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Medicinal Properties of Desert Date Plants (*Balanites aegyptiaca)* – An Overview

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Abstract: *Balanites aegyptiaca* (L.) Del, an evergreen, woody, spinous flowering tree about 10 m height referred to as 'desert date,' is a fabulous therapeutic source of curing ailments. It is a member of the family *Balanitaceea* which is broadly spread in waterless land areas of Africa and Southern part of Asia. It consists of saponins, flavonoids, alkaloids, lipids, proteins, carbohydrates and organic acids. Different parts of the plant are confirmed to be utilized in folkloric medicines for the treatment of many diseases. These traditional uses of *B. aegyptiaca* (L.) Del were scientifically proven by many studies including *in vivo*, *in vitro* and even one pilot randomized controlled trial (RCT). This paper presents the folkloric and scientific review of the *B. aegyptiaca* (L.).

Key words: *Balanites aegyptiaca* · Folkloric Medicine · Bioactive Compounds · Pharmacological Properties

INTRODUCTION

Balanites aegyptiaca (L.) Del. is in the family of *Balanitaceea*.The word *Balanites* is derived from the Greek word acorn, which means fruit by Alire Delile in 1813, who substitute Agihalid name rooted from the Arabic word heglig [1]. The entire genus of *Balanites* is consist of nine species and eleven intra-specific taxa [2]. It is a true arid and semi arid multibranched, evergreen spiny tree species (Figure 1) with a wide range of geographical distribution [3]. It is found in the Sudan-Sahel region of Africa, the Arabian Peninsula and South Asia [4-6]. In addition to this wide distribution, it can also grow in many soil type, including sand, heavy clay with different climatic moisture levels [7, 8]. Also, the tree has a good adaptive mechanisms to grow and thrive under combined water and salinity stresses [9].

Balanites is known to be multiple uses and multiple users arid land tree with a wide range of products and values such as food, fodder, shade, oil and traditional medicine [10-13] and potential shelterbelts and agroforestry species [14, 15]. However, the most important part of the tree is its fruits [16-19]. The fruit is known as desert date (common name) and lalobe (Arabic name), is a drupe, pubescent when green, becoming yellowish and glabrous (Figure 2), after ripening [4]. It contains four layers [20]. The outer skin called epicarp (Figure 3), the fleshy pulp called mesocarp (Figure 4), the woody shell called endocarp (Figure 5) and the inner seed called kernel (Figure 6). All of the four layers can be utilized for different industrial and pharmaceutical products [21]. The seed contains high amounts of oil [22-24]. The oil is consumed in human food [25, 26], or can be converted into biodiesel [27, 28]. Also, the oil can used for medicinal purposes [22]. The cake remains after oil extraction is a good source for animal feed supplement [29]. However, the most important product obtains from different parts of the tree is the saponins. This compound proved to have wide range of industrial and pharmaceutical applications [30, 31]. In other words, different parts of the plant were reported to have medicinal properties in many ethnobotanical studies as antihelmenthic, a purgative, leukoderma and emetic [27, 32]. It was also used as anticancer, antivirus as well as antimicrobial [33, 34], and act as a good antidiabetic and antioxidant agents [35, 36].

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Fig. 1: *B.aegyptiaca*

Fig. 2: *Fruit*

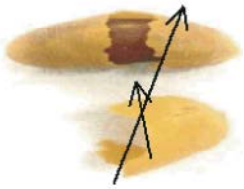

Fig. 3: *Epicarp*

Fig. 4: *Mesocarp*

Fig. 5: *Endocarp*

Fig. 6: *Kernel*

Botanical History: *Balanites aegyptica* (L.) Delile (the desert date or Heglig tree) was first named as Agihalid after the Arabic name'Heglig'in 1592 by Prosper Alpinio [37]. In 1753 Linnaeus described it as *Ximenia aegyptiaca*, while in 1813 Delile replaced Agihalid name by Balanites which was originally a Greek word acorn, meaning the fruit [37,38]. The placement of the genus Balanites was debatable a long its history. It was originally placed in *Zygophyllaceae* then shifted to *Olacaceae*, *Simaroubaceae* and finally *Balanitaceae*. Boesewinkel [39], supported the recognition of a separate family *Balanitaceae* based on its unique ovule and seed characters. The molecular work on floral anatomy, embryology, taxonomy and pollen morphology supported the retention of the genus under *Zygophyllaceae* [40, 41]. However, according to very thorough and extensive review it was recognized as independent separate family of *Balanitaecae* [2, 37]. This revision concluded that the whole genus Balanites has nine species and eleven intraspecific taxa (*1-Balanites wilsoniana (var. wilsoniana, var. mayumbensisandf var. glabripetata)*; 2-*Balanites maughamii* (*subsp. Maughamii* and *subsp. Acuta)*; *3- Balanitestriflora; 4- Balanitesroxburghii*; *5- Balanitesaegyptiaca* (*var. aegyptiaca*, *var. ferox*, *var. pallida*, *var. quarrrei* and *var. tomentosa)*; *6- Balanitespedicellaris* (*subsp.. pedicellaris* and *subsp. Somalensis)*; *7- Balanitesangolensis,* (*subsp. Angolensis and subsp. Welwitschii)*; *8-Balanitesrotundifolia*, (*var. rotundifolia*, *var. scillia* and *var. setulifera)*; *9-Balanitesglabra)*

Taxonomic Classification: The taxonomic classification of *B. aegyptiaca* (L.) Del was reported by National Plant Data Center [42], as seen below:

Taxonomic classification:	
Kingdom	Plantae – Plants
Subkingdom	Tracheobionta – Vascular plants
Superdivision	Spermatophyta – Seed plants
Division	Magnoliophyta – Flowering plants
Class	Magnoliopsida – Dicotyledons
Subclass	Rosidae
Order	Sapindales
Family	Balanitaceea – Creosote-bush family
Genus	Balanites Delile – balanites
Species	Balanites aegyptiacus (L.) Delile – desert date

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 [32].

Vernacular Names: Arabic (zachun, zaccone, heglig (tree)), Lozi (mwalabwe); Luganda (musongole); Amharic (kudkuda, jemo, bedeno), Jericho balsam,lalob tree, heglig, Egyptian myrobalan, desert date, torch wood); French (dattier sauvage, dattier du desert, myrobalau d' Egypte); Hindi (engua, ingudi, betu, hingan, hingn, hingot, hongot, hingota); Bemba (katikayengele, mubambwangoma) Bengali (hin); English (soap berry tree, simple-thorned torchwood, simple thorned torch tree, heglig berries (in the sudan), Mandinka (sumpo); Nyanja (nkuyu); Sanskrit (ingudi); Swahili (mjunju, mwambangoma); Tamil (nanjunda); Tigrigna (indrur, mekie); Tongan

(mulyanzovu, mwalabwe); zacon, kuge, lalob (fruit)); Trade name (desert date (dried fruit, egyptian myrobalan) [1].

Botanical Features: *Balanites aegyptiaca* (L.) Del is a tree with multiple branches, spiny shrub having height of 10m. Crown rounded, dense (but still seen through) with lengthy stout branchlets. Bark grey and trunk, intensely fissured longitudinally [1, 7].

Leaves and Seeds: The plant has compound leaves with spiral arrangement on its shoots, murky green with two firm coriaceous leaflets; having different shapes and dimensions. Petiolecanaliculate, five mm to twenty mm with a short rachis. It usually specifies a greatest length of eight mm for the plant in Uganda. Margin of every leafletentire; lamina commonly up to six cm long, four cm broad, although actually lesser (1-3 x 0.3-1.5 cm) as in the Sahara and Palestine. The seed is pyrene, one and half to three cm long, radiance brown, tough and extremely rigid. It makes up fifty to sixty percent of the fruit. About five hundread to one thousand five hundread dry clean seeds per kg [7].

Flowers and Fruits: Inflorescence is a dumpy pedunculate fascicle of a few flowers. The flower buds are ovoid and covered with a short tomentose pubescence. A flowers hermaphroditic, pentamerous an actinomorphic, is 8-14 mm in diameter and generally greenish-yellow. Pedicels heavily greyish, pubescent and rarely reaching10 mm in length, although 15 mm is reported for Zambia and Zimbabwe.The normal length is about 8 mm. Fruit ellipsoid, up to 4 cm long, green. Ripe fruit brown or pale brown with a delicate coat enclosing a brown or brown-green muggy pulp and a hardstone seed [7].

Flowering and Fruiting Habit: The flowering behavior differs, indeed, there is no specific time for its flowering in the Sahel region, where as it normally happens in the dry season. Consequently, flowering season in Nigeria ranges from November to April and fruits are ripen during December and January and seldom from March to July. somewhere else, foliage and fruit production occur at the peak period of the dry season [7].

Pollination apparently takes place when the insects scents its flowers. It starts fruiting from 5-7 years, with an rising yields for about two decades.These fruits actually take at least a year to get matured and consequently ripen. Mammals and birds eat the fleshy and safe fruit, throwing away, reiterating, i.e discarding the seeds [7].

Distribution and Habitat

Ecology: *Balanites aegyptiaca* (L.) Del has extensive ecological distribution; nevertheless, it reaches its maximum growth as an entity, low-lying, level alluvial sites with profound sandy loam and continuous access to water like valley floors, river banks or the foot of rocky slopes. It is intolerant to shade after the seedling stage and therefore prefers open wood land or savannah for natural revival [43-45].

Also, *B. aegyptiaca* (L.) Del is an Afro Asiatic tree with a enormous geographical distribution. In Africa, its region extends west to east, in the Sahelian band from the Atlantic Ocean (Senegal, Mauritania) as far as Eritrea. This distribution extends across the Sahara, to Algeria where its periphery is situated at 27° N; then in East Africa in the strip going from Egypt and Libya, as far as Zimbabwe (19° S), while in the Middle East from South to North as far as latitude 35° 25' N, in the Arabian Peninsula, Burma, India and Pakistan, along the Arabian Gulf [43-45].

Biophysical Limits: Orwa *et al*. [1] reported the following biophysical limits of *B. aegyptiaca* (L.) Del:

Altitude: 0-2000 m, mean yearly temperature: twenty to thirty degree, mean yearly rainfall: 250-1200 mm.

Type of Soil: It ranges from coarse sands, grimy clay loams, sandy loams or clays.

Documented Species Distribution

Native: Djibouti, Egypt, Gambia, Kenya, Libyan Arab Jamahiriya, Morocco, Myanmar, Chad, Cote d'Ivoire, Democratic Republic of Congo, Benin, Burkina Faso, Nigeria, Burundi, Cameroon Sudan Saudi Arabia, Senegal, Eritrea, Ethiopia, Somalia, Algeria, Angola, Ghana, Guinea, India, Israel, Tanzania, Uganda, Yemen, Republic of Zambia, Zimbabwe [1].

Exotic: Cape Verde, Dominican Republic, Puerto Rico[1].

Ethnomedicinal and Folklore Reports: Although, there is massive advancement in the field of synthetic drugs, plants still hold their special importance, considering the fact that they have no side effects. Different components of *B. aegyptiaca* (L.) Del possess an enormous convetional medicinal properties. On the other hand the therapeutic properties of the plant such as antihelminthic, febrifuge, vermifuge, emetic, a purgative have been reported,it cures different types of diseases that include

malaria, colds, skin boils, leukoderma, syphilis, liver and spleen disorder, wound healing and pains [46]. The bark of the plant is helpful in curing epilepsy, yellow fever, jaundice, mental diseases and syphilis and can at the same time act as a fumigant for healing circumcision injuries [46]. The poach root of the plant are employed as a potage against stomach pain, anthrax and its concoction serves as an antidote to snake bite [34]. The mixture of root bark has been documented to exterminate diarrhea, in hemorrhoid, as well as a fish poison [33]. The paste of shoot is utilized for dressing of wounds and as tooth fluoresher. The thorns are employed as medicaments for healing leprosy. The leaf is employed in curing anthrax, due to their antihelminthic properties and as well as flushing away malignant wounds [46]. The fruit cures oral ulcer, whooping cough, sleeping sickness and skin infections. Fruit kernel has been found as a mild laxative, an antidote for avoiding poisons and as a vermifuge [34]. The seeds are helpful in making cream for curing cough, colic pain and at same time exhibit magicoreligious properties [33, 34].

Phytochemical Constituents

Leaves: The Egyptian species of the plant contains six flavonoids which are quercetin 3-rutinoside, 3-glucosides, 3-rutinoside, quercetin3-glucosides, 3-7 diglucoside and 3-rhamnogalactosides of isorhamnetin, which were isolated from the leaves and branches [47]. Also, the leaves, contain six diosgenin glucosides including di-, tri- and tetraglucosides. Hydrolysis of the saponins gave 25D-spirosta-3, 5-diene and 3β-chloro-25D-spirost-5-ene[56-59] balanitin-1, -2 and -3[48-50].

Fruit: Mesocarp contains about 7.2% saponin, while 6.7% is found in the Kernel [51]. Balanitin A, B, C, D, E have been isolated from pulp while kernel contains only Balanitin F and G [52].. The oil extracted from the kernel composed mainly of triglycerides constituting 44–51% w/w, with little amount of diglycerides, phytosterols, sterol esters and tocopherols [53]. Additionally, a famous spirostanol glycoside, balanitin-3 and sapogenol, 6-methyldiosgenin, furostanol saponin, balanitoside and two pregnaneglycosides have been separated from the fruits (mesocarp) of *B. aegyptiaca* (L.) Del [54-56]. Chemical analysis proposed the chemical structure of the glycoside as 26-O-β-dglucopyranosy l-3-β,22,26trihydroxy-furost-ene, 3-O-α-lrhamnopyranosyl-(1>2)-β-d-glucopyranosyl-(1>4)-β dglucopyranoside and the saponins present in the mesocarp of *B. aegyptiaca* fruit are a mixture of 22R and 22S 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 [57]. Nine saponins were isolated from kernel cake of *B. aegyptiaca* and out of them, six were with molecular masses of 1196, 1064, 1210, 1224, 1078 and 1046Da were identifed, with the compound of mass 1210 Da being the main saponin present (ca. 36%) [23].

Flower: According to Umar et.al [58], the nutrient and antinutritional content of *B. aegyptiaca* (L.) Del flower composition found were ; ash (6.67±0.29%), moisture (43.3±2.89%); crude protein (10.8±0.49%) crude lipid (4.5±0.50%), crude fibre (3.8±0.29%), available carbohydrate (74.2±0.49%) and calorific value (380.5kcal/100g), Na (42.1mg/100g), K (81.8mg/100g), P (5.91mg/100g), Ca (49.8mg/100g), Mg (19.36mg/100g), Mn (0.35mg/100g), Fe (31.46mg/100g), Cu (0.42mg/100g), Zn (3.69mg/100g), Cd (0.19mg/100g), Co (0.33mg/100g), Cr (0.35mg/100g) and Ni (6.33mg/100g).

Due to its high percentage of carbohydrates content and calorific value as seen above, it is actually serves as an excellent source of energy and consequently contains adequate essential nutrients which include protein, lipid, mineral elements and amino acids.

Root: The specimen of the the East African roots revealed a Balanitin 1, 2 and 3, alkaloids and diosgenin [59-61]. Furthermore, it contains steroidal saponin1% glycosides with the major sapogenin is yamogenin [62, 63]. Other forms of glycosides are; (3β,12 α, 14β, 16β)-12-hydroxycholest-5-ene-3,16-diyl bis(β-Dglucopyranoside), (3β, 20S, 22R, 25R)-, (3β, 20S, 22R, 25S)-26-(β-D-glucopyranosyloxy)-22-methoxyfurost-5-en-3-ylβ-D-xylopyranosyl-(1>3)-β-D-glucopyranosyl-(1>4)[α-L rhamnopyranosyl-(1>2)]-β-D-glucopyranoside;(3β,20S,22R,25R) and (3β,20S,22R,25S)-spirost-5-en-3-yl β-D-xylopyranosyl-(1>3)-β-D-glucopyranosyl-(1>4)[α-L-rhamnopyranosyl-(1>2)]-β-D-glucopyranoside [64]. Balanitins 1 to 7 have also been reported from both root and bark of *B.aegyptiaca* (L.) Del [61, 65].

Stem Bark: The stem bark of the Indian species, *Balanites*. *Roxburghii* contains balanitol and the saponins, deltoninand protodeltonin [66]. Furanocoumarin, bergapten and a dihydrofuranocoumarin (marmesin) have been isolated from the chloroform extract of the stem bark [67]. 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 *Balanites roxburghii* [66]. Dicholoromethane extract has yielded two different kind geometric isomers of alkaloid N-trans-feruloyltyramine and N-cis-feruloyltyramine respectively and other metaboliteslike vanillic acid, syringic acid and 3 hydroxy-1-(4-hydroxy-3 methoxyphenyl)-1-propanone [69].

Seeds: Four new cytostatic saponins have been extracted from the seeds of *B. aegyptiaca* (L.) Del, namely, balanitins 4, 5, 6 and 7 [65]. Also, they contain deltonin and isodeltonin which both are used as molluscicidal agents [70].

Pharmacological Activities

Antidiabetic Activity: Different extracts of *B. aegyptiaca* (L.) Del show antidiabetic and hypoglycemic effects as rported by many studies done to prove and understand the possible mechanisms involved. The water extract of the mesocarp of fruits of *B. aegyptiaca* (L.) Del was studied to possess lowering suger level effect in STZ-induced diabetic mice [71]. Similarly, ethyl acetate extract (EAE) from *B.aegyptiaca* (L.) Del has a defensive effect against oxidative stress induced by streptozocine with reduction in blood glucose levels, HbA1c, malondialdehyde and vascular endothelial growth factor (VEGF) in diabetic retina [36].

In same context, the bark extract has shown a reasonable effect on the activity of α-amylase that is accountable for the decomposition of oligosaccharides [72]**.** Also, the fruit extracts (1.5 g/kg bw) decreased the level of the blood glucose by 24% with decreasing liver glucose-6-phosphatase activity extensively in diabetic infected rats. The aqueous and ethanolic extracts of *B. aegyptiaca* (L.) Del fruit induce significant reduction in every component of diabetes which include serum glucose, glucagon, total lipids, total cholesterol, triglycerides level and transaminases [aspartate aminotransferase (AST), alanine aminotransferase (ALT) and ãGT (gamma aminotransferase)] activities [73, 74].

In comparing to similar effects in other plants, the roots of *Panax ginseng* or traditionally known as Korean ginseng have a great value in folk medicine especially within East Asian countries, such as Japan, Korea and China for about 2000 years [75]. The roots of *Panax ginseng* has been shown to improve insulin sensitivity and glucose homeostasis with reduction of blood glucose simulating the effect of an insulin sensitizer [75, 76].

A prominent hyopoglycemic activity was reported from the water extract of mesocarps in the fruits of *B. aegyptiaca* (L.) Del 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 [77]. Additionally, homogeneous extracts of fruits using cell-based bioassays showed augmented basal glucose uptake by 52%; which is twice the activity of 100 nM insulin with sugar particles [78]. Whereas, the dichloromethane and ethyl acetate extracts showed 37 and 41% increase in the glucose uptake, respectively [78]. Another possible explanation of the hypoglycemic effect may be due to trigonelline which was isolated from *B. aegyptiaca* (L.) Del fruit [79].

A more recent study was able to isolate the subfraction-D from butanol fraction which exhibited the highest inhibitory activity of aldose reductase enzyme (IC50 = 12.8±1 µg/ml) in *B. aegyptiaca* (L.) Del extract [80]. In the same context, a biologically active compound was isolated from the methanol extract (MeEx); 26-(O-b-D-glucopyranosyl)-22-O-methylfurost-5-ene-3b,26-diol-3-O-b-D-glucopyranosyl-(1 → 4)-[a-L-rhamnopyranosyl-(1 → 2)]-b-D-glucopyranoside [81]. It showed a significant →-glucosidase and aldose reductase inhibitory effects (IC50¼ 3.12 ± 0.17 and 1.04 ± 0.02 lg/mL, respectively) [81].

The only randomized double-blinded (pilot) clinical study conducted till the present aimed to investigate the antidiabetic efficacy of the 70% ethanol extract of the pericarps of *B. aegyptiaca* (L.) Del with a nutritional intervention in elderly people [82]. It showed a reduction in both post prandial plasma glucose and fasting plasma glucose by 26.88% and 10.3%, respectively. This is a clear evidence of the antidiabetic effect on humans.

In the same context*, Artemisia sieversiana*, medical herb widely distributed in China, has shown a similar anti-diabetic effects [83]. It exhibited a significant acute and sustained hypoglycemic effects with decreasing plasma lipid profiles induced by an insulin-like effect on glucose transport [84, 85]. Similarly, *Withania somnifera* (L.) Dunal (Solanaceae), also known as ashwagandha, showed hypoglycemic and hypolipidemic activities with restoring all parameters of diabeti rats into normal euglycemic state [86].

Anti-microbial Activity: The anti-microbial activity of different parts of *B. aegyptiaca* (L.) Del has been proven by many studies [87-89]. The leaf extracts done in water and organic solvents (acetone and ethanol) showed

antibacterial activity against *Salmonella typhi*. In comparison of ethanolic extracts to water, the former exhibited very high antibacterial activity (16 mm zone of inhibition) than the later (4 mm zone of inhibition) at 100 mg/ml. The preliminary phytochemical analysis revealed the presence of saponins, tannins, phenols and anthraquinones which may explain the antibacterial activity [87].

In the same perspective, flavonoid extracts of callus tissue showed antimicrobial activity against; *Escherichia coli*, *Proteus vulgaris*, *Pseudomonas aureginosa*, *Citrobacter amalonaticus*, *Staphylococcus aureus*, *Micrococcus lylae*, *Bacillus subtilis* and *Sporolacto bacillus* with higher activity against gram +ve bacteria [88]. Active principles isolated were discovered as flavonoids quercetin and kaempferol. Consequently, it can be concluded that antimicrobial activity of tissue culture extracts of *B. aegyptiaca* (L.) Del may be due to the presence of these flavonoids in sufficient amount [88].

In comparstion to similar effects in other plants, *Saussure laniceps* (Compositae), commonly known as "cotton-headed snow lotus" have a great value in folk medicine especially within East Tibetan and Chinese people [90]. Its extracts showed inhibitory effects against 26 types of bacteria as well as pants' pathogenic fungi which mostly attributed to interactions with cell membrane [90].

Additionally, the hydroethanolic extracts of the bark of *B. aegyptiaca* inhibited *in vitro* the growth of multi-drug resistant *Pseudomonas aeruginosa* and *Staphylococcus aureus* in a dose-dependent manner [91]. Stem-barks of *B. aegyptiaca* (L.) Del contains furanocoumarin-bergapten that showed anti-inflammatory, antioxidant and antimicrobial activities [7]. As furanocoumarins have a lactone structure, they have a wide range of biological activity which may count for this antimicrobial activity. A corresponding inhibitory activity of both methanolic and water extracts of whole plant extract on *Staphylococcus aureus* and *Staphylococcus epidermidis* has been documented by Parekh and Chanda [89]**.** Similarly, the crude extract of *B. aegyptiaca* (L.) Del showed a significant reduction in bacterial growth in untreated well water [91, 92]. Phytochemical analysis disclose the occurrence of saponins, coumarins, triterpenes, steroids and tannins which might be responsible for this activity [91].

In the same context, the genus Garcin (family *Clusiaceae*) is a medical herb widely distributed in India, has shown a similar anti-microbial effects [93]. It exhibited a similar effect to clarithromycin. Similarly *andrographis paniculata* (Burm.f) showed anti-microbial activity that effect various bacteria and fungi [94].

Anti-cancer Activity: Saponin extracted from *B. aegyptiaca* (L.) Del fruit showed anti-tumor activity. According to two studies –conducted in mice-, it reduced the number of ehrlich ascites carcinoma (EAC) in both therapeutic group and preventive groups with an increase in life span compared to controls [95, 96].

In the same context, it showed anti-proliferative and cytotoxic activity using various extracts as ethylacetae extract, ethanol extract and chloroform with ethylacetae extract being the most effective among them [97]. Moreover, it also has anti-proliferative activity against human foreskin fibroblast (HFF), MCF-7 human breast cancer cells and HT-29 human colon cancer cells with *in vitro* inhibition rates up to 82% [98]. Also, it showed anti-proliferative activity in opposition to both HepG2 and Caco2 cells with more prominent effect on HepG2 cells [99].

Interestingly, when a mixture of balanitin-6 and -7 were used in mice bearing murine L1210 leukemia grafts, it increased their survival time and with a significant anti-cancer activity [30]. Furthermore, methanol extract of *B. aegyptiaca* (L.) Del stem bark acted as anti-tumor agent in mice injected with HCT-116 cells with significant reduction in cancer cell growth [100].

Anti-oxidant Activity: The studies of different parts of *B. aegyptiaca* (L.) Del extracts has been reported to have an anti-oxidant effects [101]. In addition, a raise in antioxidant enzymes as superoxide dismutase and catalase in mice treated with these extracts was an evident in comparison to control group [96].

Another study testified that methanol extract of *B. aegyptiaca* (L.) Del revealed the highest anti-oxidant activities while hexane and water extracts were with unimportant activity. Also, it revealed a strong positive relation between total flavonoid and total phenolic contents and ferric reducing anti-oxidant power although a negative relation was found between both against Di (pheny)-(2,4,6-trinitrophenyl) iminoazanium (DPPH) and 2,2-azino-bis-3-ethylbenzothiazoline-6-sulfonic acid (ABTS) [100].

Moreover, it helps in scavenenging free radicals in diabetic patients and provide anti-oxidant protection as a result of increasing endogenous production of anti-oxidant agents [35]. Phenolic and flavonoid contents of *B. aegyptiaca* (L.) Del were found to be responsible for their anti-oxidant effect; both have redox properties that

allow them to act as hydrogen donors, single oxygen quenchers and reducing agents [100]. It also prevents lipid oxidation in food thus inhibiting many diseases as cancer and atherosclerosis [102]. According to some reports, the anti-oxidant activity of desert date extract is dose dependent with safety dose up to 1000 mg/kg [95, 103].

Anti-viral Activity: Extract of *B. aegyptiaca* (L.) Del bark aqueous is used to treat both acquired immune deficiency syndrome (AIDS) and leukemia. When this extract was orally administrated for a month to AIDS patients, it showed good results. The same was done with leukemia patients, an increase in the stem bark extract was tested against Herpes Simplex Virus, Coxsackie B2, Semliki forest A7 and *Vesicular stomatitis* Virus, it gave negative results with no activity on them as reported by Maregesi *et al*. [104].

Anti-inflammatory Activity: It has been reported that both methanol and butanol extracts of desert dates have a significant anti-inflammatory effect on the rat paw edema with respect to controls. Furthermore, methanol extract had no dose-response relation, as both the lowest (200 mg/kg) and the highest (400 mg/kg) doses showed the same effect on edema reduction. Although, butanol extract showed a significant dose-response relation [105].

A study conducted on rats indicated that petroleum and ethanolic extracts of aerial parts of desert dates have a significant effect on carrageenan-induced hind paw edema in comparison to the effect of the standard drugs as control group, indomethacin and diclofenac sodium, respectively. The same study reported that ethanol extract had more significant effect on treating inflammatory related pains [106].

CONCLUSION

Balanites aegyptiaca (L.) Del has been used in folkloric remedy for a extensive period of time with several and diverse uses [107-111]. Recently, numerous studies reported that *B. aegyptiaca* (L.) Del has proved these actions and activities as antidiabetic, antimicrobial, antioxidant, anticancer, antiviral and anti-Inflammatory activity as clearly mentioned [81, 83].

It is apparent that future studies are needed to explore *B. aegyptiaca* (L.) Del utilization along with pharmacological activites and possibility to cure and treat different diseases both safely and effectively with better understanding of the exact mechanisms of actions.

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