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Balanites aegyptiaca (L.) Del., a Semi-Arid Forest Tree: A Review

[1]*Prashant Kumar Dubey,* [1]*Mahesh Yogi,* [1]*Akhil Bharadwaj,* [1]*M.L. Soni,*
[2]*Ajeet Singh and* [2]*Anupam Kr. Sachan*

[1]School of Pharmacy, Suresh Gyan Vihar University, Jagatpura, Jaipur, Rajasthan, India
[2] Dayanand Dinanath College, Institute of Pharmacy, Kanpur, Uttar Pradesh, India

Abstract: *Balanites aegyptiaca* (L.) is an important tree in the semi-arid eco system with beneficial attributes. It has diverse use as a treatment of diarrhoea, hermorrhoid, stomach aches, jaundice, yellow fever, syphilis and epilepsy. The fruit is used to treat liver disease and as a Purgative. The oil is consumed for headache and to improve lactation. Bark extracts and the fruit repel snails and copepods, organisms that host the parasites schistosome and guinea worm, respectively. The plant is containing saponins, flavonoids and alkaloids. Two new steroidal saponins were isolated and their structures were determined as 26-*O*-Abeta-d-glucopyranosyl-(25R)-furost-5-ene-3 beta,22,26-triol 3-*O*-[alpha-l-rhamnopyranosyl-(1----2)]-[beta-d-xylopyranosyl-(1----3)]-[alpha-L-rhamnopyranosyl-(1----4)]-beta-D glucopyranoside and its 22-methyl ether. An ethanolic extract of the epicarps, contain two known flavonol glycosides, isorhamnetin-3-O-robinobioside and isorhamnetin-3-*O*-rutinoside. *B. aegyptica* also having alkaloids N-trans feruloyltramine and N-cis-feruoyltyramine and three metabolites vanillic acid, syringic acid and hydroxy-1-(4-hydroxy-3-methoxyphenyl)-propanone. Various pharmacological activities in the B.aegyptica is reported by researcher like toxicity study, anti inflammatory, analgesic, antioxidant, anti tumor, larvicidal, Anti nonciceptive, Anthelmentic and anti diabetic activity which can we discussed in this review article.

Key words: *Balanites aegyptiaca* · Analgesics · Anti-inflammatory · Antioxidants · Anti-venom · Anti-microbial · Anti-diabetic

INTRODUCTION

Balanites aegyptiaca is a species of tree, classified either as a member of the Zygophyllaceae or the Balanitaceae. This tree is native to much of Africa and parts of the Middle East. This is one of the most common trees in Senegal. 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. This is one of the most common trees in Senegal. 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 [1]. This tree reaches 10 m (33 ft) in height with a generally narrow form. The branches are thorny. The tree produces several forms of inflorescence bearing yellow-green bisexual flowers which exude nectar. The larva of the cabbage tree emperor moth *Bunaea alcinoe* causes defoliation of the tree [2]. The dark green compound leaves are made up of two leaflets which are variable in size and shape. The yellow, single-seeded fruit is edible, but bitter. Many parts of the plant are used as famine foods in Africa; the leaves are eaten raw or cooked, the oily seed is boiled to make it less bitter and eaten mixed with sorghum and the flowers can be eaten. The tree is considered valuable in arid regions because it produces fruit even in dry times. The fruit can be fermented for alcoholic beverages. Bark grey, 6 mm thick; leaves 2-foliolate, leaflets elliptic or obovate; flowers small, greenish white, fragrant, in axillary, few-or many-flowered fascicles; drupes ovoid, woody, 2.5-6.0 cm long, 5-grooved, enclosing an oily seed the plant also having antivenin potential [3].

Chemical Constituent: Phytochemical screening of methanol and acetone extract of stem bark of *B. aegyptiaca,* the presence of alkaloids, flavonoids and glycosides was not detected however saponins, tannins and volatile oils [4] were detected by the use of this model [5].

Correspondent Author: Prashant Kumar Dubey, School of Pharmacy, Suresh Gyan Vihar University, Jagatpura, Jaipur, Rajasthan, India

Sl. No.	Chemical Constituents	Acetone Extract	Methanolic extract
1.	Saponins	+ve	+ve
2.	Tanins	+ve	+ve
3.	Flavonids	-ve	-ve
4.	Alkaloids	-ve	-ve
5.	Glycosides	-ve	-ve
6.	Volatile oils	+ve	+ve
7.	Terpens	+ve	+ve

+ve indicates presence of chemical constituents and-ve indicates absence of chemical constituents

A long chain aliphatic compound 10-methyl-n heptocosone and new sugar, diglucosyldirhamnoside have been isolated from the ethanolic extract of the stem bark *B. aegypyiaca* [6].

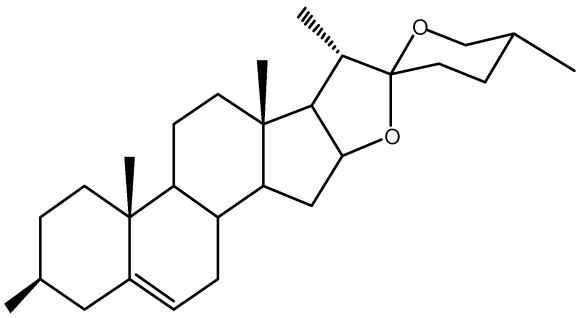
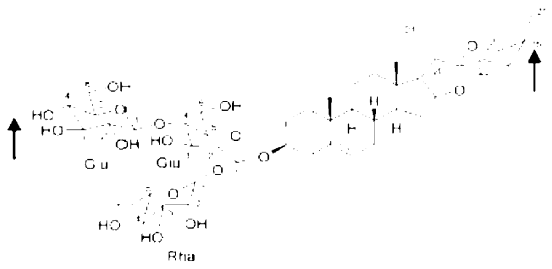
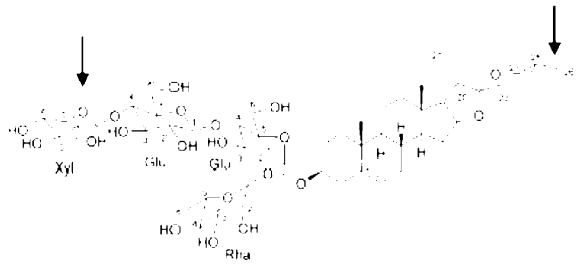


Figure: Chemical Structure of Diosgenin

Six Flavonoids Glycosides: quercetin-3-glucoside, quercetin-3-rutinoside and 3-rhamnoglactoside of isorhamnetin were extracted and identified from leaves of B. aegypyiaca only isorhamnetin: 3-rutinoside and 3-rhamnogalactoside were recorded from the fruit of the plant [7]. The oil contain 54.53% unsaturated fatty acid and 1.14% steroids. The fixed oils exhibited anticancer activity against lung, liver and brain carcinoma cell lines [8]. Two new steroidal saponins were isolated and their structures were determined as 26-O-beta-D-glucopyranosyl-(25R)-furost-5-ene-3 beta,22,26-triol 3-O-[alpha-L-rhamnopyranosyl-(1→2)]-[beta-D-xylopyranosyl-(1→3)]-[alpha-L-rhamnopyranosyl-(1→4)]-beta-D-glucopyranoside and its 22-methyl ether. In addition, two known saponins, 26-O-beta-D-glucopyranosyl-(25R)-furost-5-ene-3 beta,22,26-triol 3-O-(2,4-di-O-alpha-L-rhamnopyranosyl)-beta-D-glucopyranoside and its methyl ether were isolated and identified [9]. The bark of B. aegypyiaca contains a number of alkaloids balanitin-6-and-7 disgenyl saponins isolated from B. aegypyiaca Display significant anti-tumor activity in-vitro and in-vivo [10]; such as N-trans-feruloyltryramine and N-cis feruloyltryramine [11] and common phenolic compound such as vanillic acid, syringic acid and 3 hydroxy1-(4-hydroxy-3-methyloxyphenol)1-propanone [12]. The fruit mesocarp contains a large variety of chemical agent such as glucoside, Comurins, flavonoides and 6-methyl diosgenin. High performance liquid chromatographic (HPLC) analysis of a dichloromethane extract of the stem-barks of *B. aegypyiaca* has yielded two known alkaloids, 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 [13]. Balanitin-6 and-7 have been iso;lated from *B. aegypyiaca* using similar procedure previously used [14]. Five new steroidal glycosides were isolated from the roots of *Balanites aegyptiaca.* On the basis of spectroscopic and chemical evidence, their structures were determined as (3β,12 α,14β,16β)-12-hydroxycholest-5-ene-3,16-diyl bis(β-D-glucopyranoside) (1), (3β,20S,22R,25R)-and (3β,20S,22R,25S)-26-(β-D-glucopyranosyloxy)-22-methoxyfurost-5-en-3-yl β-D-xylopyranosyl-(1→3)-β-D-glucopyranosyl-(1→4)[α-L-rhamnopyranosyl-(1→2)]-β-D-glucopyranoside (2 and 3, resp.) and (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 (4 and 5, resp.) [15].



Balanitin-6



Balanitin-7

Chemical structure of balanitin-6 and-7, the arrow point to the diffrence between balanitin-6 and-7: the lack of a xylose in balanitin-6 when compaired to balanitin-7 and an axial C25 methyl position for balanitin-6 (yamogenin) and as equatorial for balanitin-7 (disogenin)

Reproductive Biology: *B. aegyptiaca* provide nectar from the nectariferous disc as a reward together with the pollen, which attracts a wide range of insect pollinators.

In *B. aegyptiyaca*, pollen is released in big quantities (22-600 per flower) with 91% viability. This viability decreases progressively down to Zero within about storage 5 days storage at ambient temperature. There is high correlation between percentage viability and germination rate of pollen obtained by FCR. This test indicates that the medium used in this test is favorable to the germination of *B. aegypyiaca* [16].

B. aegypyiaca shows synchronization between male and female phase. The quick loss of pollen bioability and the high frequency of Diptera, slightly mobile, furthering transport on short distance between flower of a same inflorescence or of a same tree, all leads towards geitonogamy which is main strategy developed in *B. aegypyiaca*, the ratio of allopollination (37%) can be related to wind and also another population of insects may be very mobile carrying pollens on long distances. This reproductive strategy found in *B. aegypyiaca* is well adapted to the different vectors of pollination observed while in the importance of male investment, shows the uncertainty of the transport system found in other woody forest species like Faridhribia albida [17]. The low seed/ ovule ratio and the number of ripe fruits show that there is an important rate of abortion in *B. aegypyiaca*. This high rate of abortion is usual in the sabelian environment where trees produce a greet number of flowers to attract pollinators [18] and after fertilization according to resources allocated selected most competitive fruits for maturation [19, 20]. *B. aegypyiaca* has hermaphrodiate flowers. The localization of potential food sources (pollen and nectar) for Diptera and Hymenopetra, the main pollinarors insects found on Balanites inflorescence concerning system. The species is partially auto compatible with a low fruit/flower ratio resulting to high fruit abortions interpreted as an active screening of the progeny best fitted to the environment [21].

***In vitro* Clonal Propagation:** *In vitro* propagation technique of *B. aegypyiaca*, a multipurpose woody tree was studied. Nodal segments including axillary bud from mature tree were used as an explant and their morphogenetic potential was tested on MS media with various concentrations (2.5-15.0 μM) of 6-benzyladenine (BA), Kinetin and Thidiazuron alone or in combination with different concentrations (0.5-2.5 μM) of α-naphthalene acetic acid (NAA). Nodal segments showed axillary bud proliferation in almost all media tried. MS medium containing 12.5 μM BA alone was effective for inducing multiple shoots (5.0 ± 0.22) with an average shoot length (3.7 ± 0.26 cm) in 67% of cultures. A better shoot differentiation and elongation was achieved in a combined treatment of BA (12.5 μM) and NAA (1.0 μM). Half strength MS medium supplemented with Indole-3-butyric acid (IBA) gave the best result for rooting. The maximum frequency of root formation (68%), number of roots (5.3 ± 0.32) and root length (4.1 ± 0.38 cm) was obtained on half strength MS medium containing 1.0 μM IBA. The regenerated plantlets were potted and acclimatized successfully in a growth chamber and then moved to the greenhouse [22].

Pharmacological Screening

Toxicity Study: B. aegypyiaca seeded oil has been used in Nigeira as ingredientand substituted to groundnut oil in the preparation of local foods. A four-week repeated dose toxicity of crude *B. aegypyiaca* seed oil was performed on Wister strain rats. The rates were divided in four groups of five animals each and feed diet containing 0, 0.5, 1 and 5% crude *B. aegyptiyaca*. seed oil, result showed no significant ($P<0.05$) changes in AST and ALT, except in the 5% group where ALT activity was elevated, no significant ($P<0.05$) changes in serum total protein, albumin, A/G ratio, serum urea, creatinine, mean final body weight, food consumption and relative liver and kidney weight were observed. The result showed that dietary exposure of crude B. aegyptiyaca seed oil in rats did not result in marked changes in the toxicological parameters been assayed. Thus, consumption of the crude oil at the present level of exposure may be of no serious safety concern, especially in liver and kidney injury [23].

Anti-inflammatory and Analgesic Activity: The Anti-inflammatory and analgesic effect of ethanolic and petroleum ether extract of *B. aegypyiaca* were evaluated in experimental animals. The anti-inflammatory and analgesic activity of ethanolic and petroleum ether extract of dried leaves of areail parts of *B. aegypyiaca* by oral administration at dose 300 and 600mg/kg/day of body weight to healthy animals. The extract were studies for their Anti-inflammatory activity in Carrageenan induced hind paw edema in rats and the paw volume was measured, plenthysmonetrically at 0and 3 hrs after injection [24]. The ethanolic and petroleum ether extract for Analgesic activity using Eddy's hot plate method and tail flick method in albino rats [25]. The ethanolic and petroleum ether extract of *B. aegyptiaca*, significantly ($P<0.05$) reduced Carrageenan-induced paw edema in rats and analgesic activity evidenced by increasing in the reaction time by Eddy's hot plate method and tail flick method in albino rats. The ethanolic and petroleum ether extract showed a greater Anti-inflammatory and Analgesic affect comparative to the standard drug and Diclofenac

sodium respectively. The result indicted the ethanolic extract of *B. aegyptiyaca* exhibit more significant activity than petroleum ether in the treatment of inflammation [26].

Anthelmintic Activity: Four groups of approximately equal size earthworms (8±1 cm) consisting of six earthworms in each group were used for the present study Albendazole is taken as standard drug(1% gum acacia in normal saline), albendazole and aqueous extract of *B. aegypyiaca* (100mg/ml, 80mg/ml, 60mg/ml, 40mg/ml and 20mg/ml concentration) [27]. Five groups of approximately equal size earthworms consisting of six earthworms in each group were used for the present study. Each group was treated with one of the following vehicle (1% gum acacia in normal saline), albendazole and aqueous extract (100mg/ml, 80mg/ml, 60mg/ml, 40mg/ml and 20mg/ml concentration). Observations were made for the time taken to paralysis and death of individual worms. Paralysis was said to occur when the worms do not revive even in normal saline. Death was concluded when the worms lost their motility followed with fading away of their body color. It was concluded that, the aqueous extract showed marked and potent anthelmintic activity than the standard drug albendazole [28].

Antioxidant Activity: Adriamycin is an anthracycline antibiotic that is widely used as a chemotherapeutic agent. However, usefulness of this agent is limited due to its cardiotoxic effects. Increased oxidative stress and antioxidant deficit have been suggested to play a major role in adriamycin induced cardiomyopathy and congestive heart failure due to multiple treatments with adriamycin. The rationale of the present study was to evaluate the potential protective effect of *B. aegypyiaca* as a source of the natural antioxidants against adriamycin-induced cardiotoxicity in experimental mice. In present study, four groups (ten animals in each group) of experimental mice were used as follows: Group 1, mice not received both Adriamycin drug and *B. aegypyiaca* extract and served as a negative control group; Group 2, mice received Adriamycin intraperitoneally (2.5 mg/kg bodyweight) in six equal injections over a period of two weeks for a cumulative dose of 15 mg/kg bodyweight; Group 3, mice orally administered with *B. aegypyiaca* extract (400 mg/kg bodyweight), through an intragastric feeding tube over a period of three weeks; Group 4, mice treated orally with *B. aegypyiaca* extract plus intraperitoneally adriamycin administration (2.5 mg/kg bodyweight). Serum Lactate dehydrogenase (LDH), Creatine phosphokinase (CPK), Glutamate oxaloacetate transaminase (GOT), Glutamate pyruvate transaminase (GPT), Lipid peroxide (LPO), total Nitric oxide (NO), erythrocyte lysate Superoxide dismutase (SOD), Glutathion peroxidase (GPx) and plasma Catalase (CAT) were measured in all tested groups. The results showed that, Adriamycin elevated the activities of LDH, CPK, GOT, GPT, LPO and total NO content in the mice heart tissue. Also, Adriamycin drug reduced the activities of SOD, GPx and CAT. Pretreatment with *B. aegypyiaca* extract significantly ($P<0.05$) either reduced or completely prevented its toxic effects. So, these findings demonstrate the cardio protective effect of *B. aegypyiaca* on antioxidant tissue defense system during Adriamycin induced cardiac damage in mice. Therefore it could be recommended for further investigation in this potentially new indication for clinical application [29].

Antidiabetic Activity: An aqueous extract of mesocarps of the fruits of *B. aegypyiaca* exhibited a prominent antidiabetic activity by oral administration in streptozotocin induced diabetic mice. From one of the active fractions of this extract, two new steroidal saponins were isolated and their structures were determined as 26-O-beta-D-glucopyranosyl-(25R)-furost-5-ene-3 beta,22,26-triol 3-O-[alpha-L-rhamnopyranosyl-(1----2)]-[beta-D-xylopyranosyl-(1----3)]-[alpha-L-rhamnopyranosyl-(1----4)]-beta-D-glucopyranoside and its 22-methyl ether. In addition, two known saponins, 26-O-beta-D-glucopyranosyl-(25R)-furost-5-ene-3 beta,22,26-triol 3-O-(2,4-di-O-alpha-L-rhamnopyranosyl)-beta-D-glucopyranoside and its methyl ether were isolated and identified. It was revealed that the individual saponins did not show antidiabetic activity, while the recombination of these saponins resulted in significant activity. From an ethanolic extract of the epicarps, two known flavonol glycosides, isorhamnetin-3-O-robinobioside and isorhamnetin-3-O-rutinoside were isolated and identified [30].

Antinociceptive Activity: The anti-inflammatory and anti-nociceptive activities of methanol (ME), butanol (BE) extracts and of two new saponins isolated from *B. aegypyiaca* bark was evaluated. The study was carried out *in vivo* and *in vitro*. The samples, extracts and pure substances, were intra-gastrically administered to animals. Two different animal models, the carrageenan-induced edema, in the rat and acetic acid-induced writhing test in mice, were adopted. Moreover, the antioxidant power of extracts, fractions and individual constituents from *B. aegyptiaca* has been evaluated *in vitro*, using a method based on the Briggs-Rauscher (BR) oscillating reaction. Results obtained demonstrate that both ME or BE have a

significant effect at the highest dose on the number of abdominal writhes induced by acetic acid, with a 38 and 54% inhibition respectively, but no significant difference was observed for extracts at the lowest dose and for the pure compounds compared with control animals. The same extracts exhibit a significant reduction on the rat paw edema. The inhibition produced by ME is about the same (28+/-3% lowest dose, 32+/-3% highest dose) after administration. A more evident effect is obtained by BE (41+/-3% and 68+/-6% respectively) and single saponins B1 and B2 (62+/-5% and 59+/-6% respectively) after oral administration. The antioxidant activity obtained seems to be in good accordance with the pharmacological results. The histological sections of rat paw confirm the antiflogistic activity of the plant extracts [31].

Hepatoprotective Activity: The biochemical parameters such as serum Glutamate oxaloacetate transaminase (SGOT), Serum glutamate pyruvate transaminase (SGPT), alkaline phosphate (ALP) and bilirubin were estimated by reported methods [32, 33]. In the CCl_4 treated group of animals, the levels of SGOT, SGPT, ALP and bilrubin were significantly ($P<0.001$) elevated. The treatment of animal with crude ethanolic extract of *B. aegyptiaca* (Fruits) at a dose of 250 and 500-mg/kg body weight showed a significant decrease ($P<0.05$; $P<0.01$) in SGOT, SGPT and ALP but not bilrubin. The standard control drug Silymarin at a dose of 10mg/kg also significantly prevented the elevation of serum enzyme. Treatment with crude extract (250 and 500mg/kg) and Silymarin exhibited a protection of 26.5, 28.7 and 56.9% in SGOT levels, 27.3, 29.9 and 64.5% in SGPT levels and 19.2, 21.5 and 42.8% in ALP Levels Respectively [34]. Although the bilirubin levels in rats treated with both dose of *B. aegypyiaca* extract showed a decrease, but this decrease levels was not found to be statically significant. On the other hand, the silymarin treated group of animals showed a significant decrease in bilirubin levels ($P<0.05$) [35].

Antibacterial Activity: The anti-microbial activity of the ethanolic extract of the plant materials shows that *B. aegypyiaca* demonstrate higher activity (16 mm zone of inhibition) against the test organism compared to that of M. Oleifera (8mm zone of inhibition) at 100mg/ml. The result showed that the organic extract (acetone and ethanol) had higher activity compared to the aqueous extract, it has been reported that different solvent have different solvent extract capabilities and different spectrum of solubility of phytoconstituent [36, 37]. The activities of plant extract were compared to the antibiotics Ciprofloxacin, cotrimaxazole and Chloramphenicol at 10 mg/ml. The anti-microbial activity of B. aegyptiyaca (16 mm zone of inhibition) was higher than that of Ciprofloxacin (10mg/ml-10 mm zone of inhibition), Cotrimaxazole (10mg/ml-8 mm zone of inhibition) and Chloramphenicol (10mg/ml-10 mm zone of inhibition). When both two extract mix in equal quantity 18mm zone of inhibition was obtained. These indicate the synergistic action of two extract. pH changes of medium decrease the activity of phytoconstituent if the (P^H 8¬10) moves to alkalinity [38].

Larvicidal Activity: *B. aegyptiaca* had been used over thousands of years. The fleshy pulp of the fruit is eaten fresh or dried. It contains 64-72% carbohydrates, plus crude protein, steroidal saponins, vitamin C, ethanol and other minerals. All parts of the tree have a medicinal uses including fruits, seeds, barks and roots. The most important is steroidal saponins, which yield diosgenin, a source of steroidal drugs, such as corticosteriods, contraceptives and sex hormones [39]. These tissues contain high amount of saponins. Interaction of saponins compounds with the cutide membrane of the larvae, ultimately disarranging this membrane by the association of the saponins molecules with these membrane could be the most probable reason for the death of larvae. The deficiency of dissolved oxygen in the water due to the active presence of the antioxidant saponins could not be ignored [40].

The effect of aqueous extract of the fruit pulp, seed kernel, roots, bark and leaves of *B. aegypyiaca* against the larvae of the *culex pipens* mosquito was investigated. Early fourth instars larvae of C. Pipiens Mosquitoes were exposed, for up to three days, to a dilution of 0, 0.1, 0.25, 0.5, 1.0 and 2.0% aqueous extract of fruit pulp, seed kernel, roots, bark and leaves. All tested extracts showed larval mortality, however, larval mortality was greatest with the aqueous root extract. The lowest concentration of root extract (0.1%), Showed 100% larval mortality. Aqueous extract of fruit pulp, seed kernel and leaves showed less larval mortality compared to the root and/or bark extracts. It is suggested that all parts of the *B. aegyptiyaca* contain larvicidal properties that could be developed and used as natural insecticides for mosquito control [41].

CONCLUSION

B. aegypyiaca is very useful medicinal plant which is widely used by rural population of India for the treatment of various diseases by using as anti-microbial, analgesic and anti-inflammatory herbal drug. The leaves and fruits are eaten by goats, sheep and camels; plant parts are used

as soap substitutes because of high saponin contents; thorny branches used for fencing. It is widely used as good firewood and charcoal; edible fruit and seed have 30-40% of edible oil, which is used as cooking oil in Nigeria. Saponins tannins and Volatile oil are the major constituents previously reported; some other rescuer also reported alkaloids flavonoids and alkaloids which is responsible for pharmacological activities of the plant. Now bioavilability and pahrmakokinetic study of the plant is must require for the assurance of safety reasons. The concentration of different phytoconstituent is differing according to different climatic zones.

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