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An overview of the beneficial attributes and usage of Aduwa (*Balanites aegyptiaca*) in Foods and medicinal medicine.

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Abstract

Aduwa (Balanites eagyptiaca) is also called desert dates in English. It is a thorny plant species which dwells in the drier parts of Africa down to the Arabian Gulf and some parts of Asia. Locally, the Aduwa fruit is eaten as snack, while the seed are used in oil extraction. The drawback of Aduwa fruits is the distinctive pungent taste which makes the fruit unpalatable to many people. Despite the pungent taste of the fruit, the Aduwa fruit contains many other functional compounds like polyphenols, flavonoids, alkaloids, steroids and saponins a structurally complex phytochemicals which is important in the human body. Both the Aduwa pulp, leaves and seeds contain important nutrients like carbohydrate (8-62%), protein (9-32%), lipid content of 2-49% and dietary fibre (2-30%). Other nutrients like vitamins and minerals are also present in the Aduwa parts. This paper presents a review on Aduwa plant parts with regard to science and traditions. Discussions on the medicinal compound and medicinal application, food application and phytochemical compounds are equally presented. The paper finally concludes with the potential use of the plant in functional food application.

Keywords: Aduwa, Balanites aegyptiaca, medicinal, food.

INTRODUCTION

Africa as a continent is blessed with abundant species of plants that are considered to contain significant quantities of compounds which are well known to promote human health and possibly eradicate hunger. Many of these plant species remain undiscovered or underutilized by the western society and some locals (Bamalli *et al*., 2014). *Balanites aegytiaca* (*L.*) *Delile* (Aduwa in Hausa) is one of the examples of such plants found in the African continent. The taxonomical profile of the Aduwa plant is that the plant is a dicotyledenous flowering plant that belongs to the kingdom *Plantae*, a division of *Magnoliophyta* and the Class: *Magnoliopsida*, Order: *Sapindales* from the family *Zygophyllaceae* (Jauro and Adams, 2011; Ogala *et al.,* 2018). Among its species, the *Zygophyllaceae* is one of the most common, which is found in the dry land areas of Africa and South Asia (Tula, *et al.,* 2014). In the dry regions of Africa; it grows well in the Sahel parts of Nigeria, Ghana, and Ivory Coast (Tula, *et al.,* 2014; Manji, *et al*., 2013).

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Al-Thobaiti and Zeid (2018) reported that Aduwa is found in South Asia and in the Arabian Penisula. Murthy, *et al*., (2021) reported that Aduwa grows well in Saudi Arabia, Oman, Iran, Syria, Palestine and India. Balanites aegyptiaca is well known by a very large number of local names such as Desert dates in English, Aduwa plant in Hausa, Utaz in Igbo, Teji in Yoruba, Tanni in fulfulde and Heglig in Arabic (Tula, *et al.,* 2014; Wakawa *et al.,* 2018).

Tula, *et.al.* (2014) reported that Aduwa plant can grow in various types of habitats, due to its tolerance to vast range of soil varieties, from porous sandy soils to heavy clay and also very importantly climatic moisture levels. It is also adaptive to both salinity and water stresses (Al-Thobaiti and Zeid, 2018; Selouka, *et al*., 2020), as well as tolerant to flooding and wild-fire (Bello and Dandago, 2011). These adaptive features of the Aduwa plant allows it to thrive well in zones with mean annual rainfall of 250-1200 mm and also have an annual mean temperatures of 20-30 °C (Orwa *et al*. 2009).

Aduwa plant produces single seeded fruit having a characteristic bitter taste (Bello and Dandago, 2011). Acceptability of Aduwa fruits may be greatly hindered by the characteristic bitter taste it possesses and by the dizziness effect it brings (especially when consumed in large amounts). The kernel seeds have almost 49% oil which is edible oil (Murthy, *et al*., 2021) due to the fatty acid composition it possesses. However, the oil also tends to have bitter taste after extraction by mechanical means, which also prevents its maximum utilization as cooking oil (Selouka *et al*., 2020). The Aduwa (*Balanites aegyptiaca*) is a plant with applications in food, pharmaceutical/medical and beverage industries (Selouka *et al*., 2020). The plant provides food, medicine, shelter and fuel to communities (Al-Thobaiti and Zeid, 2018). Almost every part (fruits, leaves, bark, thorns and roots) of the Aduwa plant has been reported to be useful (Gajalakshmi *et al.,* 2013). The tender leaves, flowers, fruits and seeds are all edible and are commonly used as ingredients for traditional dishes by rural communities of dry regions of Africa. Its medicinal benefits serve as purgative, antimicrobial and antidiabetic aid (Al-Thobaiti and Zeid, 2018).

There is need for cheaper sources of food and medicine in developing countries like Nigeria to improve the living standards of the masses. Aduwa is a blessed plant which is very beneficial to humans when properly utilized. However, the plant is not well recognized by urban communities in Nigeria despite its great benefits in food and medicine. In addition, there is limited knowledge of the properties of the plant. The major aim of this paper was to review and discuss the basic parts of Aduwa in relation to nutritional and medicinal properties contained therein, thereby creating awareness for proper utilization of the plant.

Aduwa Tree Parts

Leaves

Murthy *et al.,* (2021) described the leaves of Aduwa plant as distinctive obovate leaflets that are asymmetric and about 2.5 to 6 cm long. The leaves are bright green in colour and are leathery, (with fine hairs when young). Okia *et al.* (2013) conducted a study on the nutritional composition of Aduwa leaves, and reported moisture content of 1.39 and 2.20 %; ash content of 5.7 and 9.0; fat content of 2.0 and 2.7 and crude protein of 14.2 - 17.3%. Wakawa *et al*. (2018) reported a higher value of 2.96 moisture content in the Aduwa leaves as well as lower values of ash, crude fat and protein contents when compared to the reported values by Okia *et al.* (2013).

Aduwa leaves are reported to contain important minerals like potassium, sodium, magnesium, zinc, and so on. Okia *et al.* (2013) reported that Aduwa fresh leaves contain 24.59

mg/g amount of potassium (K), while that of the boiled leaves contained 12.78 mg/g. This shows that boiling tends to reduce amount of potassium in Aduwa leaves. Other mineral contents reported by Okia *et al.* (2013) include Sodium (Na) 1.62 – 4.02 mg/g, Magnesium (Mg) 1.15 – 1.35 mg/g, Manganese (Mn) 61.50 – 72.58 µg/g, Zinc (Zn) 39.73 – 50.13 µg/g and Copper (Cu) is 23.25 – 28.97 µg/g. Daya *et al.* (2011) have conducted studies on Aduwa leaves and documented that they contain saponin, furanocoumarin, and flavonoid compounds. Table 1 contains a phytochemical screening of Aduwa leaves reported by Tula *et al.* (2014).

Table 1: Phytochemical Screening of Aduwa parts

S/N	Phytochemical component	Leaves	Stem bark	Root bark
1	Anthroquinones	_	_	_
2	Cardiac glycoside	+	_	_
3	Phlobatannins	+	_	_
4	Polyphenols	+	+	+
5	Saponins	+	_	+
6	Alkaloids	_	_	+
7	Steroids	+	_	+
8	Flavonoids	+	+	+

KEY: + = Presence, - = Absence (Tula *et al*. 2014)

Flowers

Aduwa plant flowers in fascicles in the leaf axils. The flowers are fragrant, and yellowish-green in colour. Flowers of Aduwa plant are small, inconspicuous, hermaphroditic, and pollination is usually by insects (Murthy *et al*. 2021). The tree begins to bear flowers when it is about 7 years of age. The maximum fruit production is when the Aduwa tree is over 15 years old (Saboo *et al*. 2014). Flowers of the Aduwa plant are commonly used as supplementary food in West Africa and as an ingredient of a local condiment '*dawa dawa*' as flavoring in Northern Nigeria. In rural areas of the Arabian Gulf, the flowers are often sucked to remove nectar (Al-Thobaiti and Zeid, 2018). The moisture analysis of Aduwa flowers indicates a moisture content of 1.39 – 2.20 %. The flowers, however, have higher amounts of crude fat and crude protein compared to the fresh leaves. The micro mineral analysis revealed amount of potassium (K) in flowers as 28.67 mg/g (Okia *et al*. 2013).

Fruit pulp

Murtala *et al*. (2011) reported that a mature Aduwa tree in good condition produces up to 10,000 fruits annually. A typical fruit of Aduwa has a fleshy mesocarp and a hard woody endocarp encapsulating an edible oil-rich seed-nut (Okia *et al.* 2013). Murtala *et al*. (2011) described the Aduwa fruit pulp as gummy yellow to red in colour. Aduwa fruit is composed of soft edible pulp surrounding a woody stone (Murtala *et al*. 2011). The fleshy fruit pulp (ripe and unripe) are edible and can be eaten either fresh or dried. They are often processed into liquor and beverages (Murthy *et al*. 2021). In Ghana, the pulp of Aduwa fruits is often utilized to make a drink and sweetmeats, while in Nigeria, it is used to make an alcoholic liquor (Nadro and Samson, 2014; Al-Thobaiti and Zeid, 2018).

In a study conducted by Bello and Dandago (2011) on Aduwa fruit pulp, they found out that the pulp of Aduwa fruit contained 11.0 % moisture, 9.0 % ash, 0.7 % fat, 0.5 % crude protein, 0.8 % fibre and 70 % carbohydrate. In another study conducted by Daya *et al*. (2011), they reported that the fruit pulp of Aduwa contained around 1.2 to 1.5 % protein, 35 to 37 % sugars and 15 % organic acids. Igwe *et al.* (2005) revealed that Aduwa fruit pulp contained 89.6 mg/100 g Ascorbic acid while Murtala *et al*. (2011) reported that Aduwa pulp contained up to 40% sugar which is higher than the amounts reported by Daya *et al*. (2011). Amadou *et al.*

(2012) reported that Aduwa fruit pulp extract is an important source of natural anti-oxidants, and hence addition of the extracts into foods could elevate its nutritional and antioxidant composition. Table 2 shows the nutritional composition of Aduwa fruit pulp from a study conducted by Murthy *et al*. (2021).

Table 2: Nutritional composition of Aduwa pulp, seeds and leaves

S/N	Proximate (%) components	Pulp	Seeds	Leaves
1	Moisture	18.27	5.20	13.11
2	Protein	9.19	32.40	15.86
3	Fat	2.58	49.00	2.90
4	Ash	4.40	3.30	9.26
5	Carbohydrate	62.63	8.70	28.12
6	Dietary fiber	2.93	1.40	30.75
7	Energy (Kcal/100 g)	346.82	605.40	202.02

Source: (Murthy *et al*. 2021)

Seed nuts

Aduwa seed holds oil of good quality and has high protein contents (Mohamed *et al*., 2002). The nuts are very rich in oil and protein. Daya *et al*. (2011) reported that the nuts contained up to 45.0 % to 46.1 oil and about 32.4% protein. They further stated that the nuts' oil contained mainly palmitic, stearic, oleic, and linoleic acids which are the main fatty acids. In another study conducted by Mohamed and Mohammad, (2018), they reported that nuts of Aduwa have an oil content of about 46.0 – 54.7% and protein contents of 26.1 – 34.3% (which is higher than the values reported by Daya *et al*. (2011). Bello and Dandago, (2011) in their study on Aduwa fruit pulp and seed nuts also stated that nuts of Aduwa contained about 30 – 40 %. Essential elements analysed in Aduwa seeds by Bello and Dandago (2011) revealed quantities of Iron and Manganese at 0.01 mg / 100 g, Magnesium at 0.004 mg / 100 g, Zinc at 0.008 mg / 100 g and Calcium at 0.013 mg / 100 g. Aduwa seeds are a good source of carbohydrate, minerals as well as oil (Bello and Dandago, 2011).

Seed Oil

According to Food and Agricultural Organization of the United Nations (FAO) (2007) vegetable oils account for 80% of the world's natural oils and fat supply. Natural vegetable oils and fats are gradually becoming important in nutrition and commerce worldwide. This is due to the fact they are sources of dietary energy, antioxidants, biofuels and raw material for production of so many industrial products. They are widely used in food, cosmetic, pharmaceutical and chemical industries. Nutritional information on Aduwa oil proves useful to nutritionists, policy makers, development agencies and the general public in where nutrition and health benefits would be most beneficial. It has been reported that the Aduwa seed oil is rich in saturated fatty acids and may be used as cooking oil according to the National Research Council of the United States (NRC) (2008). Table 3 presents the physical properties of Aduwa seed oil published by Ogala *et al*. (2018).

Table 3: Physical properties of Aduwa seed oil

S/N	Analysis	Results
1	Color	Pale yellow
2	Odor	Mild
3	State at room temperature	Liquid
4	Percentage yield (%)	36.5
5	Moisture content (%)	7.16
6	Specific density (g/cm)	0.87
7	Refractive index	1.34

Source: (Ogala *et al*. 2018).

Aduwa seed oil has four major fatty acids in the range of C16 to C18, namely palmitic 15.5 %, stearic 19.01%, oleic 25.74% and linoleic 39.85% acids. The seed oil has a small amount of linolenic acid (< 0.7 %). The Aduwa seed oil has quantity of unsaturated fats (oleic + linoleic) of 65.59 % which is more than the saturated fats (palmitic + stearic) (34.41 %) (Okia *et al*. 2013). The oil remains stable even at high temperatures and tend to have a high smoking point, and hence its free fatty acid content is low. Fatty acid composition of the Aduwa seed oil is not affected at pressing temperatures of 115°C as reported by Mohamed *et al.* (2002). Table 4 shows fatty acid profile of Aduwa oil.

Table 4: Fatty acid profile of Aduwa seed-nut oils (n=42)

S/N	Fatty acid	Weight (%) ± SE	
1	Palmitic	15.40	± 0.26
2	Stearic	19.01	± 0.29
3	Oleic	25.75	± 0.35
4	Linoleic	39.85	± 0.48
5	Saturated	34.41	± 1.80
6	Unsaturated	65.5	± 6.92

Source: (Okia *et al*. 2013).

The acid value of Aduwa oil is 3.06 mg KOH/g, free fatty acid is 1.27% (Haftu, 2015). These values are below the FAO/WHO standard limits for cooking oils (4 mg KOH / g of acid value and 5.78-7.28 % for the free fatty acids), as reported by Haftu (2015). Oils with acid value higher than 4 mg KOH / g tend to have a high percentage of free fatty acids, and are susceptible to rancidity due to the hydrolysis of the free fatty acids at storage conditions. Similar results were reported by Manji *et al*., (2013) and Jock (2017) on the acid value and the free fatty acid contents of the Aduwa seed oils; however, Ogala, *et al.,* (2018) reported higher results.

The peroxide value of oil is a measure of the extent to which rancidity occurs during storage of the oil; it is used as an indication of quality and stability of fats and oils. In a study by Haftu (2015), the peroxide value determined for the oils of Aduwa seed-nuts was 3.71 m Eq/g. The value is within the FAO/WHO standard limits for edible oils of less than 10 m Eq/g thus implying the Aduwa seed oil is suitable for long-term storage due to low levels of lipolytic and oxidative activities (Haftu, 2015). Similar results were reported by Mohammed *et al.,* (2002) and Mohamed and Mohammed (2018). However, Babeker (2013) and Manji *et al.* (2013) reported higher values of 8.0 and 6.0 m Eq / g for peroxide value of Aduwa seed oils respectively. Research on Aduwa seed oils has been conducted by Igwe *et al.* (2005) and they described the oil as edible semi-drying oil. The authors further analyzed and found out that the oil had iodine value (IV) of 76.2 g / 100 g. However, Ya'u *et al.* (2020) in their study on the oil stated that the iodine value was 98.73 100 / g and was within the range of the FAO/WHO limits of 80-106 100/g.

The saponification value is an index of the average molecular weight of fatty acid in the oil (Manji *et al*., 2013; Babeker, 2013). These authors reported that saponification value of Aduwa oil of 168.67 mg KOH / g could be compared to the values in some vegetable oils like; sesame, neem, groundnut, palm kernel and castor oils. This value is within the FAO/WHO range for edible oils. Mohammed *et al.* (2002); Mohamed and Mohammed (2018) also reported similar results.

Food Applications of Adua

Aduwa is a perennial plant used in food, most especially in Africa and other developing countries, for various purposes. Almost every part of this plant is useful including the leaves and fruits and seeds. The leaves are used as soup ingredient in some Nigerian communities. Wakawa *et al*. (2018) reported that the young leaves provide fresh vegetables that are substituted for leafy vegetables like lettuce, spinach and cabbage The leaves can be boiled, pounded, then fried or fat added to make a dish (Wakawa *et al*. 2018).

Dandago (2011) in his study on the pulp and seed of Aduwa reported that both are used as basic ingredients to prepare local snacks like Biribiri and Annaki respectively. Murtala *et al*. (2011) documented that a processed product of Aduwa fruit pulp called "Biri-biri" is very common among communities of Gaya town in Gaya local government area of Kano state, Nigeria. It is prepared by boiling the pulp extract to a thick consistency and then adding guinea corn flour. The resultant paste is allowed to simmer for some time and molded into small circular shapes. Aduwa seed is considered as an extremely useful edible product. Bello and Dandago (2011) in their study on Aduwa fruit pulp and seed also reported that seeds of Aduwa contains about 30 – 40 % edible oil and that also the seeds are used to produce a popular local snack called "Annaki". Aduwa seed oil has been used in many countries as an ingredient and substituent to groundnut oil in the preparation of local dishes (Mohammed and Hamza, 2008; Nadro *et al.* 2009). Findings on the study of Aduwa seed oil by Bello and Dandago (2011) showed that it can be used for frying, shortening, margarine and cooking.

Medicinal Application

Medicinal herbs are an alternative to orthodox medicines due to their efficacy and safety (Pandey *et al.* 2011). The fruits of the Aduwa plant are used as folk medicine by many rural areas in Africa for the treatment of various diseases such as intestinal worm infestations, wound healing, syphilis, dysentery, constipation, diarrhea and fever (Al-Malki *et al*. 2015). The fruits of Aduwa contained a wide variety of compounds, which show a wide range of biological and pharmacological properties such as antioxidant, anti-inflammatory, antimicrobial and cytotoxic activities (Al-Malki *et al*. 2015).

In some parts of Africa and Asia, the fruit has been used to cure liver diseases, jaundice, intestinal worm infection, wounds, malaria, syphilis, epilepsy, dysentery, constipation, diarrhea hemorrhoid, stomach aches, asthma, fever and skin diseases (Al-Thobaiti and Zeid, 2018; Saboo *et al.* 2014; Hammiche and Maiza, 2006). Ojo *et al.* (2006) reported that in Sudan the Aduwa fruit has been used to cure various illnesses including diarrhoea, hermorrhoid, stomach aches, yellow fever, syphilis and epilepsy. Furthermore, it has also been used for the treatment of cough and Typhoid fever (Doughari *et al.* 2007; Hena *et al*. 2010). The anti-dysenteric and anti-diarrheal properties of medicinal plants is because of the alkaloids, flavonoids, saponins and reducing sugars contained in them (Tula *et al.* 2014).

The bark of Aduwa has been used for treating syphilis and round worm infection (Gajalakshmi *et al*. 2013). The fiber obtained from tender fresh bark or older dried bark of Aduwa plant has also been used for the preparation of medicines (Murthy *et al*. 2021). Al-Thobaiti and Zeid, (2018) highlighted that different parts of the plant have medicinal properties, in many ethno-botanical studies as an antihelmenthic, a purgative, a leukoderma and emetic. Root and bark of Aduwa are used as a purgative and an anthelmintic. A decoction of roots is used to treat malaria. The bark is often used to deworm cattle, and the roots are boiled into a soup and used to treat edema and stomach pains in humans. A decoction of bark is also used as an antidote in West African traditional medicine (Murthy *et al*. 2021).

In addition, Aduwa seed oil is used as a laxative and for the treatment of hemorrhoids, stomach aches, jaundice, yellow fever, syphilis and epilepsy, reported Ojo *et al*. 2006; Ya'u *et al*. 2020).

Medicinal compounds in Adua plant

Aduwa plant possesses hypoglycemic effect which might be related with the availability of compounds such as flavonoids, saponin, carvacrol and/or cinnamyl alcohol. Both carvacrol and cinnamyl alcohol enhance pancreatic secretion of insulin from β-cells and glucose homeostasis (Al-Thobaiti and Zeid, 2019). Currently, the management of diabetes mainly requires a sustained reduction in hyperglycemia by the use of biguanides, thiazolidinediones, sulphonylureas, Diphenylalanine derivatives, meglitinides and α-glycosidase inhibitors in addition to insulin (Al-Malki *et al*. 2015). But, due to undesirable effects, the efficacies of these substances are debatable and there is a demand for new substances in the management of diabetes (Garba *et al*. 2017). Nadro *et al*. (2009) reported that medicinal plant extracts have been an important anti-diabetic agents and may involve one or more active substances which may be responsible for reduction of blood glucose levels. Nadro and Samson (2014) treated Wistar rats for three weeks with Aduwa seed cake, there was a significant reduction ($p<0.05$) in the blood glucose levels of the experimental animal, when compared to the control group. Furthermore, the Aduwa seed cake and dictated that showed significant ($p<0.05$) reduction in elevated levels of ALT, AST and ALP as well as improving renal and hepatic functions. Mhya *et al*. (2018) reported that the leaf extract of Aduwa is capable of stimulating erythrocytes glucose uptake in patients with type II diabetes and also inhibited alpha amylase activity *in vitro*.

Flavonoids can retard the development of fluids that result in diarrhoea by acting on the intestinal cystic fibrosis trans-membrane conductance regulator Cl–transport inhibiting cAMP-stimulated Cl–secretion in the intestine (Schuier *et al.* 2005). Tula *et al.* (2014) also reported similar findings. Phytochemical screening of various parts of Aduwa had shown that it contained a variety of compounds (Motaal *et al*. 2012; Gidey, 2016). Alkaloids are very important therapeutically significant plant compounds, isolated pure alkaloids and the synthetic derivatives are used as basic medicinal agents because of their analgesic, anti-plamodic and bacterial activities as they point out marked physiological effects when administered to animals Gidey, 2016). This may justify why Aduwa root extract is effective in the treatment of pain, malaria, and enteric fever in folk medicine.

Amadou *et al.* (2012) conducted study on the effect of Aduwa extract on stomach cancer cells and the results of *in vitro* test on the cancer cells showed that the boiled extract of Aduwa to exhibited lethal activity on stomach cancer cell SGC790 at all concentrations than the fresh extract. Gastric cancer is one among most common causes of malignancy-related mortality globally, and diet therapy may be a promising way to stop or retard the process of carcinogenesis. Cos *et al*. (2006) also reported similar findings on Aduwa extract.

Doughari *et al.* (2007) conducted a study on the aqueous leaf extract and saponins isolated from Aduwa. The study revealed that Aduwa leaves had anti-bacterial activity and a potent larvicidal activity (Elfeel and Sherif, 2014). Saponin is an important steroidal which yields diosgenin, a source of steroidal drugs, such as corticosteroids and contraceptives (Elfeel, 2010). Bishnu and Wiesman (2005) reported the Potency of Aduwa leaf extract in the control of *C. pipiens* mosquito larvae and there was interaction of saponin compound with the cuticle membrane of mosquito larvae. According to these authors, Aduwa leaf extract subsequently killed the larvae by disarranging its membrane. Oil of the Aduwa seed showed antiviral

activity against Herpes simplex virus, antimicrobial activity on some strains of Gram-positive bacteria, Gram-negative bacteria, and *Candida* (Daya *et al.* 2011).

Conclusion

Aduwa is a wild plant that dwells in different parts of the world. Aduwa is found in northern part of Nigeria in Kano, Katsina, Jigawa and Sokoto states and so on. Aduwa is known to be medicinal and has potentials to cure many kinds of illnesses such as epilepsy, diarrhea, and so on. Almost every part of the plant is used in traditional medicine. The fruits, seeds, flowers, and leaves are all edible to humans and animals. Aduwa tree parts are rich in important nutrients and very importantly- medicinal compounds and hence can be consumed as a functional food to combat malnutrition and / or other nutrition related illnesses. Aduwa is an important plant in the community and it is very important if it is properly utilized.

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