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Dacryodes edulis (G. Don) H.J. Lam: A Review on its Medicinal, Phytochemical and Economical Properties

K.K. Ajibesin
Department of Pharmacognosy, Olabisi Onabanjo University, Sagamu Campus, Ogun State, Nigeria

ABSTRACT

Dacryodes edulis is a dioecious, shade loving, evergreen tree, indigenous to the Gulf of Guinea and widely cultivated in other tropical parts of Africa for its fruit. The edible fruit to which the plant owes its principal values is a rich source of nutrients such as lipids, vitamins and protein. The fruit yields a high content of fixed and essential oils. The fruits are highly consumed and traded locally and internationally, conferring enormous economic value on the plant. The plant has long been used in the traditional medicine of some African countries to treat various ailments such as wound, skin diseases, dysentery and fever. The extracts and secondary metabolites have been found to show biological activities such as antimicrobial, antioxidant and anti sickle cell anemia. A wide range of chemical constituents such as terpenes, flavonoids, tannins, alkaloids and saponins have been isolated from the plant. This review provides a comprehensive detail of the plant's ethnomedicinal uses, biological effects, chemical constituents and economic property as a medicinal plant.

Key words: *Dacryodes edulis*, ethnomedicine, chemical constituents, bioactivity, economic property

INTRODUCTION

The generic name *Dacryodes* is derived from the Greek word Dakruon meaning tear, referring to resin droplets on the bark surface of its members, while *edulis* means edible, emphasizing the importance of the nutritious fruit in the plant's cultivation (Anonymous, 2010). The plant belongs to the family Burseraceae whose members are characterized by an ovary of 2 to 5 cells, prominent as in ducts in the bark, wood and intrastaminal disk (Chunduff, 1984).

The genus *Dacryodes* consists of about 40 species (Verheij, 2002). However, (Rehm, 1994) indicated 80 species to encompass subspecies, varieties, forms and cultivars. Two varieties are recognized: var. *edulis* and var. *parvicarpa* J.C. Okafor, whose conical fruits are smaller with the pulp. Var. *edulis* exhibits verticillate or subverticillate branching, while the branching is slender and opposite or bifurcate in var. *parvicarpa* (Okafor, 1983; Kapseu and Tchiegang, 1996; National Research Council, 1996). *Dacryodes edulis* (G. Don) H.J. Lam gives four synonyms viz., *Canarium edule* Hook. f., *C. saphu* Engl., *Pachylobus edulis* G. Don and *P. saphu* Engl (Burkill, 1985; National Research Council, 1996). However, *C. edule* (G. Don) Hook.f. and *P. edulis* G. Don have long been considered as the most unambiguous synonyms (Boutelje, 1980). The common names are (in English) African pear, African pear tree, Bush butter, Bush butter tree, Bush fruit tree, Eben tree, Native pear and, in French, Safoutier (Burkill, 1985).

Origin and geographical distribution: It is an indigenous fruit tree in the Gulf of Guinea and Central African countries (Troupin, 1950), but to popularity of the nutritious fruit for consumption,

the plant is widely cultivated, extending its area of distribution to Sierra Leone, Uganda, Angola, Zimbabwe and Nigeria (Anonymous, 2010). It rarely grows wild. Thus, the exact natural area of distribution is obscure (Verheij, 2002).

Botanical description: *Dacryodes edulis* is a dioecious shade loving species of non-flooded forests in the humid tropical zone. It is a medium-sized, evergreen tree reaching a height of 18-40 m in the forest but not more than 12 m in plantations (Hutchinson and Dalziel, 1958; Burkill, 1985; Verheij, 2002), comparable with the tree of *Coula edulis* (Adebayo-Tayo and Ajibesin, 2008). It is generally low branching with a deep dense crown. The bole is 50-170 cm in diameter, short, shallow fluted and more or less sinuous. The bark is yellowish-grey to pale-grey, often rough with lenticels and horizontal folds exuding white aromatic resin. Leaves are compound, imparipinnate, with 5-8 pairs of leaflets. They are glossy and pubescent, the pubescence disappearing with age. They are oblong-lanceolate or ovate-lanceolate, up to 20 (-30)×6 (-8) cm, broadly cunaete to rounded and asymmetric at base. They are acuminate at apex and margin is entire and glabrescent. Flowers are unisexual, subtended, 3 lobed and conspicuous with caducous low bract (Medenbach de Rooy, 1994; Verheij, 2002). However, Ikhuoria and Maliki (2007) reported bisexual state for the flower, emphasizing that the flowers gather in panicles which to fruit bunches. Flowers are fragrant, about 5 mm across and are trimerous except for the ovary. They are arranged in dense, ferruginous, stellate-tomentose inflorescence. Sepals and petals are 3, the former showing brown colour and the latter, cream colour. Stamens are 6 and are slightly shorter than petals. Disc is also 6 but lobed, surrounding the two-celled, glabrous ovary. Styles are very short and stigma is 2-4 lobed. Inflorescence axis is 10-42 cm long or may be longer and deeply grooved. Fruits are ellipsoid drupe and vary in size, 4-12×3-6 cm, resembling olives. The exocarp is thin and pink ripening to form blue-green, purple or brilliant black. The fruits are one-seeded, with pulpy pericarp, about 5 mm thick and thin, cartilaginous endocarp. Seeds are oblong-ellipsoid, up to 5.5 cm long. The cotyledons are very much thickened and deeply folded or conduplicate, appearing palmately lobed (FAO, 1982; Medenbach de Rooy, 1994).

In Nigeria, the fruit of *D. edulis* var. *edulis* is large, elongated and cylindrical and are usually more than 5×2.5 cm. The fruit pulp is thick, about 3.5-9 mm. Usually, the tree has whorled branching and the branchlets are stout and ascending. Conversely, the fruit of *D. edulis* var. *parvicarpa* is small, rounded or more or less conical, usually less than 5×2.5 cm. The fruit pulp is thin, about 2-3.5 mm. Often, the tree has bifurcate branching with slender, drooping branchlets (Okafor, 1983).

Ethno medicinal uses: *Dacryodes edulis* is a versatile plant in African ethnomedicine, as its various parts are employed to treat several diseases. The bark of the plant has long been used to cicatrize wound in Gabon (Walker and Silans, 1961). In this case, the bark is pulped and then applied directly to the wound. In Democratic Republic of Congo, the plant is employed for the treatment of divers ailments. The decoction of the bark is taken orally to treat leprosy. It is also used as gargle and mouth-wash to treat tonsillitis (Bouquet, 1969). The bark is comminuted with meleguetta pepper to cure dysentery, anaemia, spitting blood and as an emmenagogue; when mixed with palm oil, it is applied topically to relieve pains, debility, stiffness and skin diseases (Bouquet, 1969). The leaves are chewed with kolanut as an antiemetic. The leaf sap is used as ear drop to treat ear trouble, while a leaf decoction is prepared to produce vapour that treats fever and headache (Bouquet, 1969; Bouet, 1980). In Congo Brazzaville, the leaves are boiled with those of

Lanata camara, *Cymbopogon citratus* and *Persea americana* in water to form a decoction for treating malaria. A steam bath can also be taken from the decoction to treat the same ailment (Diafouka, 1997). Boiling the leaves with those of *P. americana* alone can be used to treat headache, antalgic and cephalgy (Diafouka, 1997). Recently, Jiofack *et al.* (2010) reported that the leaves are made into plaster to treat snakebite in Southwest Cameroon. The bark resin is used in Nigeria to treat parasitic skin diseases and jiggers (Dalziel, 1937; Hutchinson *et al.*, 1963). When applied in lotions and creams, the resin smoothens and protects the skin (Ekpa, 1993). The aroma of the resin when liberated through burning is believed to ward off evil spirit in Nigeria (Sofowora, 2008). The leaves are often crushed and the juice released to treat generalized skin diseases such as scabies, ringworm, rash and wound, while the stem or stem twigs are employed as chewing sticks for oral hygiene (Igoli *et al.*, 2005; Ajibesin *et al.*, 2008b).

Phytochemical property: A lot more work was carried out on the fruits and seeds of the plant for their chemical composition than on any other parts. Often, the fruit pulp and seeds were characterized for lipid, essential oil and proximate components.

Lipids and terpenes: The fruit pulp of the plant is rich in lipid (Omoti and Okiy, 1987; Kinkela and Bezard, 1993), the oil content of which was determined on a dry basis to fall between 30 and 60% (Silou and Kama Niamayoua, 1999), depending on the origin and the ripening condition of the fruit (Bezard *et al.*, 1991). However, Ikhuoria and Maliki (2007) reported a lower value of 23.2% for oil content of the Nigerian fruit pulp when comparing is composition with that of Avocado pear. In rare cases, the oil content could go as high as 70% (Kinkela *et al.*, 2006). It has also been demonstrated that geographical orientation and fruit distribution of a tree by level to the ground can influence the percentage yield and relative composition of the oil (Kinkela *et al.*, 2006). The lipid yields fatty acids such as palmitic acid, oleic acid, linoleic acid and stearic acid, whose percentage composition vary markedly ranging from 30-62% (Palmitic acid), 15-24% (Linoleic acid), 18-60% (Oleic acid) and 1.3-5.5% (Stearic acid) (Busson, 1965; Burkill, 1985; Omoti and Okiy, 1987; Obasi and Okolie, 1993; Silou, 1996; Silou and Kama Niamayoua, 1999; Mbofung *et al.*, 2002; Kinkela *et al.*, 2006; Ikhuoria and Maliki, 2007). In addition, arachidonic acid was identified as an important fatty acid in the pulp and seed oil (Ajayi and Adesanwo, 2009). Even at the regional level, relative variation in fatty acid content (49-58%) was observed for the fruits of Cameroon, Congo Brazzaville, Congo Kinshasha and Gabon, the constituent countries of Guinea Equatorial region (Mbofung *et al.*, 2002). These values were found to be higher than those reported for Nigeria (32%) (Omoti and Okiy, 1987) and Cote D'Ivoire (30%) (Larousille *et al.*, 1994). The unsaponifiable fraction of the oil was reported to contain sterols, triterpene alcohols and traces of tocopherols-. Mineral elements such as phosphorus, calcium, magnesium, potassium, sodium, zinc and manganese are also found in the pulp and seed of the plant (Ajayi and Adesanwo, 2009).

Unlike other oily fruits, the seed oil possesses the same fatty acids as the fruit pulp (Silou, 1996) and the seed may contain up to 18-70% oil (Gunstone and Norris, 1982). In a recent study on the seed oil of the Nigerian fruits, Arisa and Lazarus (2008) reported oil content of 50 %. The good physicochemical properties shown by the seed oil suggests that the oil can be useful for consumption and industrial application. Soxhlet extraction method was reported to give the best yield of seed oil (Dzondo-Gadet *et al.*, 2004).

Essential oils have been isolated and analyzed from different parts of *D. edulis*. The fruit contains about 1.5% essential oil whose main constituents are α-pinene, α-terpineol, myrcene and

germacrene-D, while minor compounds include α-cadinol, δ- cadinol and β-eudesmol (Onocha *et al.*, 1999). In another study on the essential oil of untreated, boiled and roasted fruits, many constituents were isolated among which α-pinene (47.1-60.5%), α-pinene (6.7-8.2%), myrcene (12.9-14.8%) and limonene (3.4-6.4%) were discovered to be the main compounds (Jirovetz *et al.*, 2003). These and other compounds such as phellandrene, cadinol, sabinene, p-cymene, dimethyl sulfide and hexanal were found to be responsible for various odours of the plant (Jirovetz *et al.*, 2003). The stem bark essential oil of the plant growing in Nigeria contains predominantly terpinen-4-ol, α-thujene and α-pinene, while α-phellandrene is the main constituent of root bark oil (Onocha *et al.*, 1999). β-caryophyllene, similarly found as the main sesquiterpene in the essential oil of the leaves of Cinnamomum zeylanicum growing in Nigeria (Tira-Piccos *et al.*, 2009), also occurs as the main constituent of the leaf essential oil of *D. edulis* growing in Nigeria (Onocha *et al.*, 1999). Furthermore, the ethanol extract of the stem bark gave oil that contained thirteen compounds including hydrocarbon (1-isopropyl-1-methyl-2-nonylcyclopropane), carboxylic acid (octadecanoic acid), ketone (3-methylheptan-4-one) and an alcohol (6-methylheptan-1-ol) (Okwu and Ighodaro, 2009). The resin obtained from the tree has been reported to yield peppery essential oil rich in sabinene, β-phellandrene and limonene and compounds such as crystalline canaric acid from non-volatile fraction and triterpene alcohols such as 3-epi- α-amyrin, 3-epi-lupeol and α-amyrin from neutral fraction (Ekong and Okogun, 1969).

Phenolics: Ajibesin (2005) had identified phenolics such as ethylgallate and quercitrin in the plant leaves. Flavonols such as quercitrin, isoquercitrin, isorhamnetin and rhamnoside, as well as anthocyanins such as petunidin and cyanidin were also reported to be present in the fruit skin zone and pulp of *D. edulis* during ripening (Missang *et al.*, 2003). The stem exudates of the plant were reported to contain tannin (0.47 mg/100 g) (Okwu and Nnamdi, 2008).

Other classes of compounds such as saponins (2.08 mg/100 g) and alkaloids (0.28 mg/100 g) were also detected from the stem exudates and quantified (Okwu and Nnamdi, 2008).

Biological activity: The presence of bioactive compounds such as saponins, tannins, alkaloids and flavonoids identified in the plant has been suggested to be responsible for the various uses of *D. edulis* in traditional medicine to cure ringworm, wound, scabies, skin diseases and inflammation (Okwu and Nnamdi, 2008). In addition, the potential health-related functions of dietary plants were found to include antibiosis, immunostimulation, nervous system action, detoxification, anti-inflammatory, antigout, antioxidant, glycemic and hypolipidemic properties (Johns, 2001).

Antimicrobial activity: The essential oils of the plant resin were investigated for antimicrobial and antioxidant activities. The essential oil showed more potent antibacterial effect against bacteria such as *Staphylococcus aureus, Bacillus cereus, Escherichia coli, Salmonella enteric* and *Proteus mirabilis* than antifungal effect against Candida albicans and this effect was found to be due to the presence and high content of terpinen-4-ol (19.8%) and α-pinene (17.4) (Obame *et al.*, 2008). In all the antibacterial cases, the Minimum Inhibitory Concentration (MIC) of 1-16 mm was equivalent to the Minimum Bactericidal Concentration (MBC). In another study, the antibacterial effect of the essential oil of the plant resin was confirmed to be due to the presence and high content of the same foregoing terpenes, but antifungal effect of the oil was reported to be lacking (Koudou *et al.*, 2008). Since compounds such as alkaloids and saponins are known to be antimicrobial (Ajibesin *et al.*, 2006), their presence has been suggested to account for the

antimicrobial activity of the plant (Okwu and Nnamdi, 2008). In screening some Nigerian plants for antibacterial activity, the leaf extract demonstrated the best activity for which ethylgallate and quercitrin were identified as responsible (Ajibesin, 2005). Like many other Nigerian plants, the leaves showed better activity than the stem and root which lends credence to the wider application of leaves in Nigerian traditional medicine than the other plant parts (Ajibesin *et al.*, 2002, 2003, 2008a,b; Ekpo *et al.*, 2008).

Antioxidant activity: In Cameroon, the extracts of 42 medicinal plants used for anaemia, diabetes, AIDS, malaria and obesity were investigated for phytochemical substances and antioxidant properties. The leaves of *Dacryodes edulis* elicited very high antioxidant effect when analyzed against three assay methods: Folin (Folin Ciocalteu Reagent), FRAP (Ferric Reducing Antioxidant Power) and DPPH (1, 1-diphenyl-2-picrylhydrazyl), ranking second behind Alchornea cordifolia (Agbor *et al.*, 2007). This antioxidant property was attributed to the presence of flavonoid in the plant. The essential oil of the plant resin also demonstrated good antioxidant activity. In a DPPH test system, the IC_{50} value of *D. edulis* oil was reported to be 68.5±2.29 μg mL^{-1}, while oxidation of linoleic acid was effectively inhibited by the plant (70%) in the β-carotene-linoleic acid test (Obame *et al.*, 2008). However, this antioxidant capacity was ascribed to the mono and sesquiterpenes present in the plant essential oil. Employing similar antioxidant assay methods, Koudou *et al.* (2008) reported significant antioxidant effect of the resin oil, including DPPH radical scavenging activities and inhibition of lipid peroxidation and suggesting that *D. edulis* may help prevent oxidative damage in the human body such as lipid peroxidation associated with cancer, premature aging, atherosclerosis and diabetes. More recently (Nguefack, 2009) confirmed the significant antioxidant and free radical scavenging activities in the aqueous and ethanol extracts of *D. edulis*.

Cardiovascular activity: *Dacryodes edulis* oil was reported to decrease the HDL cholesterol level in serum of rats (Leudeu *et al.*, 2006). Thus, potential health related functions of dietary plants such as *D. edulis* was reported to include immunostimulation and nervous system action (Johns, 2001).

Antidrepanocytary activity (anti-sickle cell anemia): Among the 13 Congolese plants examined for antidrepanocytary activity, the aqueous and ethanol extracts of *D. edulis* leaves were discovered to normalize the SS blood erythrocytes, following the deoxygenation of haemoglobin in anaerobic condition, thus validating their use in traditional medicine (Mpiana *et al.*, 2007).

Toxicity: No part of *D. edulis* is known to be toxic. During the survey of toxic plants of Akwa Ibom State of Nigeria, D. edulis was not among the plants implicated for eventual toxicity evaluation (Ajibesin *et al.*, 2002). Obasi and Okolie, (1993) supported this position when they reported lack of toxic principles in the seed of the plant. However, the findings of Hanson (2009) opposed this report when he found the seed to contain antinutrient factors such as oxalate, tannins, phytate and trypsin inhibitory activity. Thorough processing of the seed before use was therefore suggested. On the other hand, Dike (2010) reported lack of toxins in the fruit when he indicated values below toxic level for the antinutrient factors such as tannins and cyanide. Sometimes the fruit sold in the market may be contaminated with metal pollutants. Akinola and Adenuga (2008) reported the presence of heavy metals on the fruit wall, with lead showing a toxic concentration and others such

as cadmium and zinc falling below the maximum permissible concentration. The source of the fruits before reaching the market and their exposure to atmospheric factors were advanced as possible reasons for the contamination. However, there is yet to be report on the toxicity study of the plant in experimental animals.

Economic properties: The tree wood is heavy, elastic and is found suitable to make axe-handles, mortals and can be for general carpentry (Dalziel, 1937; Walker and Silans, 1961). The dead branches of the tree are used as firewood (Ayuk *et al*., 1999), while the twigs serve as chewing sticks (Ajibesin, 2005). The resin is used as pitch on the inner surfaces of calabashes and for mending earthenware (Burkill, 1985). The resin can also serve as fuel (Ekong and Okogun, 1969). The fruit is the most important part to which the tree owes its principal economic values and for which the tree is widely cultivated, domesticated and commercialized (Leakey, 1999; Leakey *et al*., 2002; Waruhiu *et al*., 2004; Anegbeh *et al*., 2005). The fruit consists of a seed (stone) surrounded by a pulpy butyraceous pericarp, which is the portion consumed either raw or cooked to form a sort of butter. The fruit is rich in lipids, proteins, minerals and vitamins which make it an excellent source of nutrition to consumers, stimulating its increase in production and commercialization for decades (Silou, 1996; Kenmegne *et al*., 1997). The fruit yields oil found suitable for cosmetics and food, while the flower nectar provides a good honey (Ayuk *et al*., 1999; Verheij, 2002). Safou fruit oil, when incorporated into foods can boost their nutritional values, thus making them more marketable. Mbofung *et al*. (2002) while studying the economic values of safou fruit oil, observed that the protein content of a biscuit increased by 39% when the margarine in the biscuit recipe was substituted for safou pulp oil. The bark resin also finds application in the food and cosmetic industries as thickener, flavour, stabilizers and as and as an emulsifying agent (Ekpa, 1993).

So highly traded are the safou fruits that transactions now cut across local and international boundaries, so much so that the fruits are marketed in specialized markets in Europe (Awono *et al*., 2002). The farm-level value of fruit production may reach USD 161 a year per grower/collector (Ayuk *et al*., 1999). Whereas, the other medicinal parts of the plant such as leaves, stems and roots are sold in the herb section of domestic markets, the fruits are ubiquitous in every section of the market. The average price of the fruit in the markets in Nigeria where home consumption accounts for about 70% ranges from USD 300-700/ton of fruits. Between January and June 1995, almost 600 tons of fruits, valued at USD 244,000 were traded in the humid lowlands of Cameroon (Verheij, 2002). However, the marketed volume of safou fruits increased to 2,324 tons at a value of USD 1.5 million in 1999, when nine markets were surveyed in different parts of Cameroon (Awono *et al*., 2002). The trade is so active in Cameroon that it is extended to neighbouring countries such as Gabon.

At international markets, African pear fruits imported into Europe are generally intended for nationals of the exporting countries, with the volume increasing since 1982 (Tabuna, 2000). The principal importing countries of safou fruits are Belgium, France and United Kingdom from African countries such as Cameroon, Nigeria, Congo Brazzaville, Democratic Republic of Congo and Central Africa Republic. The potential market in these importing countries in 2002 alone was well over 120,000 people (Awono *et al*., 2002), with the number increasing ever since. The major snag of safou international trade however is the perishability of the fruit. In spite of this, *D. edulis* has become the main source of food cash incomes, employment and enhanced livelihood for subsistence farmers and traders.

CONCLUSION

Dacryodes edulis is a tree widely cultivated for its fruit. The edible fruit, which bears high oil content, is a rich source of nutrients. Thus, the fruit confers huge economic values on the plant through local and international trade, while the other plant parts are employed in traditional medicine to treat various diseases.

Biological tests carried out on the plant for antimicrobial, antioxidant, antisickle cell anemia and cardiovascular activities revealed significant results without adverse side effects. Conversely, the plant showed no molluscicidal activity against *Bulinus globosus* (Sofowora and Adewunmi, 1980). Most of these activities were found to be due to major chemical constituents such as terpenes, saponins, tannins, saponins and alkaloids present in the plant.

It is hoped that the detailed information provided in this review on the plant's ethnomedicinal, phytochemical, biological and economic properties would serve as a useful tool for proper evaluation of the plant in medicine which may lead to drug discovery and agriculture.

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