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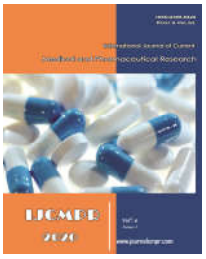

PHARMACOLOGICAL ACTIVITIES OF BAOBAB (*ADANSONIA DIGITATA*)

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ABSTRACT

Background: Adansonia digitata also known as ''baobab'' is a tree attracting recent interest especially due to the high nutritional value of the fruit pulp. However, few studies are reported on the secondary metabolite content, showing high variability depending on the geographical region.
Methods: In this study, the chemical profiles of baobab fruits, leaves and bark were investigated by HPLC coupled with a photodiode array (PDA)/UV and an electrospray ionization (ESI) mass spectrometer (MS) and gas chromatography (GC)/MS.
Results: The phytochemical screening of the plant samples revealed that phenols, Saponins, Flavonoids, Alkaloids, Tannin, Terpenoids and Cardiac glycoside were present. The presence of these compounds was known to show medicinal potentials as well as exhibiting physiological activity and this justified the use of baobab leaves as one of the major source of soup in African dishes. The results further implied that the species has potentials in food industry, pharmaceuticals and other allied industries.

INTRODUCTION

Baobab or *Adansonia digitata* L. belongs to the Malvaceae family (Bremer *et al.*, 2003) and is a deciduous tree native to arid Central Africa (Yazzie *et al.*, 1994). Its distribution area is large and this species can be found in most of Sub-Sahara Africa's semi-arid and sub-humid regions as well as in western Madagascar (Diop *et al.*, 2005).

The tree has been introduced to areas outside Africa and grown successfully (Sidibe & Williams, 2002). Baobab is a very long-lived tree with multipurpose uses. The different plant parts are widely used as foods, medicines and the bark fibres are also used (Sidibe & Williams., 2002). The tree provides food, shelter, clothing and medicine as well as material for hunting and fishing (Gebauer *et al.*, 2002). Every part of the baobab tree is reported to be useful (Igboeli *et al.*, 1997) and (Gebauer *et al.*, 2002).

Local Uses

Fruits

The baobab fruit pulp is probably the most important foodstuff. It can be dissolved in water or milk. The liquid is then used as a drink, a sauce for food, a fermenting agent in local brewing, or as a substitute for cream of tartar in baking (Sidibe & Williams, 2002)

Figure 1 Preparation of baobab fruit pulp porridge: (1-2-3) pulp, seeds and fibres are diluted in water; (4) seeds and fibres are removed (4a) and dissolved pulp remains (4b); (5-6-7) at the same time, water is added to e.g. maize flour, boiled and thickened to a porridge which is mixed with the dissolved baobab pulp (Source: Emmy De Caluwé, Benin, 2004).

The pulp has recently become a popular ingredient in ice products in urban areas (Scheuring *et al.*, 1999), (Gebauer *et al.*, 2002), in different kinds of juices and jams (Figure 2). The pulp is never cooked as the hot drinks are being prepared; rather it is added at the end of the preparation process after the drinks are allowed to cool (Sidibe *et al.*, 1996). Fruit pulp is important in local diets as a seasoning component and appetizer (Ajayi *et al.*, 2003). When the pulp is soaked in

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water, it produces a milky solution, which can be consumed as a milk substitute (Ajayi *et al.*, 2003). The baobab fruit pods are also good for burning and a potash-rich vegetable salt may be obtained from this ash for making soap (Ajayi *et al.*, 2003).

Seeds

Baobab seeds can be eaten fresh, or they may be dried and ground into a flour which can either be added to soups and stews as a thickener, or roasted and ground into a paste, or boiled for a long time, fermented and then dried for use (Sidibe & Williams, 2002), (Nnam & Obiakor, 2003).

Figure 3 Left: after boiling the seeds, the latter can be shelled more easily and prepared into sauces baobab seeds (Source: Emmy De Caluwé, Benin, 2004); Right: (1) crushed baobab seeds are (2) fermented in the sun and (3) prepared into a sauce (Source: Emmy De Caluwé, Benin, 2004).

Leaves

The leaves of the baobab tree are a staple for many populations in Africa, especially the central region of the continent (Yazzie *et al.*, 1994), (Gebauer *et al.*, 2002). During the rainy season when the baobab leaves are tender, people harvest the leaves fresh. During the last month of the rainy season, leaves are harvested in great abundance and are dried for domestic use and for marketing during the dry season. The leaves are typically sun-dried and either stored as whole leaved or pounded and sieved into a fine powder (Gebauer *et al.*, 2002) (Figure 4). Young leaves are widely used, cooked as spinach, and frequently dried, often powdered and used for sauces over porridges, thick gruels of grains, or boiled rice (Sidibe & Williams, 2002).

Figure 4 Left: baobab leaves drying in the sun (Source: Camille De Moor, Mali, 2007); Middle: woman selling baobab leaf powder at market (Source: Camille De Moor, Mali, 2007); Right: woman selling fresh baobab leaves at market (Source: Emmy De Caluwé, Mali, 2007).

Bark

Baobab bark is mainly used for medicinal properties. Secondly, the bark is wellknown for its fibers used to make ropes, sacks, clothes, baskets and mats (Sidibe & Williams, 2002) (Figure 5). The bark from the lower part of the stem can be removed to produce a valuable fibre. If managed properly the trees are not seriously damaged, and even after repeated use the bark regenerates and can be stripped again some years later (ICRAF, 2007). (Modibbo *et al.,* 2009) found that baobab appears to have high percentage extension at break compared to other fibres. The relative proportions of amorphous which are relatively high in baobab bast fibres, to crystalline regions are presumed to be the major determinant.

Figure 5. Left: bark fibres of baobab twisted into ropes. (Source: Emmy De Caluwé, Benin, 2004); Right: baobab bark as ropes used for a well (Source: Camille De Moor, Mali, 2007).

The alkaloid 'adansonin' in the bark is thought to be the active principle for treatment of malaria and other fevers (Sidibe & Williams, 2002). Baobab bark which is often given to infants to promote weight gain (Lockett & Grivetti, 2000) was found to be high in fat, calcium, copper, iron, and zinc (Lockett *et al.*, 2000). Friedelin, lupeol and baurenol (all three terpenoids) were identified in the leaf bark of baobab. In addition, betulinic acid was isolated from the bark whereas the leaf exclusively yielded taraxerone and acetate of lupeol and baurenol (Shukla *et al.*, 2001).

Phytochemistry

In general baobab pulp is rich in vitamin C, the leaves are rich in good quality proteins – most essential amino acids are present in the leaves and minerals, and the seeds in fat. Moreover, pulp and leaves exhibit antioxidant activity (Chadare *et al.*, 2009). A variety of chemicals have been isolated and characterised from A. digitata. They belong to the classes of terpenoids, flavonoids, steroids, vitamins, amino acids, carbohydrates and lipids (Shukla *et al.*, 2001).

Qualitative Analysis of Phytochemical Constituents

Test for Alkaloids

The presence of alkaloid was determine as described by (Harborne., 1973), (Trease and Evans, 1996). A Portion of the plant powder (5g) was reacted with a few drops of hagers reagent (1.0cm3) and another 5g portion was treated with wegner's reagent (1.0cm3) turbidity or precipitate with either of these reagents was taken as an evidence for the presence of alkaloids.

Test for Tannins

A portion of the plant sample was diluted with distilled water in the ratio of 1:4 and a few drops of 10% ferric chloride was added to produce a blue black or green color. 5g of dried powdered sample of the plant was boiled in 20ml of distilled water in a test tube and then filtered using a hydrophilic filter (5.5cm in size) and funnel (35mm in size) placed in a conical flask. 0.1% FeCl3 was added to the filtered samples and observed for brownish green or a blue-black coloration, which shows the presence of tannins (Trease and Evans 1996).

Test for Saponnins

5g of powdered sample of the plant was boiled together with 20 ml of distilled water in a water bath and then filtered. 10ml of the filtered sample was mixed with 5ml of distilled water in a test tube and shaken vigorously to obtain a stable persistent froth. The frothing observed for the formation of emulsion which indicates the presence of saponins.

Test for Flavonoids

A few drops of 1% NH_3 solution was added to the aqueous plant sample in a test tube, a yellow coloration is observed if flavonoid compound is present.

Test for Terpenoids

5g of the plant sample was mixed with 2ml of $CHCL_3$ in a test tube. 3ml of concentrated H_2SO_4 was carefully added to the mixture to form a layer; an interface with a reddish-brown coloration is formed if terpenoids constituent is present.

Test for Cardiac Glycoside

2ml of concentrated H_2SO_4 was prepared in attest tube. 5g of plant sample was mixed with 2ml of glacial acetic acid CH_3CO_2H containing 1 drop of $FeCL_3$ .The mixture was carefully added to the 1ml of concentrated H_2SO_4 so that the concentrated H_2SO_4 is underneath the mixture. If cardiac glycoside is present in the sample, a brown ring will appear indicating the presence of the cardiac glycoside constituent (Harborne., 1973).

Test of Phenols

Two ml of the extracts was mixed with ferric chloride solution. A green or dirty green precipitate indicates the presence of phenolic compounds.

Pharmacology

Anti-oxidant Activity

Dietary antioxidants, including polyphenolic compounds, vitamins E and C, and carotenoids, are believed to be effective nutrients in the prevention of oxidative stress related diseases (Besco *et al.*, 2007), such as inflammation, cardiovascular disease, cancer and aging related disorders (Besco *et al.*, 2007). The high antioxidant capacity of products deriving from *Adansonia digitata* show their therapeutical, nutraceutical and cosmoceutical potential. Moreover, in view of the very high antioxidant capacity, some authors (Vertuani *et al.*, 2002), (Besco *et al.*, 2007) have proposed the red fiber as a new value-added ingredient for food preparation and/ or nutraceutical application in the promotion of health. Research studies have (Vertuani *et al.*, 2002), (Besco *et al.*, 2007) compared the overall antioxidant capacity (IAC), corresponding to the sum of the corresponding water- and lipid-soluble antioxidants capacity, of baobab plant products with those of orange and kiwi. The IAC value for the examined products resulted as follows: baobab red fibre (1617.3) >>> baobab fruit pulp (240.5) >> baobab fresh leaves (89.0) >> baobab seeds (51.4) > orange fresh fruit pulp (24.3) > kiwi fruit pulp (2.4).

Vitamin C Healing Effect

Vitamin C is a powerful antioxidant and extremely important in human nutrition. Vitamin C has been shown to be related to low blood pressure, enhanced immunity against many tropical maladies, lower incidence of cataract development and lower incidence of coronary disease. The daily recommended intake for healthy, non-smoking adults is 65 mg; smokers need more vitamin C than non-smokers. While 65 mg/day is the minimum recommended intake, a full saturation of the total pool of vitamin C in the body is about 140 mg/day. Convalescents recovering from infectious diseases or nursing mothers benefit significantly from daily intakes exceeding 250 mg. using the average vitamin C content of baobab fruit, 2800 mg/kg, the recommendations can be converted into amounts of baobab powder. The daily recommended dose of vitamin C can be obtained from 23 g of baobab powder. The daily saturation of the vitamin C pool in the body requires 50 g of baobab powder; the special dosage for convalescents is 90 g (Sidibe *et al.*, 1996).

Anti-viral Activity

Adansonia digitata root-bark and leaf methanol extracts have shown high antiviral activity against Herpes simplex, Sindbis and Polio (Anani *et al.*, 2000), together with viricidal (direct inactivation of virus particles) and also intracellular antiviral activity, which could indicate the presence of multiple antiviral compounds, or a single compound with multiple actions (Hudson *et al.*, 2000). Whether such studies will show as effective results in humans is unknown but these couple of preliminary reports may provide rationale behind some of the medicinal uses of this plant.

Anti-inflammatory and Anti-pyretic Activity

According to Ramadan and co-workers (1993), aqueous extract of the baobab fruit pulp produced a marked anti-inflammation activity. This effect could be due to the presence of sterols, saponins and triterpenes in the fruit pulp. The extract also shows a marked antipyretic activity (Ramadan *et al.*, 1993). The antipyretic activity of the extract resembles that normally induced by standard dose of administered acetylsalicylic acid (ASA) in hyperthermic rats (Ramadan *et al.*, 1993). Analgesic and antipyretic activities were also mentioned by UN (Masola *et al.*, 2009), probably due to the presence of sterols, saponins and triterpenes in the fruit pulp. Leaves are applied locally for a variety of inflammatory conditions, insect bites and guinea worm sores (Shukla *et al.*, 2001).

Anti-microbial Activity

An acid medium, as created by the addition of baobab pulp powder to tempe fermentation could prevent the growth of pathogenic bacteria such as *Salmonella* sp., *Bacillus* sp. and *Streptococcus* sp. (Afolabi *et al.*, 2005). Moreover, increasing concentrations of baobab pulp powder led to an increase in the population of lactic acid bacteria. This is beneficial to consumers since most of the lactic acid bacteria species are nontoxic and have been reported to produce an enzyme that breaks the oligosaccharides in soybean (main component of tempe) down to their mono- and disaccharide constituents. The presence of lactic acid bacteria in tempe prepared as it is being done locally in Nigeria will not only improve the digestibility of tempe, but will also extend the shelf life of the product because of the preservative attributes of lactic acid bacteria (Afolabi *et al.*, 2005).

There was some antibacterial activity against *Staphylococcus aureus, Streptococcus faecalis, Bacillus subtilis, Escherichia coli* and *Mycobacterium phlei* (Masola *et al.*, 2009). Stem and root barks of baobab contain bioactive constituents which are responsible for antimicrobial activity of the crude aqueous and ethanolic extracts. This explains the scientific basis for the use of crude stem and or root bark extracts in traditional medicine e.g. for treatment of fever caused by malaria (Masola *et al.*, 2009).

Uses in Traditional Medicine

Baobab leaves, bark, pulp and seeds are used as food and for multiple medicinal purposes in many parts of Africa (Yazzie *et al.*, 1994), (Diop *et al.*, 2005). Ethnomedicine has been an intensive area of research, with several authors discussing the main ethnomedicinal uses of baobab products.

Fruit

Baobab is used in folk medicine as an antipyretic or febrifuge to overcome fevers. Both leaves and fruit pulp are used for this purpose. Fruit pulp and powdered seeds are used in cases of dysentery and to promote perspiration (i.e. a diaphoretic) (Sidibe & Williams, 2002). Baobab fruit pulp has traditionally been used as an immunostimulant (Al-Qarawi *et al.*, 2003), anti-inflammatory, analgesic (Ramadan *et al,* 1993), (Al-Qarawi *et al.*, 2003), pesticide (Tuani *et al.,*1994), (Al-Qarawi *et al.*, 2003), antipyretic, febrifuge, and astringent in the treatment of diarrhoea and dysentery (Ramadan *et al.,* 1993), (Al-Qarawi *et al.*, 2003). The fruit pulp has been evaluated as a substitute for improved western drugs (Al-Qarawi *et al.*, 2003). The aqueous extract of baobab fruit pulp exhibited significant hepatoprotective activity and, as a consequence, consumption of the pulp may play an important part in human resistance to liver damage in areas where baobab is consumed (Al-Qarawi *et al.*, 2003). Medicinally, baobab fruit pulp is used as a febrifuge and as an anti-dysenteric, and in the treatment of smallpox and measles as an eye instillation (Wickens, 1979). In Indian medicine, baobab pulp is used internally with buttermilk in cases of diarrhoea and dysentery. Externally, use is made of young baobab leaves, crushed into a poultice, for painful swellings (Sidibe & Williams, 2002).

Seeds

Seeds are used in cases of diarrhoea, and hiccough. Oil extracted from seeds is used for inflamed gums and to ease diseased teeth (Sidibe & Williams, 2002). Since seed oil is used to also treat skin complaints, it can be considered to have cosmetic applications as well (Sidibe & Williams, 2002).

Leaves

Powdered leaves are used as an anti-asthmatic and known to have antihistamine and anti-tension properties. The leaves are also used to treat a wide variety of conditions including fatigue, as a tonic and for insect bites, Guinea worm and internal pains, and dysentery (Sidibe & Williams, 2002); and diseases of the urinary tract, opthalmia and otitis (Sidibe & Williams, 2002). In Indian medicine, powdered leaves are similarly used to check excessive perspiration (Sidibe & Williams, 2002). Baobab leaves are used medicinally as a diaphoretic, an expectorant, and as a prophylactic against fever, to check excessive perspiration, and as an astringent (Wickens, 1979). The leaves also have hyposensitive and antihistamine properties. Leaves are used to treat kidney and bladder diseases, asthma, general fatigue, diarrhoea, inflammations, insect bites and guinea worm (Wickens, 1979).

Bark

The widest use in tradition medicine comes from the baobab bark as a substitute for quinine in case of fever or as a prophylactic. A decoction of the bark deteriorates rapidly due to the mucilaginous substances present. This process can be prevented by adding alcohol or a small quantity of sulphuric acid to the decoction (Sidibe & Williams, 2002). Baobab bark is used in Europe as a febrifuge (antipyretic). In the Gold Coast (Ghana), the bark is used instead of quinine for curing fever (Shukla *et al.*, 2001). In Indian medicine, baobab bark is used internally as a refrigerant, antipyretic and antiperiodic. It is used as a decoction, 30 g/l of water, boiled down to two thirds (Sidibe & Williams, 2002). The activity of baobab bark as a febrifuge, however, has not been detected in experimental malaria treatments, although it is both diaphoretic and antiperiodic (Wickens, 1979). The bark, however, is certainly used for the treatment of fever in Nigeria (Wickens, 1979). Moreover, the bark contains a white, semi-fluid gum that can be obtained obtainable from bark wounds and is used for cleansing sores (Wickens, 1979). According to Loustalot & Paga (Wickens, 1979) there are no alkaloids present in the bark, and accounts from Nigeria are inconclusive (Wickens, 1979). However, according to Watt & Breyer-Brandwijk (Wickens, 1979) the bark contains the alkaloid 'adansonin', which has a strophanthus-like action. In East Africa, the bark is used as an antidote to strophanthus poisoning. In Congo Brazzaville, a bark decoction is used to bathe rickety children and in Tanzania as a mouthwash for toothache (Wickens, 1979). Furthermore, a new flavanonol glycoside was reported in the root bark (Ramadan *et al.*, 1993). Baobab bark, fruit pulp and seeds appear to contain an antidote to poisoning by a number of Strophanthus species. The juice of these species has been widely used as an arrow poison especially in East Africa. In Malawi, a baobab extract is poured onto the wound of an animal killed in this way to neutralize the poison before the meat is eaten (Wickens, 1979), (Sidibe & Williams, 2002). An infusion of roots is used in Zimbabwe to bathe babies to promote smooth skin (Sidibe & Williams, 2002).

CONCLUSIONS

Adansonia digitata L. is a multipurpose tree species widely used for food and medicine.

The baobab fruit pulp is probably the most important foodstuff. It can be dissolved in water or milk. The liquid is then used as a drink, a sauce, a fermenting agent in local brewing, or as a substitute for cream of tartar in baking. The fruit pulp has a very high vitamin C content and is a rich *source* of calcium. The acidic pulp is rich in pectin, contains a high amount of carbohydrate, is low in protein, and extremely low in fat. Nevertheless, the fruit pulp can be considered as a rich *source* of amino acids and linoleic acid. It contains a very low amount of α-linolenic acid and iron. Baobab seeds can be eaten fresh, or may be dried and ground into flour which can either be added to soups and stews as a thickener, or roasted and ground into a paste, or boiled for a long time, fermented and then dried for use. The seeds can be classified as both protein- and oil-rich. They contain appreciable quantities of crude protein, digestible carbohydrates and oil, whereas they have high levels of lysine, thiamine, Ca, Mg and Fe. Baobab seeds contain high proportions of linoleic and oleic acid as well as palmitic and α-linolenic acid. Processing eliminates a number of anti-nutritional factors present in the seeds.

The leaves of the baobab tree are a staple for many populations in Africa. Young leaves are widely used, cooked like spinach, and frequently dried, often powdered and used for sauces over porridges, thick gruels of grains, or boiled rice. Baobab leaves are superior to fruit pulp in nutritional quality, and contain interesting levels of vitamin A. They appear to be a good *source* of protein, and contain particularly significant amounts

of the amino acid tryptophan. Baobab leaves are a significant *source* of Fe, Ca, K, Mg, Mn, P and Zn.

Baobab bark is mainly used for its medicinal properties and for its fibres. The alkaloid 'adansonin' in the bark is thought to be the active principle for treatment of malaria and other fevers, as a substitute for quinine. Several plant parts have interesting anti-oxidant, anti-viral and anti-inflammatory properties, and baobab has been used extensively since ancient times in traditional medicine.

However, for baobab, the nutritional and medicinal data are widely scattered and research is fragmentary.

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