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# A REVIEW OF THE TECHNO – ECONOMIC POTENTIALS OF *BALANITES AEGYPTIACA* OIL

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**ABSTRACT:**

Plants oil are becoming important in commerce and nutrition worldwide as they are good source of dietary energy and raw material for the manufacture of industrial products. Despite this fact little attention has been given to *Balanites aegyptiaca* oil. Therefore there is growing interest in understanding the potential of *Balanites aegyptiaca* oil as feedstock for improving livelihoods of communities in dryland areas. *Balanites aegyptiaca* is a multipurpose tree species in dry land of Africa. The plant seed kernel produces high quality oil that amounts for 9-10 % by weight of the whole fruit. Its seed kernel has high oil content (50 %) whose extraction is economically worthwhile. The oil parameters revealed that the oil composed of long chain fatty acids with high degree of unsaturation, making it a good feedstock for biodiesel production. It also has biologically active properties which contribute in its medicinal application. The oil is fulfilling in saturated fatty acids, as such are accustomed as cooking oil. *Balanites aegyptiaca* oil may be useful for industrialists that produce eco-friendly soap. Therefore, conversion of the oil to different products will help in domestication of this neglected and underuse dryland tree species. This may advocate wise use of renewable natural resources and not protection without possible economic benefit. Thus, *Balanites aegyptiaca* oil is a multipurpose feedstock with high economic potential and industrial applications if richly exploited. Furthermore, many prospective exploitation possibilities will emerge when further researches are made on this multipurpose oil.

**Keywords:** *Balanites aegyptiaca*; Dryland; feedstock; plant oil; Techno – economic potential

## INTRODUCTION

In 1813 the name *Balanites* (from the Greek for acorn, referring to the fruit) was given by Alire Delile. It replaced "Agialid" (derived from the Arabic name for the tree, "heglig") (Orwa *et al*., 2009)**.** *Balanites aegyptiaca* belongs to the family *Balanitecea*. The plant as depicted in plate 1 is a perennial tropical plant and an armed multi-branched tree that is 8-10 m high. Its bark is grey and leaves are spirally arranged on the shoots with 2 firm leaflets that vary widely in shape and dimension. Flowers are yellow-green of about 1.3 cm long. Its fruit is a drupe, pubescent when green, becoming glabrous and yellow during ripening. Ripe fruit is brown-pale brown with brittle coat covering a brown-green sticky pulp and a woody seed (Zang, 2018). The plant is usually propagated by seeds, and the seed germination is hypogeal (Muhammad, 2015). Its tree produces fruits that each weight 5-8 g. Fruit consists of an outer epicarp, an edible mesocarp or pulp and a hard stone endocarp containing the oil seed or kernel (Manji *et al*., 2013). The fruit's layers and their percentage composition are depicted in figure 1. *Balanites aegyptiaca* may be grown for both its fibre and oil. The oil seed or kernel is considered as edible product that has high protein content and contains good quality oil.

**Plate 1: *Balanites aegyptiaca* Tree**

The oil extracted is used for many applications and the remaining cake is considered as an extensive animal feed (Ajayi & Folorunso, 2013). Extracts from distinct parts of this tree have been intensively utilized in some developing countries including

Africa for food preparations and herbal medicine. Onyema *et al.* (2017) in his study on agro forestry practices and potential in Western Sudan reported that *Balanites aegyptiaca* has attracted attention as a prominent source of pesticides, edible oil, soap, medicines, nuts, fuel, animal feed, as well as source of income. Its stem bark could serve as a wetting and cleansing agent for household and industrial applications. The plant species is also utilized as charcoal, ornamental, shade, timber, insecticide, fuel wood, drugs, fodder for livestock, sand dune fixation and shelter belt (Muhammad, 2015).

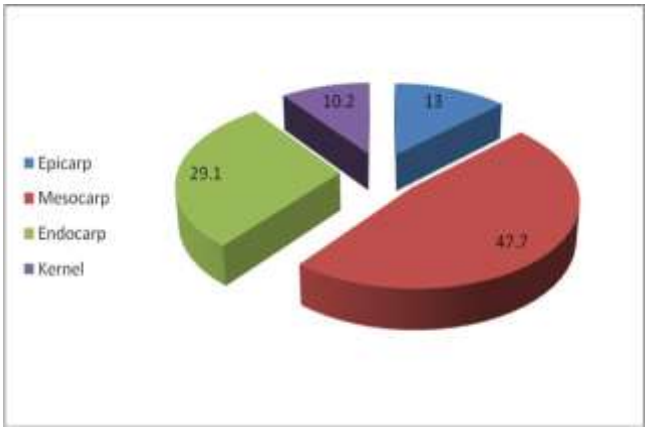


**Fig. 1: Percentage Composition of Fruit**

*Balanites aegyptiaca* has wide ecological distribution as depicted in figure 2. It can be found in Africa and in some regions of western Asia. It is also predominant in tropical, subtropical, warm temperate, and in drier areas including Africa. *Balanites aegyptiaca* is extremely abundant in dry and semi-dry regions, mainly in sub-Saharan regions such as the Middle East, South Asia and the sub-Saharan region of Africa (Zang, 2018).

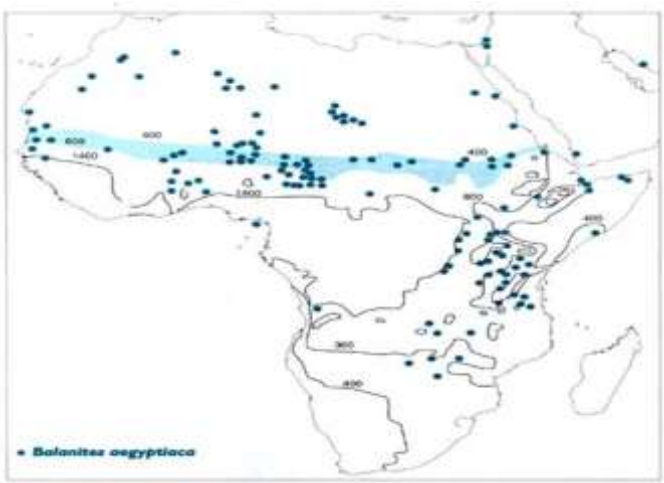


**Fig. 2: Natural Distribution of *Balanites aegyptiaca***

*Balanites aegyptiaca* composed of about 25 genera and 240 species. It adapts to variety of soil types and conditions. The plant can survive in various types of soil ranged from fluvial soil, dark clay soil, sandy soil, river bank soil, but is mainly found on level fluvial soil. The plant can be growing up to 2000 m altitude with average annual rainfall of 250-400 $mm^3$ and average annual temperature of 20-30 °C (Orwa *et al*., 2009). It has full potential of producing reliable yield under unreliable conditions as it can withstand high wind velocity, severe drought and high temperature. The drought-resistant tree can grow wild with no fertilization, irrigation, or care under different ecological conditions (Bambara, 2018). It can grow with minimal rainfall and moisture (Onyema *et al.*, 2017). In spite of the ecological significance of *Balanites aegyptiaca* and the multipurpose potential of all its parts especially oil, the plant remain among the major disregarded tree species in the dry regions.

The potential of *Balanites aegyptiaca* oil under management remain gloomy. Therefore, it is important to generate capacity and establish a picture of variation within natural range, in order to raise plant oil with desirable features as described. Thus, this study highlights the overall potential of *Balanites aegyptiaca oil.*

## PLANTS OIL

### Definition of Oil

The name oil is use as a generic term to describe oily fluids or all substances that are greasy at room temperature and soluble in organic solvents such as benzene, chloroform, diethyl ether, etc. but insoluble in water. These heterogeneous biochemical substances have in common, the property of being insoluble in water. Fats and oil are obtained particularly from various domesticated plants and animal. They are of immense important in distinct industrial application (Zang, 2018). Plant oil remains one of the key resources that can be cheaply obtained from biomass and readily processed to provide suitable raw material for multitude industries, and have both edible and non-edible

applications such as: paints, soap production, lubricants, varnishes, cosmetics, biodiesel, lubricant and insulating materials (Ogala, 2018). The oil selection criteria for industrial application include: clarity, presence of natural characteristic aroma, good natural color, freedom from solid particles, very low moisture content, and freedom from flat and rancid (unpleasant) odour (Elmustafa, 2015).

**Oil Extraction**

The process of oil production from parent seeds involves separation of the oil from oil-bearing substances by either mechanical or chemical means. Various techniques are used in order to get high quantity oil. There are generally three techniques or methods of oil extraction namely; distillation, solvent extraction and expression. The solvent extraction process is essential in large-scale operations to remove the oil from oil-bearing substances with a non-toxic fat solvent such as hexane at low temperatures (Nada, 2011). When the amount of oil in plant seed kernel is very little or plant materials and properties would be destroyed or altered by steam or water distillation using other oil extraction techniques, solvent extraction is used. Hence, recovery of oil under expression and distillation conditions is less efficient. In solvent extraction, the solvent is passes through the plant (seed) material. The plants (seed) components including requisite oil, waxes and fatty acids are dissolved by solvent. The remaining components make up the cake after the mixture was distilled off. The requisite oil is extracted from the seed component using alcohol. The fatty acids and waxes are then separated as they are not alcohol soluble. The alcohol is then released through secondary distillation, leaving behind the essential oil (Roseli, 2005).

**Balanites aegyptiaca Oil.**

*Balanites aegyptiaca* plant has high oil yield (38.2–54.5 %) from its seeds kernel (Ogala, 2018). The seed oil as depicted in plate 2 is light yellow in color, and was reported to be rich in four saturated fatty acids: olein, linolein, palmitic and stearic acid but in varying proportions base on study sites (Elmustafa, 2015).

**Plate 2: *Balanites aegyptiaca* seed kernel oil**

Physico-chemical properties of any oil are of immense important when determining its nutritional quality as well as its commercial value. Physicochemical properties of *Balanites aegyptiaca* oil from selected literatures are shown in table 1.

**Table 1: Physicochemical characteristics of *Balanites aegyptiaca* oil**

| **Properties** | **Units** | **Literature values** | | |
|---|---|---|---|---|
| | | **(Zang, 2018)** | **(Yunus & Zuru, 2017)** | **(Elmustafa, 2015)** |
| Saponification value | (mg KOH/g) | 200.02 | 167.60 | 224.63 |
| Peroxide value | (m Eq/kg) | 2.95 | - | 1.18 |
| Acid value | (mg KOH/g) | 2.14 | - | 1.53 |
| Iodine value | $gI_2/100g$ | 104.39 | 105.65 | 122.42 |
| Specific gravity | - | 0.92 | - | - |
| Viscosity | (cst) | - | 36.10 | 21.55 |
| Density | $(g/cm^3)$ | - | 0.92 | 0.91 |
| Free fatty acid | % | 0.82 | 0.65 | 3.17 |
| Oil yield | % | 45 | 46 | 43 |

## ECONOMIC VIABILITY OF *BALANITES AEGYPTIACA* OIL

Oil are valuable resources with global demand. *Balanites aegyptiaca* seed kernel oil constitutes about 46.7 percent based on dry weight (Sylvester *el al*., 2014). Recent studies claimed that the finest of the trees can yield a maximum of 52 kilogram of the fruits per tree. Tesfaye (2015) reported that one tree could approximately produce 100-150 kg per year. Researches revealed that more than 400,000 tonnes of *Balanites aegyptiaca* fruits are produced annually in Sudan. Okia (2008) added that the plant oil has high demand rate both in rural areas and local markets including neighboring Southern Sudan. Currently *Balanites aegyptiaca* oil is sold in Sudan is at USD1.5 at home and USD 2.0 per litre in local & urban markets (Okia, 2008). From the economic point of view, studies disclosed successes in large scale *Balanites aegyptiaca* plantations in many tropical countries. The plant fruit yield per tree in a year is about 72 kg (Nada, 2011). Usman (2019) in his study reported that a single tonne of *Balanites aegyptiaca* seed kernel could bring forth 426 liters of oil using soxhlet extractor and n-hexane as solvent. The large shells of the *Balanites aegyptiaca* seeds account for the huge mass, which gives a low yield of recovered oil. The parent oil extracted (409.9 g) from *Balanites aegyptiaca* seeds kernel (1404 g) gave 29.2 percent yield. However, when the shells are excluded from the calculations, the oil recovery increased to about 47 per cent (Sylvester *el al*., 2014). Syrup for indigestion manufactured from *Balanites aegyptiaca* oil costs USD 12 per liter (Okia, 2008). The oil is also used to enrich cream, soap, and lotions he added. Elmustafa (2015) justified the fact that cost of establishing and running a small scale oil milling enterprises could be from income generated from oil extraction.

## TECHNICAL BENEFITS OF *BALANITES AEGYPTIACA* OIL

### Biodiesel Production Viability from *Balanites aegyptiaca* Oil

Oil brought forth from plants tend to be located in the seeds and act as a reservoir of nutrients to provide nourishment to seedlings as they grow. It is this very oil that is converted to biodiesel after extraction (Hiranmayee, 2009). Sources of biodiesel include non edible vegetable oil, oil from algae, animal fats and recycled cooking oil. Conventional vegetable oil from plants such as *Balanites aegyptiaca*, cotton seed, sunflower, linseed, castor, peanut, coconut, soybean, palm and many others have emerged as promising candidates of biodiesel used in diesel engine. Currently, the greater portion of these conventional vegetable oil produced locally are used in production of cooking oil, human and animal food, soap and other industrial products. Due to competition between food and fuel, it is highly unlikely to justify the utilization of edible vegetable oil for the production of biofuels (Hem, 2008). In West Africa, oil production especially in West African dry and semi-dry areas where the soil and climatic condition are not favorable to produce the plants commonly used for biofuel production (like Soybean, Jatropha or rapeseed), *Balanites aegyptiaca* could be an alternative feedstock (Garba, 2011). A number of Literatures have indicated *Balanites aegyptiaca* to be a very good source of vegetable oil for biodiesel production; yielding about 89 % of the fuel in short alkali catalyzed transesterification time under both homogeneous and heterogeneous conditions (Usman, 2019). Studies by Ajayi and Folorunso (2013) showed that, production and use of *Balanites aegyptiaca* biodiesel have reported to contribute towards decrease in fossil diesel demand and global warming potential. In addition to its exploitation as energy source, soil degradation, deforestation and desertification problems could be resolved. Therefore, selection of *Balanites aegyptiaca* would be a multipurpose opportunity. The Zygophyllaceae plant was considered as an underutilized species for fuel production. 91.5 g of the plant oil produced 68.2 g of long-chain fatty ester showing 74.5 percent biodiesel yield (Sylvester el al., 2014). Findings from Usman (2019) study suggested *Balanites aegyptiaca* seed as prominent raw material for sustainable biodiesel production and its biodiesel as suitable alternative to diesel fuel in the dryland areas, as the plant revealed 82.7 % biodiesel yield from its based oil via alkali catalyzed transesterifcation process. In addition to the enticing characteristics described above, Bambara (2018) investigated the process of transesterifying *Balanites aegyptiaca* oil for biodiesel production, and studied the use of the biodiesel as a fuel for diesel engines. From the light of his result, he concluded that plant seed oil is a promising feedstock for oilseed-based biofuels production. However, the local farmers may change from food crops production to *Balanites aegyptiaca* cultivation due to its foreseeable market value. Garba (2011) in his studies identifies *Balanites aegyptiaca* oil to be among the targeted feedstock for the biodiesel industry. In fact, the plant has already been targeted for the production of oilseed-based biofuels. Despite this fact, the plant has not been domesticated on large scale production by either the Nigerian subsistence or commercial farmers.

### Soap Formulation Viability from *Balanites aegyptiaca* Oil

*Balanites aegyptiaca* oil contains phenolic compounds including; saponins which belong to the chemically diverse and complex collection of compounds that deduce their name from their capability to form in aqueous solution, stable foam that is soap-like in nature. Manji *et al*. (2013) conducted research on the plant and reported that the plant's oil is non-drying and contain saponin. He formulated shampoo and liquid soap using the oil and the properties of the manufactured products were evaluated. The result finally suggested the oil as a good raw material for the formulation of liquid soap, as it was found that the products possesses features that are favorably similar to products sold in the market regarding color, pH, solubility in water and percentage alkali. Zang (2018) conducted another study on the feasibility of using the oil to formulate soap and lotion. The formulated soap was considered to be of good soap properties based on the soap quality parameters determined. The Lotion formulated when subjected to lotion stability test revealed good stability.

### Nutritional Benefits from *Balanites aegyptiaca* Oil

Plants oil plays a vital role in addressing food security issues, industrialization and economy of the rural dwellers in many African countries. In Nigeria, the oil obtained from *Balanites aegyptiaca* seed kernel has been used especially in the Northern part of Nigeria as substitute to groundnut oil which is usually very expensive. The presence of one of the three essential fatty acids in *Balanites aegyptiaca* oil makes it nutritionally competent and highly commended for human consumption (Elmustafa, 2015) .This oil is used for frying food while adding flavor to the food. It is also used in a tea as flavor additive. *Balanites aegyptiaca* oil was considered to be a good substitute to groundnut oil as food supplement. The plant seeds kernel produce edible cooking oil with good scent

and taste (Azene, 2015). Hena *et al.* (2017) reported that its free fatty acid content is very scanty, because the oil maintained stability when heated and have higher smoking point. *Balanites aegyptiaca* seed kernel is considered to contain high amount of nutritive oil (38.2–54.5 %) when extracted with soxhlet extractor using petroleum ether as solvent (Elmustafa, 2015). The oil can be used for human consumption and cosmetics (Ogala, 2018). It can also be used in baking and frying different foods (Okia, 2008). *Balanites aegyptiaca* seed kernel is a good source of dietary oil. Edible oil have dietary properties and plays vital role nutritionally as carrier of fat soluble vitamins and concentrated source of energy. *Balanites aegyptiaca* oil is nutritionally important due to the presence of carotene, which are highly unsaturated hydrocarbons that are basically lipid or vitamin precursors. In an attempt made to determine the possible effects of long term consumption of *Balanites aegyptiaca* seeds oil. Ajayi and Folorunso (2013) fed group of rats with diets containing 10 % *Balanites aegyptiaca* seed oil for six weeks. Dietary exposure of the crude oil to rats did not reveal any toxicological effect but should be used with caution having revealed subtle hepatotoxic effects in the 5 % treated set of rats. A total of fourteen rats were fed with diets containing *Balanites aegyptiaca* seed oil for six weeks in another study conducted by Onyema *et al.* (2017). The rats showed good physical appearance and suffer no toxicological effect. The overall finding revealed that *Balanites aegyptiaca* seed oil could successfully be used as substitute to groundnut oil in rat diet with other supplements after refining it. Thereby, it can be safe for animal and human consumption.

**Medicinal Viability of *Balanites aegyptiaca* Oil**

Treatment of skin disease, diabetes, hypoglycemia, sleeping sickness, rheumatism and promise for HIV/AIDS patients are some of the medicinal benefits of the plant seed oil (Al-thobaiti & Zeid, 2018). All parts of the plant have various pharmacological benefits. Oil from *Balanites aegyptiaca* seed kernel has being used to cure diseases such as: abdominal pains, chest pain, skin infections, oedema, liver, skin diseases and snake bites (Okia, 2008). The plant has being used in treatment of several diseases and disorders. The oil also contains steroids such as sapogenins, saponins, diosgenins, which are good raw material for industrial production of anabolisants, corticoids, contraceptive pills and sexual hormones (Seifu, 2018). Elmustafa (2015) reported that unsaturated fatty acids have anticancer, antimutagenic and antimicrobial activity. *Balanites aegyptiaca* seed oil is used to treat wounds and tumors. It is also used in treatment of epilepsy stomach aches, hemorrhoid, yellow fever, syphilis and jaundice (Tesfaye, 2015). Early studies have shown that the presence of saponin compounds in the oil bring about the main attributes behind its ethno-medicinal application.

**Other applications of *Balanites aegyptiaca* Oil**

*Balanites aegyptiaca* oil was reported to have good lubrication property (Okia, 2008). Hena *et al.* (2017) demonstrated that saponin from *Balanites aegyptiaca* oil can be used as an environmentally friendly alternative to hazardous chemicals that have been used for the control of intermediary hosts of schistosomiasis. The oil was also reported to have a significant effect during storage on development and survival of cowpea weevil *Callosobruchus maculates* in cowpea seeds (Nwaogu, 2013).

## CONCLUSION

The above detailed information from extensive literature survey, on various economic and technical prospects of *Balanites aegyptiaca* oil have provided detailed evidence on the economic viability of the oil as it has high oil content. It also revealed that the oil having good properties is a prominent feedstock for many products that are oil based such as biodiesel, lubricants, shampoo, lotion, soap, cooking oil and medicine. This may promote processing and marketing of the oil, which can help to broaden opportunities for income generation in rural communities in the dryland areas where the plant is found in abundant. Therefore, *Balanites aegyptiaca* seed oil is economically viable oil that could be used as good raw material for both domestic and industrial purposes if richly exploited. Furthermore, more application feasibilities will emerges when further research is made on this multipurpose oil.

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