

A review on *Balanites aegyptiaca* Del (desert date): phytochemical constituents, traditional uses, and pharmacological activity

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ABSTRACT

Balanites aegyptiaca Del. (Zygophyllaceae), known as 'desert date,' is spiny shrub or tree up to 10 m tall, widely distributed in dry land areas of Africa and South Asia. It is traditionally used in treatment of various ailments i.e. jaundice, intestinal worm infection, wounds, malaria, syphilis, epilepsy, dysentery, constipation, diarrhea, hemorrhoid, stomach aches, asthma, and fever. It contains protein, lipid, carbohydrate, alkaloid, saponin, flavonoid, and organic acid. Present review summarizes the traditional claims, phytochemistry, and pharmacology of *B. aegyptiaca* Del reported in scientific literature.

Key words: *Balanites aegyptiaca*, Balanitin, desert date

INTRODUCTION

Balanites aegyptiaca Del., also known as 'Desert date' in English, a member of the family Zygophyllaceae, is one of the most common but neglected wild plant species of the dry land areas of Africa and South Asia.^[1,2] This tree is native to much of Africa and parts of the Middle East. In India, it is particularly found in Rajasthan, Gujarat, Madhya Pradesh, and Deccan.^[3] This is one of the most common trees in Senegal.^[4-7] It can be found in many kinds of habitat, tolerating a wide variety of soil types, from sand to heavy clay, and climatic moisture levels [Figure 1].

Taxonomical profile^[8]

Kingdom	:	Plantae
Division	:	Magnoliophyta
Class	:	Magnoliopsida
Order	:	Sapindales

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Family	:	Zygophyllaceae
Genus	:	Balanites Delile
Species	:	Balanites aegyptiaca (L.) Delile

Synonyms: *Ximenia aegyptiaca* L. (excl. *Balanites roxburghii* Planch), *Agialida senegalensis* van Tiegh., *Agialida barteri* van Tiegh., *Agialida tombuctensis* van Tiegh., *Balanites ziziphoides* Milbr. Et Schlechter, *Balanites latifolia* (van Tiegh.) Chiov.

Vernacular name:

Ayurvedic	:	Ingudi, Angaar Vrksa, Taapasadrum, Taapasa vrksa, Dirghkantaka.
Unani	:	Hingan, Hanguul.
Siddha	:	Nanjunda.
Folk	:	Hingol, Hingota, Hingothaa.
English	:	Desert date, Soapberry tree, Thorn tree, Egyptian balsam



Figure 1: *Balanites aegyptiaca* Del

Arabic	:	Heglig
French	:	Dattier du desert, Hagueleg, Balanite
Spanish	:	corona di Jesus

BOTANICAL DESCRIPTION

It is multibranched, spiny shrub or tree up to 10 m tall. Crown spherical, in one or several distinct masses. Trunk short and often branching from near the base. Bark dark brown to grey, deeply fissured. Branches armed with stout yellow or green thorns up to 8 cm long. Leaves with two separate leaflets; leaflets obovate, asymmetric, 2.5 to 6 cm long, bright green, leathery, with fine hairs when young. Flowers in fascicles in the leaf axils, and are fragrant, yellowish-green.

Fruit and seed description

Fruit is a rather long, narrow drupe, 2.5 to 7 cm long, 1.5 to 4 cm in diameter. Young fruits are green and tomentose, turning yellow and glabrous when mature. Pulp is bitter-sweet and edible. Seed is the pyrene (stone), 1.5 to 3 cm long, light brown, fibrous, and extremely hard. It makes up 50 to 60% of the fruit. There are 500 to 1 500 dry, clean seeds per kg.

Flowering and fruiting habit

Flowers are small, inconspicuous, hermaphroditic, and pollinated by insects. Seeds are dispersed by ingestion by birds and animals. The tree begins to flower and fruit at 5 to 7 years of age and maximum seed production is when the trees are 15 to 25 years old.

Distribution and habitat

Natural distribution is obscured by cultivation and naturalization. It is believed indigenous to all dry lands south of the Sahara, extending southward to Malawi in the Rift Valley, and to the Arabian Peninsula, introduced into cultivation in Latin America and India. It has wide ecological distribution, but is mainly found on level alluvial sites with deep sandy loam and free access to water. After the seedling stage, it is intolerant to shade and prefers open woodland or savannah for natural regeneration. It is a lowland species, growing up to 1000 m altitude in areas with mean annual temperature of 20 to 30°C and mean annual rainfall of 250 to 400 mm.^[9,10]

Traditional Uses

Aqueous extract of fruits showed spermicidal activity without local vaginal irritation in human being, up to 4% sperms becoming sluggish on contact with the plant extract and then immobile within 30 s; the effect was concentration-related. Protracted administration of the fruit pulp extract produced hyperglycemia-induced testicular dysfunction in dogs. Seed is used as expectorant, antibacterial, and antifungal. Fruit is used in whooping cough, also in leucoderma and other skin diseases. Bark is used as spasmolytic.^[11]

The seed is used as a febrifuge.^[12] Root extracts have proved 'slightly effective' against experimental malaria.^[13,14] In Kenya, a root infusion is used as an emetic.^[15] In asthma, about 10 gm of seed powder is taken with glass of water in the morning for

10 days.^[16] Tablets are prepared from roots mixed with 'Hing' powder (*Ferula asafoetida*); by adding *Piper betle* leaf, juices are taken once with water for 9 days, soon after the menstruation to avoid unwanted pregnancy.^[17] In Egyptian folk medicine, the fruits are used as an oral hypoglycemic^[18] and an antidiabetic; an aqueous extract of the fruit mesocarp is used in Sudanese folk medicine in the treatment of jaundice.^[19] Used in food preparations and herbal medicine, especially in Africa and some developing Countries.^[20] The fresh leaf of the plant *Acalypha* is pounded with small amount of root of *B. aegyptiaca* and *Cissus quadrangularis*, and then soaked in water for an hour or two. It is decanted and administered intranasally and orally. Latex of the plant is used in epilepsy, administered through intranasal route.^[21] Used as tooth brush.^[22] Fruits are used to treat dysentery and constipation. The seed oil is used to treat tumors and wounds.^[23] Used as laxative, also used in treatment of hemorrhoid, stomach aches, jaundice, yellow fever, syphilis, and epilepsy.^[24] A fruit is used to treat liver disease and as a purgative, and sucked by school children as a confectionary in some countries.^[25,26] The bark is used in the treatment of syphilis, round worm infections, and as a fish poison. The aqueous leaf extract and saponins isolated from its kernel cakes have antibacterial activity.^[27,28] Seeds are used as anthelmintic and purgative. Ground seeds are given to camels to cure impaction and colic.^[29]

In Chifra District, the root of plant is used for the treatment of render pest and anthrax. In East Africa, it is widely used as anthelmintic. Root is used in various folk medicines for the treatment of abdominal pain and as purgative, while the bark is employed as a fish poison and also as a remedy for malaria and syphilis. The root, bark, kernel, and fruit have been shown to be lethal to mollusks.^[30] In Sudanese folk medicine, it is used to treat jaundice.^[31] Its antimalarial and molluscicidal activity is well studied.^[32-35] *In vitro* antiplasmodial test of the dichloromethane and methanol (ME) extract of stem bark of the plant showed antimalarial activity.

In Senegal, Nigeria, Morocco, and Ethiopia, *B. aegyptiaca* is taken a purgative for colic and stomach ache. In Chad, fresh twigs are put on the fire in order to keep insects away. For intestinal worm, the fruits are dried and mashed in millet porridge and eaten.^[36] In Libya and Eritrea, the leaves are used for cleaning infected wounds. In Sudan and chadthe bar, *B. aegyptiaca* is component of soap.^[37] The use of the kernel oil for treatment of wounds has been reported from Nigeria.^[38] For contraception, in Nigeria, a mixture of dried leaves powder of *B. aegyptiaca* and *Ricinus communis* in water and in Somalia, the bark of root is crushed and mixed with two glasses of water, which is then filtered. This preparation is repeated for three days and one glass is drunk three times daily for three days.^[39]

PHYTOCHEMICAL CONSTITUENTS

Leaves

It contains saponin, furanocoumarin, and flavonoid namely quercetin 3-glucoside, quercetin-3-rutinoside; 3-glucoside,

3-rutinoside, 3-7-diglucoside and 3-rhamnogalactoside of isorhamnetin.^[40,41]

Fruit

Mesocarp of fruit contains 1.2 to 1.5% protein and 35 to 37% sugars, 15% organic acids, other constituents like 3-rutinoside and 3-rhamnogalactoside,^[42] diosgenin;^[43] it also contain 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. However, kernel contains a xylopyranosyl derivative of above saponin present in mesocarp.^[44] Balanitoside (furostanol glycoside) and 6-methyldiosgenin,^[45] balanitin-3 (spirostanol glycoside) have been reported from fruits (mesocarp) of *B. aegyptiaca*.^[46] Balanitin-6 and -7: Diosgenyl saponins,^[47,48] two pregnane glycosides namely pregn-5-ene-3β,16β,20(*R*)-triol 3-*O*-(2,6-di-*O*-α-L-rhamnopyranosyl)-β-D-glucopyranoside (balagyptin), and pregn-5-ene-3β,16β,20(*R*)-triol 3-*O*-β-D-glucopyranoside,^[49] long chain hydrocarbon. The kernels contained 45.0 to 46.1% oil and protein (32.4%), oil contains mainly palmitic, stearic, oleic, and linoleic acids which were

the main fatty acids.^[50-53] The oil exhibited anticancer activity against lung, liver, and brain human carcinoma cell lines. It also had antimutagenic activity against *Fasciola gigantica*-induced mutagenicity besides anthelmintic activity against hepatic worms (*Schistosoma mansoni* and *Fasciola gigantica*). Preliminary screening showed that the oil had antiviral activity against Herpes simplex virus. It also had antimicrobial activity against selected strains of Gram-positive bacteria, Gram-negative bacteria, and *Candida*.^[54] Nine saponin have been reported from kernel cake of *B. aegyptiaca*, from the nine components, six saponins with molecular masses of 1196, 1064, 1210, 1224, 1078, and 1046 Da were identified, with the compound of mass 1210 Da being the main saponin (ca. 36%).^[55] The leaves and fruit kernels of *B. aegyptiaca* L. were found to contain six diosgenin glucosides including di-, tri-, and tetraglucosides. Hydrolysis of the saponins gave 25D-spirosta-3, 5-diene and 3β-chloro-25D-spirosta-5-ene^[56-59] balanitin-1, -2, and -3 [Figure 2].^[60]

Root

It is reported to contain steroidal saponin about 1% glycosides and major sapogenin is yamogenin^[61,62] other glycosides;

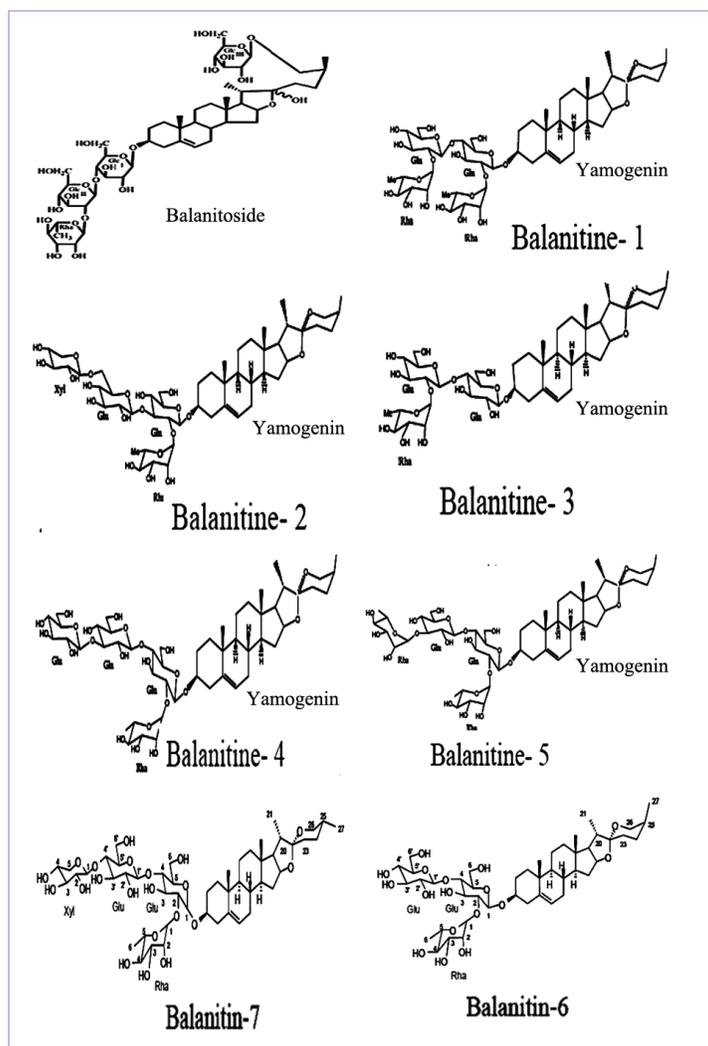


Figure 2: Chemical constituents of *Balanites aegyptiaca*

(3 β ,12 α ,14 β ,16 β)-12-hydroxycholest-5-ene-3,16-diyl bis(β -D-glucopyranoside), (3 β ,20*S*,22*R*,25*R*)-, and (3 β ,20*S*,22*R*,25*S*)-26-(β -D-glucopyranosyloxy)-22-methoxyfurost-5-en-3-yl β -D-xylopyranosyl-(1 \rightarrow 3)- β -D-glucopyranosyl-(1 \rightarrow 4) [α -L-rhamnopyranosyl-(1 \rightarrow 2)]- β -D-glucopyranoside; and (3 β ,20*S*,22*R*,25*R*)- and (3 β ,20*S*,22*R*,25*S*)-spirost-5-en-3-yl β -D-xylopyranosyl-(1 \rightarrow 3)- β -D-glucopyranosyl-(1 \rightarrow 4) [α -L-rhamnopyranosyl-(1 \rightarrow 2)]- β -D-glucopyranoside,^[63] Balanitins 1 to 7 have been reported from root and bark of *B. aegyptiaca*.^[64,65]

Bark

It is reported to contain furanocoumarin bergapten and dihydrofuranocoumarin D- marmesin,^[66] two alkaloid namely, N-trans-feruloyltyramine and N-cis-feruloyltyramine, and three common metabolites, vanillic acid, syringic acid; and 3-hydroxy-1-(4-hydroxy-3-methoxyphenyl)-1-propanone,^[67] long-chain aliphatic compound, 10-methyl-n-heptacosane, and a new sugar, diglucosylidrirhamnoside, have also been reported from the stem-barks.^[68-71] It also contains beta-sitosterol, bergapten, marmesin, and beta-sitosterol glucoside,^[72] balanitin-1,-2, and -3; balanitin-1 for example possesses a yamogenin aglycone with a branched glucose and rhamnose side chain.^[73]

PHARMACOLOGICAL ACTIVITY

Cardioprotective cum antioxidant activity

The plant acts as antioxidant against adriamycin-induced cardiotoxicity in experimental mice. Adriamycin when administered intraperitoneally, it cause elevation of serum lactate dehydrogenase, creatine phosphokinase, glutamate oxaloacetate transaminase, glutamate pyruvate transaminase, lipid peroxide, total nitric oxide, erythrocyte lysate superoxide dismutase (SOD), glutathione peroxidase (GPx), and plasma catalase (CAT) in mice heart tissue. Adriamycin drug reduced the activities of SOD, GPx, and CAT. Pretreatment with *B. aegyptiaca* extract significantly ($P < 0.05$) prevented these alterations and restored the enzyme activities to near normal levels.^[74]

Anthelmintic activity

The crude aqueous extract of root bark of *B. aegyptiaca* was showed a dose-dependent inhibition of spontaneous motility (paralysis) in adult earthworms. And also possesses vermifugal activity.^[75] It is reported that stem bark water extract (9 g/kg body weight) of *Albizia anthelmintica* and fruit mesocarp water extract (9 g/kg body weight) of *B. aegyptiaca* shows significant anthelmintic activity compared with albendazole (20 mg/kg body weight) against *Fasciola gigantica* adult worm.^[76] And a single dose of 200 mg/kg body weight of *B. aegyptiaca* fruit mesocarp also showed activity against *Substosoma mansoni* in infected mice when compared with praziquantel.^[77] Balanitin-7 is isolated from aqueous extract of *B. aegyptiaca* seed and reported as anthelmintic agent when tested by *in vitro* means of an original anthelmintic assay, using *Caenorhabditis elegans* as a biological model.^[78] The methanolic extract of *B. aegyptiaca* fruits is reported to have anthelmintic

action against different stages of *Trichinella spiralis* in rats compared with anthelmintic drug albendazole.^[79] The aqueous extract of *B. aegyptiaca* also has molluscicidal agent to juvenile and adult *Bulinus globosus* and *Bulinus truncatus*.^[80]

Antibacterial effects

The aqueous and organic leaves extracts of *B. aegyptiaca* and *Moringa oleifera* were reported to have antibacterial effect against *Salmonella typhi* isolated from blood clot culture using the disc diffusion method. The extracts of *B. aegyptiaca* plants demonstrated the highest activity than *Moringa oleifera*. The ethanolic extracts of both plants demonstrated the highest activity whereas the aqueous extracts of both plants showed the least activity at 100 mg/ml as compared with ethanolic extracts. The activities of these plant extracts were comparable with those of antibiotics, ciprofloxacin, cotrimoxazole, and chloramphenicol, commonly used for treating typhoid fever. The antibacterial activity appears to increase when extracts of the two plants were used in combination at 100 mg/ml each. Preliminary phytochemical screening showed that plant extracts contain saponins, tannins, and phenols, and *B. aegyptiaca* possesses anthraquinones. The antibacterial activities of the extracts on *S. typhi* were reasonably stable when treated at 4, 30, 60, and 100°C for 1 hour. However, it reduces significantly when the pH was altered toward alkalinity.^[81]

The aqueous and ethanolic extracts of leaves of six plants viz., *B. aegyptiaca* (L.) Del, *Hyptis suaveolens* Poit, *Lawsonia inermis* L., *Leucas aspera* L., *Lobelia nicotianifolia* Roth, and *Phyllanthus maderaspatana* L. were reported as antibacterial when tested individually and in combinations against five different diarrheagenic bacteria, *Bacillus cereus*, *Staphylococcus aureus*, *Escherichia coli*, *Salmonella enteritidis*, and *Listeria monocytogenes*. Ciprofloxacin (20 μ g) was used as antimicrobial standard. The highest antimicrobial activity was in both crude aqueous leaf extract and crude ethanolic leaf extract of *Lobelia nicotianifolia*, when all extracts were tested individually. However, in combination, the highest activity was observed in crude ethanolic leaf extract *Lobelia nicotianifolia* + *B. aegyptiaca* against *S. aureus*.^[82,83]

Antivenin activity

The acetone and methanolic extracts of stem bark of plant has reported an antivenin activity against saw-scaled (*Echis carinatus*) viper venom concentration at lethal dose (0.194 mg/ml), when administered intramuscularly to Wistar albino rats. Both extracts were found to be effective at 75 and 100 mg/ml concentrations.^[84]

Anticancer activity

A mixture of steroidal saponins: balanitin-6 (28%) and balanitin-7 (72%), isolated from *B. aegyptiaca* kernels, demonstrated appreciable anticancer effects in human cancer cell lines *in vitro* by using against A549 non-small-cell lung cancer (IC₅₀, 0.3 μ M) and U373 glioblastoma (IC₅₀, 0.5 μ M) cell lines. Bal6/7 displayed higher antiproliferative activity than etoposide and oxaliplatin, markedly less active than taxol. It indicated that balanitin 6/7 mixture is more a cytotoxic compound than a cytostatic one. *In vitro* anticancer activities are due to partly depletion of [ATP], leading in turn to major disorganization of actin and it does not

induce an increase in intracellular reactive oxygen species. *In vivo*, bal6/7 increased the survival time of mice bearing murine L1210 leukemia grafts to the same extent reported for vincristine.^[85,86]

Anti-inflammatory and analgesic activity

The ethanol and petroleum ether extracts of aerial parts of *B. aegyptiaca* have been reported to have significant anti-inflammatory action on carrageenan-induced hind paw edema in rats, the paw volume was measured plethysmometrically at 0 and 3 hours after injection and analgesic activity by using Eddy's hot plate method and tail-flick method in albino rats. The ethanol and petroleum ether extracts showed a greater anti-inflammatory and analgesic effects comparative with the standard drugs, indomethacin and diclofenac sodium, respectively. It also indicated that the ethanolic extract of *B. aegyptiaca* exhibited more significant activity than petroleum ether in the treatment of pain and inflammation.^[87]

In vitro antioxidant, xanthine oxidase and acetylcholinesterase inhibitory activities

It is reported that the galls and leaf extracts and fractions of *B. aegyptiaca* showed a significant antioxidant, xanthine oxidase, and acetylcholinesterase inhibitory activities. The total phenolics and flavonoids were measured using Folin-Ciocalteu and AlCl_3 reagents, respectively. Two methods, that is, FRAP (Iron (III) to Iron (II) reduction activity) and ABTS (2,2-azino-bis(3-ethylbenzothiazoline-6-sulphonate) assay were used to estimate the total antioxidant capacity of the plant materials. Dichloromethane fraction of the Gall and ethyl acetate fractions of the leaves were reported to have highest antioxidant activity. The antioxidant activities were correlated significantly with the total phenolic and flavonoid contents. The study also showed that *B. aegyptiaca* galls and leaves fractions exhibited a moderate xanthine oxidase inhibitory activity compared with the acetylcholinesterase which was weakly inhibited by the tested extracts and fractions.^[88]

Anti-inflammatory, antinociceptive and antioxidant activities

Methanolic and butanol (BE) extracts and of two new saponins isolated from *B. aegyptiaca* showed significant anti-inflammatory, antinociceptive activity in the carrageenin-induced edema in the rat, and acetic acid-induced writhing test in mice and antioxidant action by using *in vitro*, using a method based on the Briggs–Rauscher oscillating reaction. The samples, extracts and pure substances, were intragastrically administered to animals.^[89]

Mosquito larvicidal activity

Fruit kernel extracts against *Anopheles arabiensis*, *Culex quinquefasciatus*, and *Aedes aegypti*

A saponin extract and water extract from fruit kernel of *B. aegyptiaca* was investigated as a mosquito larvicide. Both extracts were tested against second and fourth instar larvae of the three mosquito species namely *Anopheles arabiensis*, *Culex quinquefasciatus*, and *A. aegypti*, and LC_{50} and LC_{90} values were determined. Second instar larvae were more susceptible than fourth instar larvae in all cases. The larvae of *Anopheles arabiensis* were more susceptible

than *Culex quinquefasciatus* and *A. aegypti* to its larvicidal effects. The saponin was more active than the water extract.^[90]

Mesocarp of fruit extracts against *A. aegypti*

The various extract mesocarps of fruits viz. chloroform, ME, BE, ethyl acetate, and five fractions of ME extract showed larvicidal activity against *A. aegypti* mosquito larvae. The highest larval mortality was found in ME extract. The amount of saponin is correlated with larval mortality.^[91] Mesocarp of fruit extracts has also reported mosquito larvicidal activity against *A. aegypti* and *Culex pipiens*^[92] and saponins from *B. aegyptiaca* callus against *A. aegypti* mosquito have been reported.^[93]

Hepatoprotective activity^[94-96]

Administration of the aqueous extract to biliary duct-ligated rats showed a dose-dependent significant decrease in serum bilirubin level. For three days, the animals were given different concentration of the extract intraperitoneally. The bilirubin concentration was reduced by 22.2% in the animal that received 1.2 g bark extract each day, by 31.6% in those given 2.4 g, and by 45.9% in those given 4.8 g.

Antidiabetic activity^[97,98]

The pure saponin, extracted from the balamite fruit mesocarp, and water extract have been reported as hypoglycemic agent when tested on albino rats in different concentrations dose and Daonil (as a standard medication). It also reported that it inhibit *Escherichia coli* growth in rats.^[99] The aqueous extract of the mesocarp of fruits of *B. aegyptiaca* was reported to have antidiabetic effect in streptozotocin-induced diabetic mice.^[100]

Antiviral activity

It is reported that bark aqueous extract of *B. aegyptiaca* used in treatment of both AIDS and Leukemia. An oral administration of the aqueous extract (30% w/v given at 100 ml every 8 hours for 30 days) for the treatment of HIV patients have shown excellent results. The same was given to patients with leukemia and a good increase in platelets and a normal blood differential reading after one month was noted.^[101]

Wound healing activity

It is reported that *B. aegyptiaca* have potent wound-healing activity, as evident from the wound contraction. The results also indicated that plant possess potent antioxidant activity by inhibiting lipid peroxidation, bleaching DPPH (2,2-diphenyl-1-picrylhydrazyl) radical, and protecting against oxidant injury to fibroblast cells.^[102]

Hypocholesterolemic activity

It is reported that whole and extracted pulp of *B. aegyptiaca* fruits reported a hypocholesterolemic effect when tested on adult albino rats.^[103]

Diuretic activity

The ethanol and methanolic extract of leaves of *B. aegyptiaca* reported diuretic effect when tested on Wistar albino rats with (150 and 300 mg/kg) oral doses. Frusemide was used as standard.

The results indicate that ethanol and methanol extracts shows a significant ($P < 0.05$) increase in the urine volume and electrolyte excretion ($P < 0.001$) when compared with control.^[104]

CONCLUSIONS

Extensive literature survey revealed that 'desert date' has a long history of traditional uses for wide ranges of disease. It has been experimentally proved that *B. aegyptiaca* Del possess antioxidant, antimicrobial, anticancer, diuretic, hypocholesterolemic, wound-healing, antiviral, antidiabetic, hepatoprotective, mosquito larvicidal, anti-inflammatory and analgesic, antivenin, anthelmintic, cardioprotective cum antioxidant activity, and antinociceptive properties. Bark, fruits, seeds, seed oil, and leaves of this plant are widely used in folk medicine. In recent years, emphasis of research has been on utilizing traditional medicines that have long and proven history of treating various ailments. So, further studies need to be carried out to explore *B. aegyptiaca* Del for its potential in curing and treating disease.

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