Phytochemistry and Pharmacological Attributes of Thar Tree - Babool [*A. nilotica* (L.) Del.]: An Exhaustive Survey for Extraordinary Commercial Worth

By

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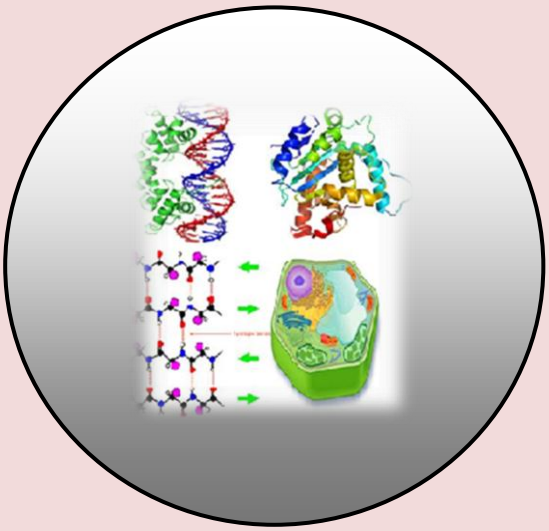

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Phytochemistry and Pharmacological Attributes of Thar Tree - Babool [*A. nilotica* (L.) Del.]: An Exhaustive Survey for Extraordinary Commercial Worth

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ABSTARCT

The use of herbal products for the prevention and treatment of numerous ailments and disorders in human beings as well as in animals has been in practice from prehistoric time. Herbal remedies is still the foundation of about 60-80% of world population, mainly in the developing countries as well as in developed countries for primary health care because of its better acceptability, better compatibility with human body as well in animals with minimum side effects and easy availability and economically affordable. Babool (Acacia nilotica), a very common and popular tree is widely used for the treatment of various diseases and maladies like in skin, sexual disorders, stomach and tooth problems etc. in human beings as well as in animals. Acacia species contains amines and alkaloids, glycosides, fatty acids and seed oils, fluoroacetate, gums, nonprotein amino acids, terpenes, diterpenes, phytosterol and triterpene, saponins, hydrolyzable tannins, flavonoids and condensed tannins. The plant is richer source of amino acids viz. cystine, methionine, threonine, lysine, tryptophan, minerals viz. K, P, Mg, Fe, and Mn. The plant chemical compounds include diester, pentacosane dioic acid dihexadecyl ester andheptacosane 1, 2, 3-triol. Seeds contain phenolic compounds consisting digallic acid, gallic acid, protocatechuic and ellagic acids, leucocyanidin, 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. Fruit also contains mucilage and saponins. Pods contain gallic acid and condensed tannins. Leaf contains apigenin, 6-8-bis-D-glucoside, rutin, 8% digestive protein.

Bark contains tannin, terpenoids, saponins and glycosides, Phlobetannin, gallic acid, protocatechuic acid pyrocatechol. Root contains octaconsanol, betulin, B-amyrin and B-sitosterol. Gum is composed of galactoaraban. In this comprehensive review authors briefly reviewed the ethnobotanical as well as therapeutic uses of Acacia nilotica with traditional uses and phytoconstituents occurring in various parts of babool tree.
Keywords: Acacia nilotica, Antispasmodial, Phytoconstituents, Pharmacological attributes, and Traditiona usage.

INTRODUCTION

Babool [*Acacia nilotica* (L.) Willd. ex Del.] has been recognized worldwide as a multipurpose tree is also known as Gum Arabic tree, Egyptian thorn, or Prickly Acacia is multipurpose nitrogen fixing tree legume. It is widely distributed throughout dry and semi dry zones of the world including India. It occurs from sea level to over 2000m and withstand at extreme temperature (>50^{o}C) and air dryness but sensitive to frost when it is young. It is indigenously known as 'Babool' or 'Kikar' is a proverbial, medium sized tree and is broadly scattered (Sadiq MB. et al., 2015; Rather LJ. et al., 2015; Safedi R. et. al., 2020; Ali A. et. al., 2012). Traditionally the plant used widely for the treatment of various ailments, but scientifically few of them were investigated out. An exhaustive survey of literature has revealed that tannins, flavonoids, alkaloids, fatty acids and polysaccharides (gums) constitute major classes of phytoconstituents of this plant. Through this review authors have tried to explore the therapeutic potential of *A. nilotica* (1) and thus may be a promising rout for new, safe, biodegradable and renewable source of drugs with high therapeutic index. Babool is a source of many active secondary metabolites which may serve as potential candidates for drug development with greatest possibility of success in near future (Al-Mustafa & Dafallah 2000; Anderson & Karamal 1996; Ayoub SM. 1982; Baig JA. et.al., 2010; Banerji R. et .al., 1988; Bansal & Goel 2012; Banso A. 2009).

Figure 1. Babool Tree & its various parts viz leaves, flowers, spines & bark powder & gum.

In accordance with traditional description *A. nilotica* has a rich amount of nutrients and contains a high therapeutic value which is capable of prevention, mitigation, and treatment of various infectious diseases and deleterious conditions. The studies based on the animal model established that *A. nilotica* and its chief phytoconstituents play a pivotal role in anti-bacterial, anti-inflammatory, anti-diabetic, anti-cancer, and anti-hypertensive management. It is considered a safe medicinal plant and modulates the numerous therapeutic actions without any adverse effect Bapna S. et.al., 2014; Baravkar AA. et.al., 2008; Bargali & Bargali, 2009; Bashir HS. et. al., 2014; Bhargava A. et.al., 1998; Chalk RC. et.al., 1968). This comprehensive review has been compiled encircling the efficacy of this plant in all proportions from the literature. Its stretchy utility as a medicine forced the authors to bridge the information gap in this area and to write a comprehensive review on the medicinal, phytochemical and pharmacological mannerisms of this plant of extraordinary commercial worth (Fig. 2).

Figure 2. Babool pods, peeled bark, seeds.

Phytochemistry and Therapeutic Repercussions of *A. nilotica*

Acacia species contains amines and alkaloids, glycosides, fatty acids and seed oils, fluoroacetate, gums, nonprotein amino acids, terpenes, diterpenes, phytosterol and triterpene, saponins, hydrolyzable tannins, flavonoids and condensed tannins. The plant is richer source of amino acids viz. cystine, methionine, threonine, lysine, tryptophan, minerals viz. K, P, Mg, Fe, and Mn. The plant chemical compounds include diester, pentacosane dioic acid dihexadecyl ester andheptacosane 1, 2, 3-triol. Seeds contain phenolic compounds which 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. Fruit also contains mucilage and saponins (Chaubal R. et. al., 2003; Chaubal R. et al., 2005; Dev SNC. et. al., 2014; Dhabhai & Batra ., 2012; Dude JS. et. al., 2011; Eldeen IM.et.al., 2010; El-Tahir A. et.al., 2011 El-toumy S A. et.al., 2011).

Pods contain gallic acid and condensed tannins. Leaf contains apigenin, 6-8-bis-D-glucoside, rutin, 8% digestive protein. Relative levels of tannin in different parts of plant is, deseeded pods (50%), leaves (7.6%), bark (13.5%) and twigs (15.8%). Bark contains tannin (12-20%), terpenoids, saponins and glycosides, Phlobetannin, gallic acid, protocatechuic acid pyrocatechol. Root contains octaconsanol, betulin, B-amyrin and B-sitosterol. Gum is composed of galactoaraban. Major chemical constituents Acacia species contains secondary metabolites 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. The plant chemical compounds like diester, pentacosane dioic acid dihexadecyl ester and is alcohol, heptacosane 1, 2, 3-triol. Seeds contain high percentage of phenolic constituents consisting of m-digallic acid, gallic acid, protocatechuic and ellagic acids, leucocyanidin, mdigallic 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 (Jangade NM. et. al., 2014; Jigam AA. et. al., 2010; Kalaivani & Mathew., 2010; Kalaivani T. et al., 2011; Kapoor & Farooqi MIH., 1991; Kaur K. et al., 2010; Leela V. et al., 2010; Malan E., 1991; Malan & Roux ., 1975; Mamta K. et al., 2014; Manish S. et al., 2014; Mbatchou&Oumar., 2012; Misar A. e.t al., 2008). 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 saponin. It contains gallic acid & its Me-este-n-digallic acid and condensed tannins. Leaf contains apigenin, 6-8-bisD-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, (-) epigallocatechin5,7-digallate (29). Its extract contains total phenolic content ranging from 9.2 to 16.5 g/100 g (30). Root: It contains octaconsanol, betulin, B-amyrin and Bsitosterol. Gum: It is composed of galactoaraban which gives on hydrolysis L-arabinose, D-galactose, Lrhamnose, D-glucuronic acid and 4-O-methyl- Dglucuronic acid 39. Mohammad R. et al., 2014; Motlagh S. et al., 2013; Rasool N. et al., 2013; Sahai R. et. al., 1980; Santhi T. et al., 2014; Sarkiyayi & Abdulrasheed., 2013; Shaw & Hooker ., 2008; Amoussa AMO. et. al., 2020; Singh BN. et.al., 2009a; Bashir HS. et al., 2015; Rather & Mohammad., 2015; Rajvaidhya S. et al., 2015; Sadiq MB. et. al., 2015). Pharmacological data base reports have revealed significant anti-inflammatory, antioxidant, antidiarrhoeal, antihypertensive and antispasmodic, antibacterial, anthelmintic, antiplatelet aggregatory, anticancer and acetyl cholinesterase (AChE) inhibitory activities.Different parts of this plant such as the leaves, roots, seeds, bark, fruits, flowers, gum and immature pods act as anti-cancer, antimutagenic, spasmogenic, vasoconstrictor, anti-pyretic, anti-asthamatic, cytotoxic, anti-diabetic, anti-platelet agregatory, anti-plasmodial, molluscicidal, anti-fungal, inhibitory activity against Hepatitis C virus (HCV) and human immunodeficiency virus (HIV)-I and antioxidant activities, anti-bacterial, antihypertensive and anti-spasmodic activities, and are also engaged for the treatment of different ailments in the indigenous system of medicine. 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. Seed have antimalarial, antidiabetic, antihypertensive and antispasmodic activities (Katiyar S. et al., 2013; Kalaivani & Mathew., 2010; Bansal & Goel., 2012; Auwal MS. et. al., 2014; Sharma M. et. al., 2014; Singh BN. et al., 2009; Abbasian K. et al., 2015; Tindale & Roux., 1969; Jingade NM. et al., 2014; Anderson & Karamal., 1996; Kapoor VP. et al., 1991; Salem M. et al., 2011; Srivastava M. et al., 2014; Kumar M. et al., 2015; Gmaraldeen SM. et. al., 2016; Das & Chatterjee., 2014; Eldeen IM. et al., 2010).

Chemical Constituents

During the seven past decades, about 152 chemical constituents were isolated from the genus Acacia, including flavonoids (Fig. 3), terpenoids and phytosterols (Fig. 4), phenolic acids (Fig. 5), fatty acids (Fig. 6: 100-110), hydrocarbons (Fig. 7) and others compounds (Fig. 8; Fig. 9). Flavonoids, terpenoids and phenolic acids are the predominant compounds isolated from this genus. Flavonoids: Many flavonol, flavone, chalcone derivatives, flavan-3-ols and flavan-3,4-diols, which constitute the majority of the secondary metabolites from the genus Acacia have been reported several reserchers. Among them, 6 compounds, 31, 32, 35, 36, 41 and 43 were isolated as glycosides. The most frequently encountered flavonoids are catechin (17) found in six species and quercetin (5) in five species. Also, Isoliquiritigenin (1), myricetin-3-O-α-L-rhamnoside (36) and Rutin (43) were relatively common. Most flavones (6, 4, 10-15, 34 and 44) reported from Acacia genus were isolated from A. confuse.The triterpenoids are the major class of terpenoids isolated from the genus Acacia. Twenty two triterpenoids (53-74) have been reported. Sixteen triterpenoids (53-55, 57-64, 67-68, 70, 73 and 74) have been isolated from A. mellifera, 4, 56, 68, 69 and 74 from A. ataxacantha, three, 56, 67 and 74 from A. modesta, two, 65, 71 from A. saligna, two, 67, 72 from A. raddiana and Acacigenin B (66) from A. concinna. Additionally, four sesquiterpenoids (49-52), two diterpenoids (47 and 48) and two monoterpenoids (45 and 46) were also isolated (Singh R. et al., 2010; Amos S. et al., 1999; Abuelgassim OA., 2013; Sadiq MB. et al., 2017; Alli LA. et al., 2014; Misar A. et al., 2008; Gilani AH. et al., 1999; Al-Mustafa & Dafallah., 2000; Malviya S. et al., 2011;. Pande MB., 1981).

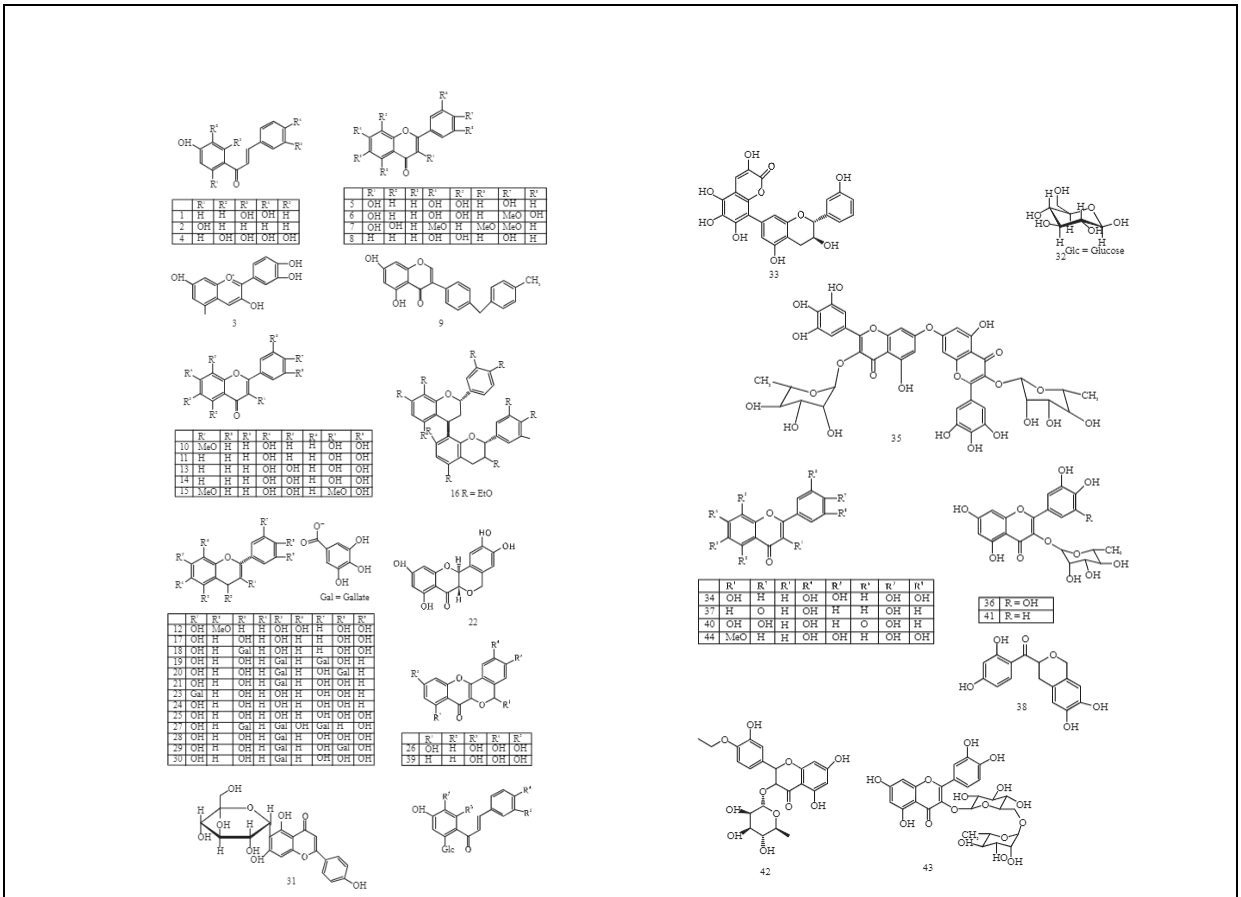


Figure 3. Chemical Structures of flavonoids extracted from genus *Acacia*.

The 3-acetyl-β-Sitosterol (75), β-Sitosterol (76) and g-Sitosterol (77) were identified from A. raddiana, A. modesta and A. karroo. Compound 78 belonging to the sitosterol derivative was also obtained from Acacia nilotica. Many gallic acid derivatives (79-81, 88, 90-92 and 94) and coumaric acid derivatives (96 and 97) have been isolated since 2008. These phenolic acid derivatives were predominantly isolated from A. nilotica and A. arabica. The most of fatty acids which were found in the genus Acacia, were isolated from A. nilotica (100-104, 107-110) and A. Arabica (104-106). Hydrocarbons: To date, 13 hydrocarbons, 111-123 have been reported in the genus Acacia , mainly isolated from A. nilotica and A. modesta species. The others constituents found in the genus Acacia, contain saponosides such as; Spirostane saponin (150), alkaloids, N-methyltryptamine (142), Tryptamine (151) and peptides, γ-Glutamylalbizziine (139), γ-Glutamylasparagine (140). Most of these compounds were isolated from Acacia nilotica species. Recently, Acthaside (7-hydroxy-2-methyl-6-[β-galactopyranosyl-propyl]-4H-chromen-4-one). From Acacia ataxacantha, a new chromen derivative (152) was also isolated (Siddhuraju P. et al., 1996; Gadilohar NR. et al., 2018; Rajbir S. et al., 2008; Pande MB., 1981; Siddhuraju P. et al., 1996; . Wassel GM., 1990; Chaubal & Tambe., 2006).

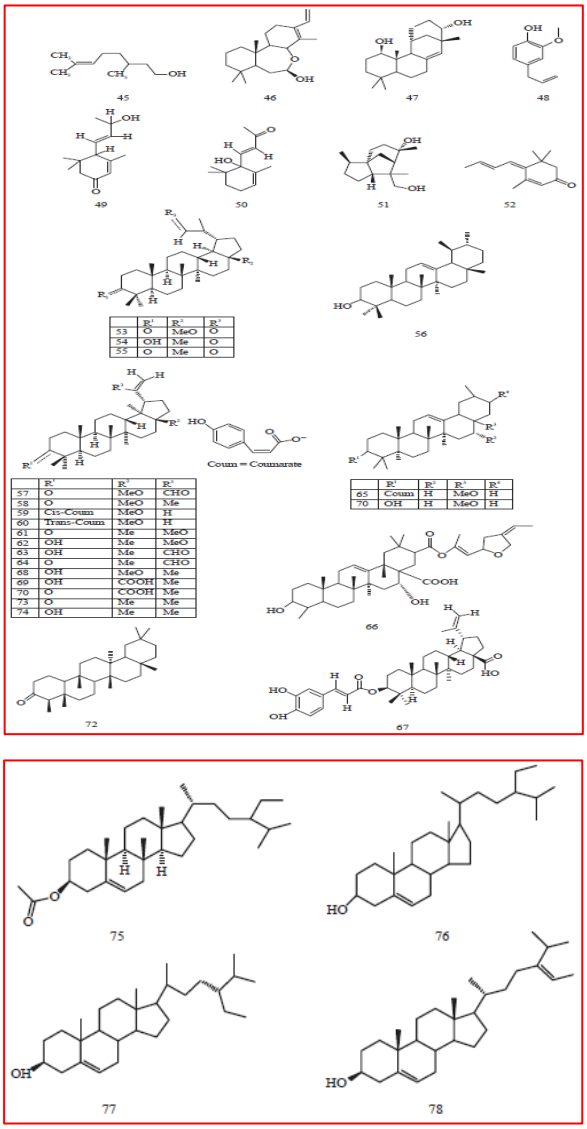
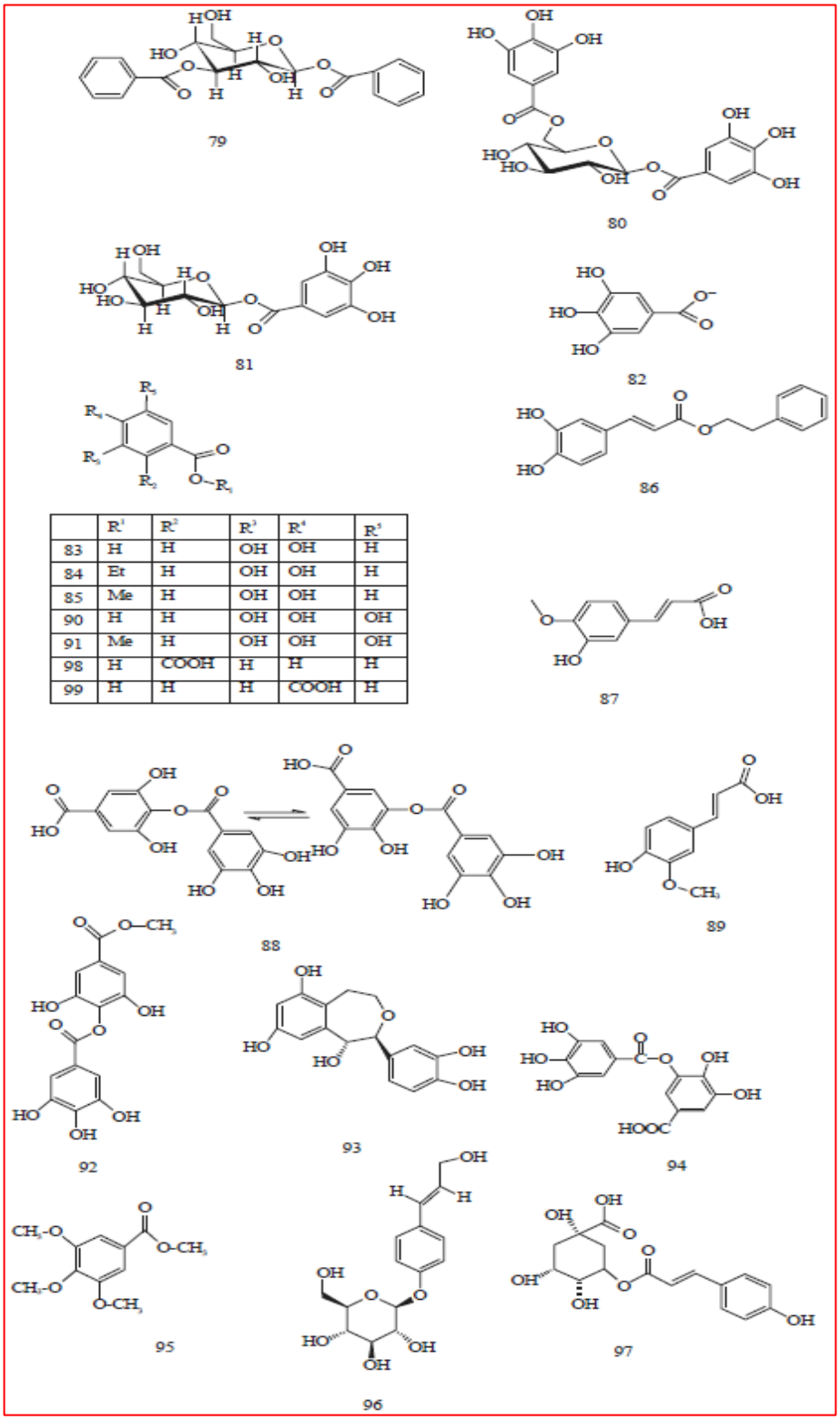


Figure 4. Chemical Structures of flavonoids extracted from genus *Acacia*.



	R¹	R²	R³	R⁴	R⁵
83	H	H	OH	OH	H
84	Et	H	OH	OH	H
85	Me	H	OH	OH	H
90	H	H	OH	OH	OH
91	Me	H	OH	OH	OH
98	H	COOH	H	H	H
99	H	H	H	COOH	H

Figure 5. Chemical Structures ofphenolic acids extracted from genus *Acacia*, phenolic acids.

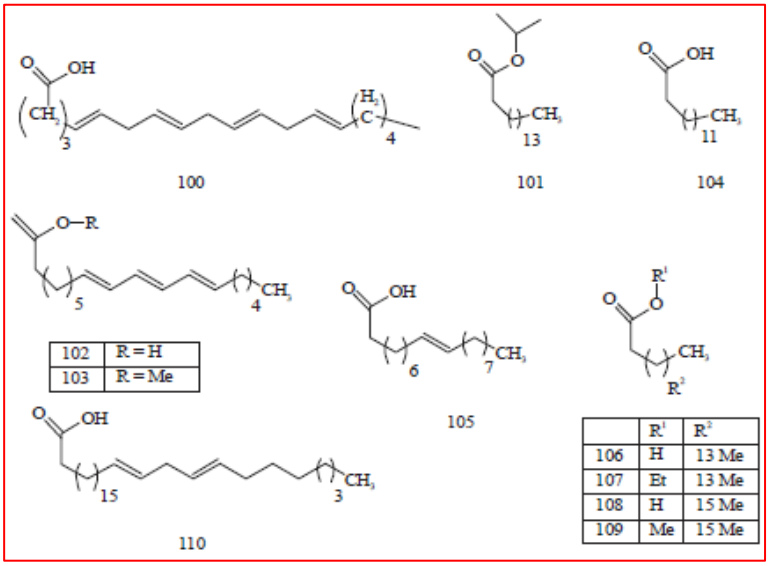


Figure 6. Chemical Structures offatty acids extracted from genus *Acacia.*

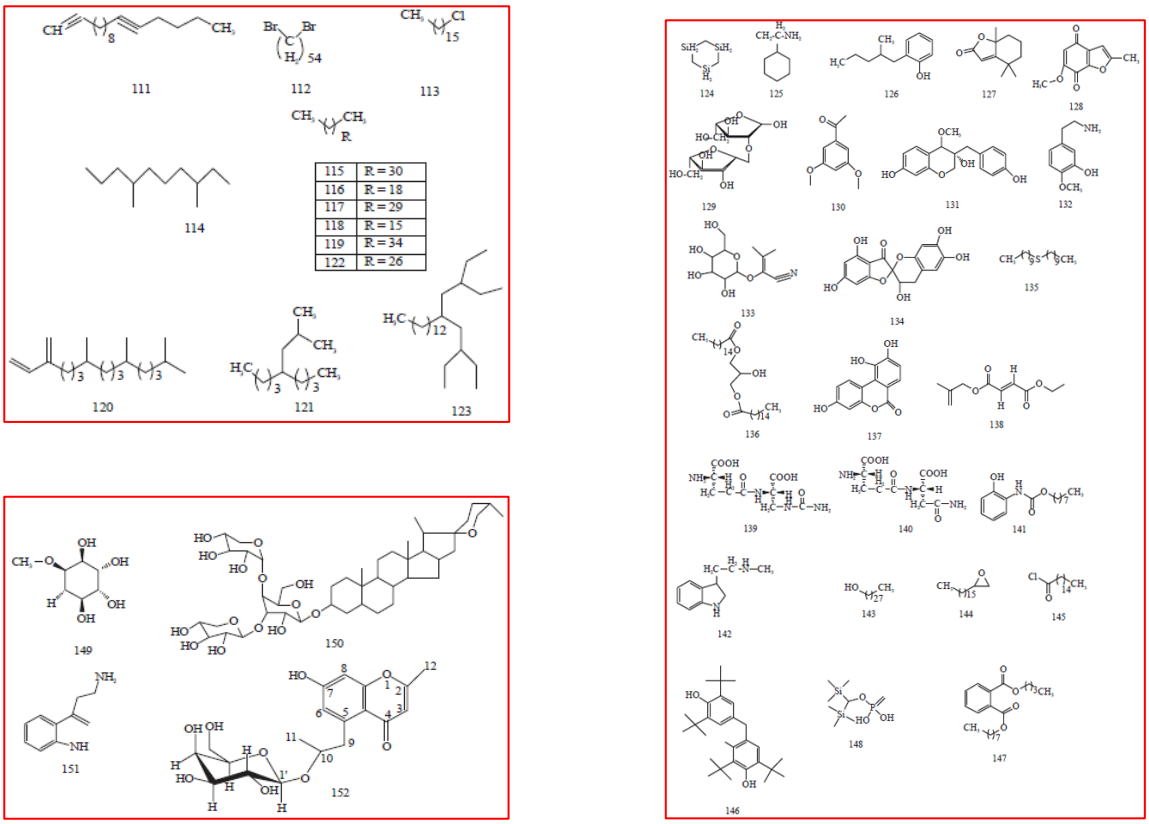


Figure 7. Structures of hydrocarbons extracted from genus *Acacia.*
Figure 8 and 9. Structures of other bioactive constituents.

Traditional Practices and Health Benefits

The popularity of Traditional medicinal plants or their derivatives role in disease prevention and management is increasing worldwide.

Babool is a source of many active secondary metabolites which may serve as potential candidates for drug development with greatest possibility of success in near future. Among the phytoconstituents found in plants like flavonoids, polysaccharides and organic acids may be mainly responsible for its pharmacological action. Tannin is an active chemical responsible for its anti-diabetic activity. Nilotica fruit is used for the treatment of sore throat, cold, bronchitis, pneumonia, ophthalmia, diarrhoea, dysentery, leprosy and venereal diseases as per Unani traditional medicine. Some of these diseases such as venereal diseases, diarrhoea, vaginitis, cystitis, pneumonia, and sore throat are microbial diseases mentioned in Unani medicine. A. nilotica is effective in aforementioned conditions because of its anti-microbial activity. A. nilotica has a therapeutic implication in disease prevention and treatment as it is a source of various types of phytoconstituents like tannins, alkaloids, polyphenolic compounds, and flavonoids (Mahgoub S., 1979; Saini ML., 2008; Solomon & Shittu., 2010; Agrawal S. et al., 2010; Gilani AH., 1999; Kaur K. et al., 2005; Ali A. et al., 2012). The most characteristic types of secondary metabolites of this genus are flavonoids. Tannins, octacosanol, B-amyrin, B-sitosterol, butelin quercestin, epicatechol gallate, gallic acid, D-catechol, epicatechol, dimer of D-catechol, protocatechuic acid, leucoiyanidin, 3-glucoside, isoquercitrin, leucocynaidin, B-oxaly diamine propionic acid, fatty acid, amino acid, 1-arabinose, catechol, galactan, glactoaraban, n-acetyld-_jenkolic acid, pentosan, and saponin . A. nilotica plays an important role as free radical scavenging properties due to a rich source of antioxidants like flavonoids, phenolics, tannins, curcumin, and terpenoids. A. nilotica ingredient shows an effective role in the management of cancer through the regulation of cell signaling pathways. It modulates the activity of various tumor suppressor genes, angiogenesis, and apoptosis. A. nilotica also plays a role as an anti-inflammatory via regulation of pro-inflammatory enzyme activities including cyclooxygenase and lipoxygenase enzyme (Baravkar AA. et al., 2008; Singh R. et al., 2008a; Singh R. et al., 2010b; Chalk RC. et al., 1968; Rai SP. et al., 2014; Singh BN. et al., 2009; El-Tahir A. et al., 1999). The compounds such as kaempferol-3-glucoside, iso-quercetin, catechin, kaempferol, galactose, l-arabinose, l-rhamnose, etc are also present in this plant. Flavonoids present in the flower, fruit, and leaves are the key constituents responsible for an anti-microbial property. The plant parts exhibit anti-microbial role through inhibition of microbial growth, inhibition of cytoplasmic membrane function, inhibition of the attachment and biofilm formation, and alteration of the membrane permeability. Acacia nilotica is a pioneer species and is economically used as a source of tannins, gums, timber, fuel and fodder. Babul plant is therapeutic used as anti-cancer, astringent, anti-oxidant, natriuretic, antispasmodial, diuretic, in intestinal pains and diarrhea, nerve stimulant, in cold, congestion, coughs, fever, hemorrhages, leucorrhea, ophthalmia and sclerosis. Seeds have antimalarial, antidiabetic, antihypertensive and antispasmodic activities. The pods have molluscicidal and algicidal properties (Chalk RC. et al., 1968; Rai SP. et al., 2014; Singh BN. et al., 2009; El-Tahir A. et al., 1999). Bark finds use in the treatment of hemorrhages, cold, diarrhea, tuberculosis and leprosy. Root is utilized as an aphrodisiac and the flowers for treating syphilis lesions. Gum obtained from the tree is pharmaceutically used as suspending and emulsifying agent and in preparation of many formulations. Its resins repel insects and water. The leaves and pods are an excellent fodder with antiinflammatory properties, rich in protein. The pods have molluscicidal and algicidal properties. Bark is used in the treatment of hemorrhages, cold, diarrhea, tuberculosis and leprosy. Root is used as an aphrodisiac and the flowers for treating syphilis lesions. 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. Aditionally, *A. nilotica* has been shown to be a potent analgesic as it is used in ophthalmic pain. The young leaves fried in ghee and wrapped around the eyes in chronic ophthalmia and subconjunctival haemorrhage. Modern researches also have revealed that it has analgesic and antipyretic activity. Traditionally, the decoction of leaves is used as astringent for the bowels. Pods and bark are useful in piles (Singh BN. et al., 2009; El-Tahir A. et al., 1999).

Another study showed that methanol extract of *A. nilotica* pods had antihypertensive and antispasmodic activity. The extensive survey of literature revealed that A. nilotica is an important traditional medicinal plant with diverse medicinal properties with an array of pharmacological activities. It has been traditionally used worldwide since ancient times. The clinical-based studies confirmed that it plays an important role in the prevention and management of various diseases. Further, evaluation needs to be carried out in order to explore the concealed areas and their practical clinical applications, which can be used for the welfare of mankind. The main objective of this review article is to describe comprehensive novel scientific studies of A. nilotica on its phytoconstituents, pharmacological relevance and traditional usage which will be noteworthy for further investigation (Chalk RC. et al., 1968; Rai SP. et al., 2014; Singh BN. et al., 2009; El-Tahir A. et al., 1999; Ayoub SMH., 1984; Tchatchedre M. et al., 2019).

DISCUSSION AND CONCLUSION

Chemical investigations on the species of the genus Acacia led to the isolation of more than 152 natural compounds during previous years. The predominant constituents isolated from plant extracts of the genus Acacia were mainly flavonoids, terpenoids and phenolic derivatives. The most studied species for their chemical constituent were A. nilotica, A. mellifera and A. Arabica. Acacia ataxacantha, A. crombie, A. tortilis and A. simplicifolia were the least studied species of the genus Acacia. Biological studies on pure chemical constituents and some crude extracts indicated antimicrobial, anti-parasitic, antioxidant, antidiabetic, anti-cancer and cytotoxicity activities. Babul plant is therapeutically 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. This plant contributes a number of groups among which are alkaloids, volatile essential oils, phenols and phenolic glycosides, resins, oleosins, steroids, tannins and terpenes. A. nilotica is a medicinal plant acknowledged to be rich in phenolics, consisting of condensed tannin and phlobatannin, gallic acid, protocatechuic acid, pyrocatechol, (+) -catechin, (-) epi- gallocatechin-7-gallate and (-) epigallocatechin-5, 7-digallate. Based on the different studies on different parts of A.nilotica, there is a grim need to isolate and identify new compounds from different parts of the tree, which have possible antimutagenic and cytotoxic activities. Therefore, the spreadilbility of naturally occurring polyphenolic compounds having ability to provide protection against certain types of mutagens and carcinogens is of great importanc. Umbelliferone, a potent antioxidant isolated from A. nilotica plant and food derived antioxidants are implicated in the prevention of cancer and aging by destroying oxidative species that initiate carcinogenesis through oxidative damage of DN. Having potential uses of this plant, it is highly recommended to cultivate widely to get maximum production for welfare of mankind. The versatile utility of this plant as a source of timber, source of fodder, tannin and gum, and also as a fence, shade and fuel tree has prompted researchers to deepen investigations for full utilization of this plant. Gum collected from itstrunk has been used in food, cosmetics, calico printing, and textiledyeing and in pharmaceutical industries. A.nilotica leaves have also been identi fied as promising bioadsorbents for the removal of heavy metals and synthetic toxic dyesfrom waste waters. It can also be used as a bioindicator to check pollution from Co and Cu heavy metals. The presence of Polyphenol mainly favonoids areresponsible for overall antioxidant activity of different extracts of A. nilotica. Future investigations should also be focused to identify by-products other than gums in order to make this medicinal plant more acceptable by the current demanding consumer market. Identification of more by-products from A. nilotica suggests a promising future forthis plant. Thus, this present review constitutes for researchers a real track to exploit for the discovery of new natural compounds with pharmacological potentials.

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