90% while DPPH radical scavenging activity ranged from 49% to 87% (52). *Acacia nilotica* bark extract also increase the antioxidant enzymes [viz., catalase (CAT), superoxide dismutase (SOD), glutathione peroxidase (GPx), and glutathione-*S*-transferase (GST)] activities in the liver of *N*-nitrosodiethylamine -administered rats.

Spasmogenic activity & Antispasmodial activity: The aqueous extract of seeds of *Acacia nilotica* shows spasmogenic activity on the isolated guinea-pig ileum. The mechanism behind it may be increase in calcium influx that results in muscle spasm (53). *Acacia nilotica* (methanolic extract) inhibited the spontaneous contraction of rabbit jejunum in a dose-dependent (0.1–3.0 mg/mL) manner. It also inhibit K^+-induced contractions, The mechanism behind it is calcium channel blockade that results in lowering of blood pressure effect (54).

Molluscicidal properties: Yousif M. (2009) has observed that lethal doses of plant that caused 100% mortality (LC100) of the adult *B. truncatus* snails were 112.50 ppm (55). Ayoub, S. M. (1982). *Acacia nilotica* have demonstrated the highest Molluscicidal Properties due to tannin activity (18-23%) (56). Hussein Ayoub (1985) exhibited highest activity using acetone, alcohol and aqueous extracts of the fruits and stem bark of these species are reported against the two snail species which host schistosomes in the Sudan i.e.*B. truncatus* and *B. pfeifferi* (57).

Antihypertensive activity & Vasoconstriction activity: Methanol extract of *Acacia nilotica* pods causes decrease in arterial blood pressure at dose (3–30 mg/kg). It produces an inhibitory effect on force and rate of contraction in guinea-pig paired atria (58). Aqueous extract of *Acacia nilotica* possess vasoconstriction by increasing calcium ion influx which are responsible for vasoconstriction action in guinea-pig ileum. The extract shows dose-dependent sustained contractile activity (53).

Anti-mutagenic activity: Gallic acid and polyphenols present in acetone extract of the plant are responsible for the antimutagenic activity (59). Acetone extract of *Acacia nilotica* exhibited antimutagenic activity against direct acting mutagens (NPD, sodium azide), and the S9-dependent mutagen 2-aminofluorene (2AF). The activity is estimated by employing the plate incorporation Ames Salmonella histidine reversion assay by using different strains of Salmonella typhimurium (60).

Cytotoxic activity& Anti-hepetocarcinogenic activity: *Acacia nilotica* acetone extract exhibit cytotoxic activity which is increased by gallic acid and other polyphenols (59). *Acacia nilotica* bark extract prevented hepatic malondialdehyde (MDA) formation and reduced glutathione (GSH) in *N*-nitrosodiethylamine treated rats. It reduced liver injury and restored liver cancer markers (61)

Anthelmintic, Analgesic & Anti-inflammatory activity *In vitro* methanolic extract of *Acacia nilotica* fruit exhibit anthelmintic activity against *Haemonchus contortus* at LC_{50} = 512.86 and 194.98 µg/ml concentration by the adultmotility assay, the egg hatch test and the larval development assay (62). The analgesic effect of *A. nilotica* against control is examined against acetic acid induced pain in rat. The potent activity was exhibited by plant. It shows high percentages of analgesia at the two doses (150, 300mg/kg bw) of plant extracts used. The anti-inflammatory activity of *A. nilotica* extract was tested using egg albumin induced paw oedema inflammation in rats It indicates the absence of paw oedema suppression and hence lack of anti inflammatory activity. The extracts did not however suppress paw oedema (42).

Milk production: Traditionally *Acacia nilotica* ssp *adansonii* (AN) can stimulate milk production in lactating women. The activity performed to determine the effect of an aqueous extract of AN on milk production in rats. The milk production is improved by 59% in first hour in rat (63).

Antiplatelet Aggregatory & Anti-quorum sensing Activity: The extract of the plant block platelet aggregation mediated by platelet agonists, arachidonic acid, ADP, platelet activating factor and collagen. It blocks aggregation of platelet induced by Ca^{+2}-channel (64).The activity is shown by HEF (pH 4) and HCF obtains from various extract of Acacia nilotica (65).

Conclusion

In the present comprehensive review, we referred primary and secondary data to compile the information

based on taxonomy, origin, distribution, description, phytoconstituents, traditional and pharmacological claims on *Acacia nilotica* (L.). Traditionally the plant used widely for the treatment of various ailments, but scientifically few of them was screened out. Thus the scientific studies should be conducted to investigate the unexploited potential of *Acacia nilotica* (L.).

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