REVIEW ARTICLE

Balanites aegyptiaca (L.) Del. (Hingot): A review of its traditional uses, phytochemistry and pharmacological properties

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Balanites aegyptiaca is an evergreen, woody, true xerophytic tree of tremendous medicinal importance. It belongs to the family Balanitaceae and is distributed throughout the drier parts of India. *B. aegyptiaca* has been used in a variety of folk medicines in India and Asia. Various parts of the plant are used in Ayurvedic and other folk medicines for the treatment of different ailments such as syphilis, jaundice, liver and spleen problems, epilepsy, yellow fever and the plant also has insecticidal, antihelminthic, antifeedant, molluscicidal and contraceptive activities. Research has been carried out using different in vitro and in vivo techniques of biological evaluation to support most of these claims. This review presents the traditional uses, phytochemistry and pharmacological properties of this medicinal plant.

Key words: Antibacterial, *Balanites aegyptiaca*, desert date, pharmacological properties, saponins, traditional uses

INTRODUCTION

Balanites aegyptiaca (L.) Del. belongs to the family Balanitaceae. It is a multibranched, evergreen tree distributed throughout the drier parts of India.[1] It is widely grown in the Sudano-Sahielian region of Africa, the Middle East and South Asia.[2] It is known by various names, e.g. Arabic names: Heglig (tree), lalob (fruit); trade name: zaccone, zachun, desert date (dried fruit);[3] in India: Hindi name is Hingot and English name is thorn tree/desert date.[4]

B. aegyptiaca is a mutibranched, spiny shrub or tree which grows up to 10 m in height. The leaves are alternate, two foliate, petioles are 3–6 mm long, leaflets are elliptic and have broadly pointed petioles up to 5 mm long. The spines of the plant are simple, straight, stout, rigid, green, alternate, supraaxillary, up to 5 cm long. Inflorescence is supraaxillary clusters or rarely supracemose. The flowers are small, bisexual, greenish white, fragrant, in axillary clusters, few or many in number, cymes or fascicles. The sepals are five in number (free), ovate and 3 mm long. The petals are five in number (two free), oblong-obovate, longer than the sepals. The stamens are ten in number, filaments glabrous, and anthers are dorsifixed. The ovary is ovoid, silky, five-celled and ovules are solitary in each cell, the style is short and conical. Fruit is an ovoid drupe, 2–5.6 cm long, found on a short thick stalk, and is faintly five grooved. The ripe fruit is brown or pale brown with a brittle coat enclosing a brown or brown-green sticky pulp and a hard stone seed. Seeds are found exalbuminous and embryo is with thick plano-convex, or two-lobed cotyledons and a superior radical.[4]

Traditionally, various parts of *B. aegyptiaca* have been reported to possess medicinal properties in different ethnobotanical surveys.[1,5-8] It finds its place in the Ayurvedic pharmacopoeia of India and has also been described in some monographs, but none have described the complete traditional uses, phytochemistry and pharmacology of this plant. Therefore, we have compiled an up-to-date and comprehensive review of *B. aegyptiaca* that covers its traditional uses, phytochemistry and pharmacological properties.

TRADITIONAL USES

Various parts of *B. aegyptiaca* have their own traditional medicinal properties. This plant has been reported to be an antihelminthic, a purgative, vermifuge, febrifuge, emetic and can also cure other types of ailments like skin boils, leucoderma, malaria, wounds, colds, syphilis, liver and spleen disorders, and aches.[6] The bark of the plant is useful in curing mental diseases, epilepsy, yellow fever, jaundice and syphilis and can also act as a fumigant to heal circumcision wounds.[6] The boiled root of the plant can be used as a soup against stomach pain, anthrax, and the infusion of root also acts as an antidote to snake bite.[5] The infusion of root bark has been used in diarrhoea, in haemorrhoid and also acts as a fish poison.[8] The paste of shoot has been used for

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dressing of wounds and as tooth brushes when frayed. The thorns are used in the treatment of leprosy. Plant leaves are used in curing anthrax, for their antihelminthic activities and to clean malignant wounds.[6] The fruit can cure mouth ulcer, whooping cough, sleeping sickness and skin diseases. Fruit kernel has been found as a mild laxative, an antidote to arrow poison, and also acts as a vermifuge.[5] Kernel oil helps in curing skin disease.[1] The seeds are useful as ointments, to cure cough, colic pain and also have magico-religious properties.[5,8]

PHYTOCHEMISTRY

The phytochemistry of its root, stem bark, leaves, fruit pulp, seed kernel, and mesocarp has been studied by different workers. *B. aegyptiaca* is a rich source of saponins. Saponins are glycosides consisting of sugar residues (one or more units of glucose, galactose, etc.) linked through oxygen with complex multiring compounds usually containing 27–31 carbon atoms. The aglycone part, which is also called sapogenin, is either a steroid (C27) or a triterpene (C30).[9] Saponin containing plants are used in folk medicine, especially in Asia, and are intensively used in food, veterinary and medical industries. *B. aegyptiaca* contains different types of saponins, namely, balanitin -1, 2, 3, 4, 5, 6 and 7 [Figure 1]. The phytochemical description of the different parts is given below.

Root

Balanitin 1, 2 and 3, alkaloids and diosgenin have been isolated from the East African specimen.[10-12] Diosgenin is a steroidal sapogenin (5-spirostan-3-ol) compound which is very useful in pharmaceutical industries as a natural source of steroidal hormones.[13] *Balanites roxburghii* is an alternative source of diosgenin.[14] The Indian species (*B. roxburghii*) contains the lowest level of both diosgenin and oil.[15-17] The root wood of the plant contains Balanitism H.[14]

Stem Bark

Balanitol (a new sesquiterpene) and the saponins, deltonin and protodeltonin, have been isolated from the bark of the Indian species (*B. roxburghii*).[18] Furanocoumarin, bergapten

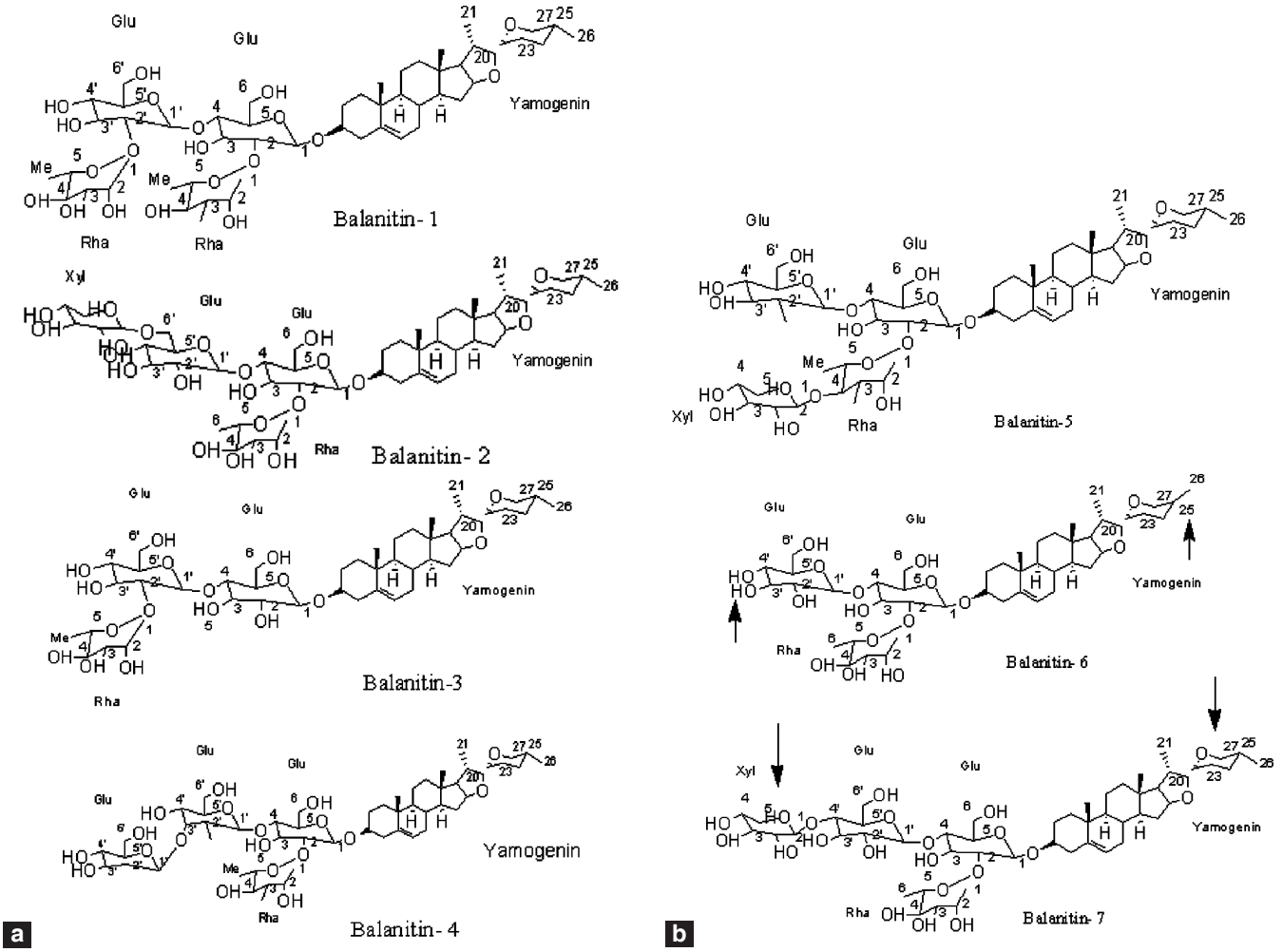

Figure 1: (a) Chemical structure of balanitin 1, 2, 3, and 4 isolated from different parts of *B. aegytptiaca*; (b) Chemical structure of balanitin 5, 6 and 7 isolated from different parts of *B. aegyptiaca*

and a dihydrofuranocoumarin (marmesin) have been isolated from the chloroform extract of the stem bark.[19] Balanitin 1, 2 and 3 have been isolated from East African species of *B. aegyptiaca* while diosgenin and sugars (glucose and rhamnose in the ratio 3:1) have been isolated from the Indian species (*B. roxburghii*).[10,20] Dicholoromethane extract has yielded two types of alkaloids N-*trans*-feruloyltyramine and N-*cis*-feruloyltyramine [Figure 2] and other metabolites like vanillic acid, syringic acid and 3 hydroxy-1-(4-hydroxy-3 methoxyphenyl)-1-propanone.[21]

Stem Wood

Balanitism 1 was isolated from the stem wood of the Indian species of *Balanites* (*B. roxburghii*).[14]

Leaf

Six flavonides, glycosides identified as quercetin 3-glucosides, quercetin 3-rutinoside, 3-glucoside, 3-glucosides, 3-rutinoside, 3-7 diglucoside and 3-rhamnogalactosides of isorhamnetin have been extracted and identified from the leaves and branches of the Egyptian plant species.[22]

Fruit

The fruit of *B. aegyptaica* consists of an epicarp, a mesocarp, an endocarp and a kernel.[23] The total saponin content has been found to be 7.2% in the mesocarp and 6.7% in the kernel.[24] Balanitin A, B, C, D, E and Balanitin F and G have been isolated from pulp and kernel, respectively.[14,25] The oil extracted from the kernel constituted 44–51% w/w and is composed of mainly triglycerides, with small quantities of diglycerides, phytosterols, sterol esters and tocopherols.[26] Besides, a known spirostanol glycoside, balanitin-3, and a new sapogenol, 6-methyldiosgenin, a new furostanol saponin, balanitoside and two pregnane glycosides have been isolated from the fruits (mesocarp) of *B. aegyptiaca*.[27-29] Spectroscopic and chemical analysis suggested the structure of the glycoside as 26-O-β-D-glucopyranosyl-3β,22,26-trihydroxy-furost-ene, 3-O-α-L-rhamnopyranosyl-(1→2)-β-D-glucopyranosyl-(1→4)-β-D-glucopyranoside and the saponins present in the mesocarp of *B. aegyptiaca* fruit are a mixture of 22*R* and 22*S* epimers of 26-(O-β-D-glucopyranosyl)-3-β-[4-O-(β-D-glucopyranosyl)-2-O-(α-L-rhamnopyranosyl)-β-D-glucopyranosyloxy]-22,26-dihydroxyfurost-5-ene.[30]

Seeds

The seeds of *B. aegyptiaca* yielded four new cytostatic saponins, namely, balanitins 4, 5, 6 and 7.[31] Seeds of *B. aegyptiaca* also contain deltonin and isodeltonin (steroidal spirostanol glycosides) which are used as molluscicidal agents.[32]

PHARMACOLOGICAL PROPERTIES

The pharmacological activity, parts used, constituent compound responsible for pharmacological properties and sources of information are shown in Figure 3.

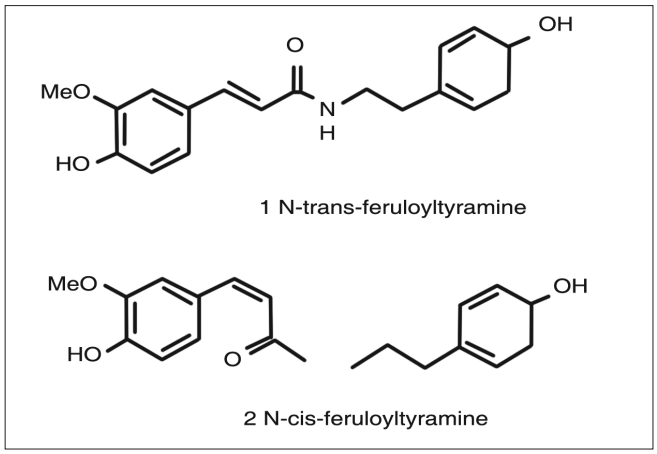

Figure 2: Structure of two alkaloids isolated from stem bark

Insecticidal Activity

B. aegyptiaca acts as a potential natural larvicidal agent against mosquito larvae due to the larvicidal activities present in the saponin rich extracts in the various tissues such as fruit pulp, kernel, root, bark and leaf.[33-37] The water extracts of fruit kernel of *B. aegyptiaca* were found to be effective against the larvae of *Aedes arabiensis*, *Culex quinquefasciatus* and *Aedes aegypti* and it was concluded that *A. arabiensis* larvae were the most susceptible, followed by *C. quinquefasciatus* and then *A. aegypti*.[33] The root extract of the plant was found to be most lethal, followed by the bark among the various parts tested (fruit pulp, seed kernel, root, bark and leaves).[35,36] On the basis the very low adult emergence (only 18%) on using only 50 ppm of the root derived callus , saponins of *B. aegyptiaca* showed a great possibility for drastically reducing the *A. aegypti* population in the concerned areas.[38] The main reason behind the larvicidal activity of plant extract may be the interaction of saponin molecules with cuticle membrane of the larvae, ultimately disarranging these.[39]

Antimicrobial Activity

Different studies were carried out to determine the antibacterial and antifungal activities of whole plant, root bark, stem bark, fruit mesocarp and leaves of *B. aegyptiaca*.[40-46]

Antibacterial activity

The leaf extracts of *B. aegyptiaca*, prepared in aqueous and organic solvents (acetone and ethanol), were tested for their antibacterial activity against *Salmonella typhi*, by using the disc diffusion method. Ethanolic extracts demonstrated higher antibacterial activity (16 mm zone of inhibition) while the aqueous extracts showed the least activity (4 mm zone of inhibition) at 100 mg/ml. The preliminary

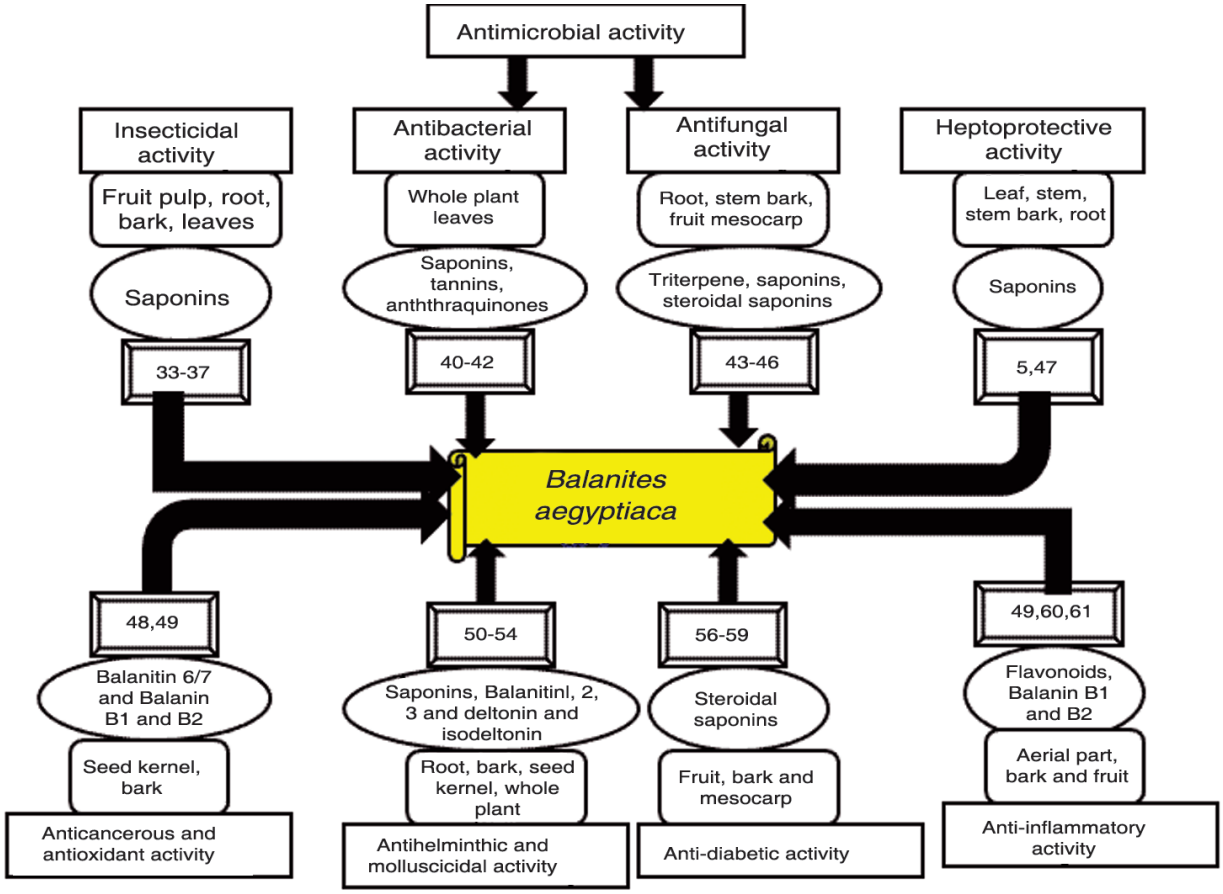

Figure 3: The pharmacological activity, parts used and constituents with sources of information

phytochemical analysis revealed the presence of saponins, tannins, phenols and anthraquinones in the extracts, and these were considered for antibacterial activity.[40]

Methanolic and aqueous extracts of whole plant extract showed 4 mm inhibition zone in *Staphylococcus aureus* and 11 mm zone of inhibition in case of *Staphylococcus epidermidis*.[41] The extract of *B. aegyptiaca* supplemented with a 60–100 mg mineral (*kadosero*) revealed 100% reduction in bacterial colony in untreated well water. Chemical analysis of *kadosero* revealed the presence of SO_4 (0.0038 mg/g), Fe^2 (0.0027 mg/g), Cl^- (232.683 mg/g) and Na^+ (151.25 mg/g).[42]

Antifungal Activity

Aqueous and methanolic (80%) extracts of root bark were screened for anticandidal activity by bioautography agar overlay method, using a standard strain of *Candida albicans* (ATCC 90028). These extracts revealed strong anticandidal activity. The identification of compounds responsible for the activity was not done.[43] The stem bark extracts isolated in various solvents were screened for their antifungal effects against *Aspergillus niger* and *C. albicans*, and these extracts also showed high antifungal activity against *C. albicans* (MFC 250 µg/ml).[44] The fruit mesocarp saponin rich extract has been tested against common phytopathogenic fungi (*Pythium ultimum*, *Fusarium oxysporum*, *Alternaria solani*, *Colletotrichum coccodes* and *Verticillium dahliae*). The inhibitory effects of these extracts were measured *in vitro* and the concentrations that reduced the colony diameter of fungus to 50% of the control were determined. At 4% concentration, growth inhibitions were reported against *P. ultimum* (81.1%) and *A. solani* (34.7%).[45] The antifungal activity may be due to presence of several triterpene saponins and steroidal saponins in *B. aegyptiaca*.[46]

Hepatoprotective Activity

The extracts of leaf, stem, stem bark and root of *B. aegyptiaca* were screened for hepatoprotective activity in Wistar albino rats. The stem bark extracts of the plant showed significant ($P < 0.05$) hepatoprotective effects as revealed by a decrease in the activity of serum transaminase and alkaline phosphatase enzymes as compared to control rats.[5] The effect of lyophilised extracts of *B. aegyptiaca* (1 g/kg) and silymarin (0.1 g/kg), a standard heptoprotective agent, given for 5 consecutive days, was tested on liver damage induced by paracetamol (0.6 g/kg) in the mice. *B. aegyptiaca* had a relatively modest hepatoprotective activity (27%) while silymarin protected about 92% of the

treated mice.[47] These results suggest that the extract could protect the paracetamol-induced liver damages perhaps by eliminating the deleterious effects of toxic metabolites from the drug.

Anticancerous and Antioxidant Activity

The mixture of balanitin-6 (28%) and balanitin-7 (72%) was evaluated *in vitro* for anticancer activity against six different human cancer cell lines, using the [3-(4, 5-dimethylthiazol-2yl)-diphenyltetrazolium bromide] colorimetric assay and *in vivo* in the murine L1210 leukaemia model. The mixture has demonstrated appreciable anticancer affects in human cancer cell lines *in vitro* as it displayed higher antiproliferative activity than etoposide and oxaliplatin but markedly lesser activity than taxol. The *in vitro* anticancer activities result at least partially from depletion of ATP, leading in turn to major disorganisation of actin cytoskeleton, ultimately resulting in the impairment of cancer cell proliferation and migration. *In vivo*, bal6/7 increased the survival time of mice bearing murine L1210 leukaemia grafts to the same extent as that reported for vincristine. These preliminary *in vivo* data suggest that it may be possible to generate novel hemi-synthetic derivatives of balanitin-6 and -7 with potentially improved *in vitro* and *in vivo* anticancer activity and reduced *in vivo* toxicity, thus markedly improving the therapeutic ratio.[48]

Balanitin B1 and B2, isolated from methanol and butanol extracts of *B. aegyptiaca* bark, have been evaluated *in vitro* and *in vivo* using a method based on the Briggs-Rauscher (BR) oscillating reaction and this revealed the antioxidant activity.[49]

Antihelminthic and Molluscicidal Activity

The root, bark, seed kernel, fruit and whole plant extracts were found to be lethal to snails, miracidia and cerearіac of schistosomes in various studies.[50,51] A mixture of deltonin and 25-isodeltonin extracted from seeds was found to be molluscicidal against snail species *Biomphalaria glabrata*.[52] The antihelminthic properties of extract of *B. aegyptiaca* were compared with those of albendazole and praziquantel.[53,54] The efficacy of therapeutics of aqueous mesocarp extract against *Fasciola gigantica* in goat was 93.20–97.7%. The characteristic lesions of liver fasciolosis, egg count per gram of faeces (EPG), packed cell volume (PCV) and total blood count were significantly different from those of control and treated groups ($P < 0.05$).[53] The efficacy of *B. aegyptiaca* fruit mesocarp (200 mg/kg) was compared with that of praziquantel (200 mg/kg) in mice infected with Sudanese strain of *Schistosoma mansoni.* A significant reduction was observed in EPG, egg burden in tissues and recovery of adult worms ($P < 0.05$) for both the extract- and the drug-treated animals.[54]

Antiparasitic

The crude methanolic extract has been found to have a moderate biological activity on *Leishmania major* in an *in vitro* study.[55]

Antidiabetic Activity

The bark extract of *B. aegyptiaca* has been also shown to have a moderate effect on the activity of α-amylase which is responsible for the degradation of oligosaccharides.[56] *B. aegyptiaca* fruit extracts (1.5 g/kg bw) reduced the blood glucose level by 24% and significantly decreased the liver glucose-6-phosphatase activity in diabetic rats.[57] The water and ethanolic extracts of *B. aegyptiaca* fruit extract induced significant reduction in serum glucose, glucagon, total lipids, total cholesterol, triglycerides level and transaminases [aspartate aminotransferase (AST), alanine aminotransferase (ALT) and γGT (gamma aminotransferase)] activities.[58] An aqueous extract of mesocarps of the fruits of *B. aegyptiaca* exhibited a prominent antidiabetic activity on oral administration in streptozotocin-induced diabetic mice. It is believed that the antidiabetic activity was due to the presence of steroidal saponins in the extracts.[59]

Anti-inflammatory Activity

The ethanolic extract of aerial parts of *B. aegyptiaca*, when given orally as a suspension at 300 mg/kg bw per day, reduced the paw volume by 55.03%, whereas in the case of administration of 600 mg/kg bw per day it was 65.54%, indicating that the effect was dose dependant. The significant anti-inflammatory activity was evaluated in methanolic and ethanolic extracts of the bark in two different animal models, the carrageenan-induced oedema in the rat, and acetic acid-induced writhing test in mice.[49] Ethanolic extract of fruit of *B. aegyptiaca* also exhibited a proinflammatory activity.[60] The phytochemicals responsible for these activities were found to be flavonoids, saponins B1 and B2 isolated from bark and aerial parts of the plant.[49,61]

CONCLUSION

B. aegyptiaca is an evergreen tree distributed throughout the drier parts of India. It has been used since ages by the tribes of Rajasthan and Haryana to cure several diseases like whooping cough, sleeping sickness, guinea worm diseases and skin disorders. Economically also, it is a very significant plant because various parts of this plant contain saponins, alkaloids and diosgenin (secondary metabolites that have high pharmacological importance). The pharmacological studies of *B. aegyptiaca* demonstrated insecticidal, antibacterial, antifungal, hepatoprotective, anticancerous, antihelminthic, antiparasitic, antidiabetic and anti-inflammatory activities of the plant. Research carried out using different *in vitro* and *in vivo* techniques of biological evaluation support most of these claims. *B. aegyptiaca* may also act as a potential natural larvicidal agent

against mosquito larvae, owing to the presence of saponins which are effective in mosquito control, safe to mammals and available in high concentration in *B. aegyptaica.* So, this plant can be used as a drug in mosquito control.

India can benefit enormously if we can build a Golden Triangle among Modern Science, Modern Medicine and Traditional Medicine.[62] Indeed, triangles are a popular concept in complementary medicine,[63] but for AYUSH, the Golden Triangle presents a golden opportunity to bring these different systems together. Numerous drugs have entered the international market through exploration of ethnopharmacological and traditional medicine. Although scientist studies have been carried out by the scientists on many of the Indian botanicals, considerably small number of marketable drugs or phytochemical entities has entered the evidence-based therapeutics. E fforts are therefore needed to establish and validate safety and practice of Ayurvedic medicines.[64]

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