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REVIEW ARTICLE

A REVIEW ON THE MEDICINAL PLANT *PSIDIUM GUAJAVA* LINN. (MYRTACEAE)

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ABSTRACT

Psidium guajava is an important food crop and medicinal plant available in tropical and subtropical countries, widely used in food and folk medicines around the world. It contains important phytoconstituents such as tannins, triterpenes, flavonoid: quercetin, pentacyclic triterpenoid: guajanoic acid, saponins, carotenoids, lectins, leucocyanidin, ellagic acid, amritoside, beta-sitosterol, uvaol, oleanolic acid and ursolic acid. In view of the immense medicinal importance of the plant, this review is an effort to compile all the information reported on its ethanobotanical, phytochemical and pharmacological activities. The present work attempts to generate interest among the masses regarding its potential in preventing and treating several common diseases. Many pharmacological studies have demonstrated the ability of this plant to exhibit antioxidant, hepatoprotective, anti-allergy, antimicrobial, antigenotoxic, antiplasmodial, cytotoxic, antispasmodic, cardioactive, anticough, antidiabetic, antiinflamatory and antinociceptive activities, supporting its traditional uses. Suggesting a wide range of clinical applications for the treatment of infantile rotaviral enteritis, diarrhoea and diabetes.

Key words: ethanobotany, myrtaceae, pharmacology, physicochemical, phytochemical, *Psidium guajava*

INTRODUCTION

Psidium guajava L. known as Guava is a medicinal plant belonging to the family Myrtaceae. *P. guajava* is a well known traditional medicinal plant used in various indigenous systems of medicine. It is widely distributed throughout India[1]. The leaves and bark of *P. guajava* tree have long history of medicinal uses, that is still employed today. It is a native of Central America but is now widely cultivated, distributed and the fruits enrich the diets of millions of people in the tropics of the world[2,3]. It is a genus of about 133 genera and more than 3,800 species of tropical shrubs and a small tree of about 10m high with spreading branches that thrives on all kinds of soils. It is one of the most gregarious fruit trees and is widely known by its common English name (guava). In Nigeria, it is called guava (Hausa), gurfa (Yoruba) and Gwaibwa (Igbo)[3]. *P. guajava* also known as the 'poor man's apple' of the tropics has a long history of traditional use, and a good proportion of which have been validated by scientific research[4].

Nutritional value of guavas are often included among superfruits, being rich in dietary fiber, vitamins A and C, folic acid; and the dietary minerals, potassium, copper and manganese. Having a generally broad, low calorie profile of essential nutrients, a single common guava fruit contains about four times the amount of vitamin C as an orange. The food value and contents of guava fruit is listed in the **Table 1.** However, nutrient content varies across guava cultivars.

Distribution

It is now cultivated in Southern Florida, Bermuda, and throughout the West Indies from the Bahamas and Cuba to Trinidad, and south to Brazil[6].

Table 1: Nutrient value of guava fruit[5]

Nutrients	Content
Moisture	2.8-5.5g
Crude fiber	0.9-1.0g
Protein	0.1-0.5mg
Fat	0.43-0.7mg
Ash	9.5-10mg
Carbohydrate	9.1-17mg
Calcium	17.8-30mg
Phosphorous	0.30-0.70mg
Iron	200-400 I.U.
Carotene (Vitamin A)	0.046mg
Thiamin	0.03-0.04mg
Riboflavin	0.6-1.068mg
Niacin	40 I.U.
Vitamin	36-50mg

Taxonomy

Kingdom : Plantae
Order : Myrtales
Family : Myrtaceae
Subfamily : Myrtoideae
Genus : *Psidium*
Species : *Guajava*
Binomial name : *Psidium guajava* Linn.

Ethanobotany

P. guajava has a long history of traditional use, a good proportion of which have been validated by scientific research[4]. The ethno-medicinal uses include the crushing of the leaves and the application of the extract on wounds, boils, skin and soft tissue infectious site[7]. Stem, bark and root-bark are astringent. Unripe fruit is indigestible, causes vomiting and feverish. Fruit is laxative, leaves are astringent[8]. Locally, decoction of the leaves is with much benefit to the prolapsus ani of children[8]; ache upsets and for vertigo[6]. *P. guajava* leaf is a phytotherapic used to treat gastrointestinal and respiratory disturbances and is used as anti-inflammatory medicine. Its anti-amoebic and antimalarial effects have also been documented[9,10]. Guava fruit paste and cheese are popular dishes in Florida, the West Indies and parts of South America[11]. The plant *P. guajava* Linn. has an ethanomedical history as it has various activities especially functionally against the hyperglycemia.

Table 2: Showing worldwide ethanomedical uses of Guava[5]

Amazonia	for diarrhea, dysentery, menstrual disorders, stomach ache, vertigo
Brazil	for anorexia, cholera, diarrhea, digestive problems, dysentery, gastric insufficiency, inflamed mucous membranes, laryngitis, mouth(swelling), skin problems, sore throat, ulcers, vaginal discharge
Cuba	for cold, dysentery, dyspepsia
Ghana	coughs, diarrhea, dysentery, toothache
Haiti	for dysentery, diarrhea, epilepsy, itch, piles, scabies, skin sores, sore throat, stomachache, wounds and as an antiseptic and astringent
India	for anorexia, cerebral ailments, childbirth, chorea, convulsions, epilepsy, nephritis
Malaya	for dermatosis, diarrhea, epilepsy, hysteria, menstrual disorders
Mexico	for deafness, diarrhea, itch, scabies, stomachache, swelling, ulcer, worms, wounds
Peru	for conjunctivitis, cough, diarrhea, digestive problems, dysentery, edema, gout, hemorrhages, gastroenteritis, gastritis, lung problems, PMS, shock, vaginal discharge, vertigo, vomiting, worms
Philippines	for sores, wounds and as an astringent
Trinidad	bacterial infections, blood cleansing, diarrhea, dysentery
Elsewhere	for anorexia, aches, bacterial infections, boils, bowel disorders, bronchitis, catarrh, cholera, chorea, colds, colic, convulsions, coughs, diarrhea, dysentery, dyspepsia, edema, epilepsy, fever, gingivitis, hemorrhoids, itch, jaundice, menstrual problems, nausea, nephritis, respiratory problems, rheumatism, scabies, sore throat, spasms, sprains, stomach problems, swelling, tonic, toothache, ulcers, worms, wounds and as an antiseptic and astringent

Various parts of the plant has been used in traditional medicine.

Leaves: The decoction or infusion of the leaves is used as febrifuge, antispasmodic and for rheumatism in India[12]. The leaves are used in USA as an antibiotic in the form of poultice or decoction for wounds, ulcers and tooth ache[13,14]. Bronchitis, asthma attacks, cough, pulmonary diseases could be also treated with guava teas[15,16].

Bark: The bark in the form of decoction and poultice is used as an astringent in the treatment of ulcers wounds and diarrhea in Philippines while in Panama, Bolivia and Venezuela, the bark is used in treatment of dysentery and skin ailments. In the form of decoction and poultice, it is used to expel the placenta after childbirth and in infections of the skin, vaginal hemorrhage wounds, fever, dehydration and respiratory disturbances[17].

Root: The root is used in West Africa as a decoction to relieve diarrhea, coughs, stomach ache, dysentery, toothaches, indigestion and constipation; while in Philippines, Fiji and South Africa, the roots are used in the form of decoction and poultice as an astringent in ulcers wounds and in treatment of diarrhea[17].

Whole plant: In general, the whole plant or it shoots are used in the form of infusion, decoction and paste as skin tonic in Tahiti and Samoa and as analgesia in painful menstruation, miscarriages, uterine bleeding, premature labor and wounds[17].

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Figure 1: Whole plant of *Psidium guajava* L.(A) along with leaves (B); fruit (C) and flower (D) Pharmacognosy

Macroscopy

P. guajava is a large dicotyledonous shrub, or small evergreen tree, generally 3-10 m high with many branches[18]. The stems are crooked and the bark is light to reddish brown, thin, smooth and continuously flaking. Root system is generally superficial and very extensive, frequently extending well beyond the canopy. Each has some deep roots but no distinct taproot[17]. The leaves are opposite and simple; stipules are absent, petiole short, 3-10 mm long; blade oblong to elliptic, veins prominent, gland dotted[18]. The flowers are white, incurved petals, 2 or 3 in the leaf axils; they are fragrant, with four to six petals and yellow anthers. The fruit is small, 3 to 6 cm long, pear-shaped, reddish-yellow when ripe[6]. The fruit contains several small seeds and consists of a fleshy pericarp and seed cavity with pulp[19,20,21].

Microscopy

The microscopy reveals the presence of abundant unicellular trichome, paracytic stomata, xylem vessels, calcium crystals and few crystal sheath[22,23,24]. The average stomatal index on upper epidermis is more than on lower epidermis for mature leaf and found opposite in case of young leaf[23]. Young leaves contain more moisture, moreover, water and alcohol soluble compounds are present nearly in same amount in both young and mature leaves. The transverse section of midribs show gutter shaped xylem and phloem and beneath the phloem pericycle present, which contain collenchymatous cells[24].

Physico-chemical studies

The proximate analysis of powdered sample of *P. guajava* leaves showed low moisture content of 1.0% and low ash value of 2.80%. The ash value indicates the quantity of inorganic components of the plant; hence a low value indicates that the powdered leaves of *P. guajava* contain more of organic components. There is also low quantity of protein and fat but an abundance of carbohydrate which makes it a source of energy. The metal analysis of powdered sample of *P. guajava* showed the presence of all the metals screened for which include; magnesium, manganese, zinc, calcium, iron, sodium and potassium. The quantity of these metals revealed that they were well below tolerable upper intake level and within the recommended daily intake in healthy individuals established by the Dietary Reference Intakes[18].

The plant extracts were also screened for the presence of bio-active components in the leaves and roots[25,26,27]. The results of phytochemical analysis showed that the crude hydro-ethanolic leaf extract of *P. guajava* have different classes of bioactive constituents such as saponins, alkaloids, tannins, cardiac-glycosides, terpenes, flavonoids and sterols. The results showed that saponins, tannins and alkaloids are present in high concentrations, followed by terpenes, flavonoids and sterols while small concentration of cardiac-glycosides[28].

Phytochemistry

Guava contains broad spectrum of phytochemicals including minerals, enzymes, proteins[29], sesquiterpenoid alcohols and triterpenoid acids[30,31,32], alkaloids, glycosides, steroids, flavanoids, tannins, saponins[33,34]. Guava is very rich in antioxidants and vitamins and also high in lutein, zeaxanthine and lycopene[35,36]. The guava leaves contain several chemical constituents such as α-pinene, β-pinene, limonene, menthol, terpenyl acetate, isopropyl alcohol, longicyclene, caryophyllene, β-bisabolene, caryophyllene oxide, β-copanene, farnesene, humulene, selinene, cardinene and curcumene, mallic acids, nerolidiol, β-sitosterol, ursolic, crategolic, and guayavolic acids, cineol, quercetin, 3-L-4-4-arabinofuranoside (avicularin) and its 3-L-4-pyranoside (essential oil), resin, tannin, eugenol,

caryophyllene (1a α-, 4a α-, 7 α-, 7a β-, 7b α-)]-decahydro-1H-cycloprop[e] azulene, Guajavolide (2 α-,3 β-,6 β-,23-tetrahydroxyurs-12-en-28,20 β-olide; 1) and guavenoic acid (2 α-,3 β-,6 β-,23-tetrahydroxyurs-12,20(30)-dien-28-oic acid, triterpene oleanolic acid, triterpenoids, flavinone-2 2'-ene, prenol, dihydrobenzophenanthridine and cryptonine[37,8,38,39,32,40]. Guavas contain carotenoids and polyphenols, the major classes of antioxidant pigments giving them relatively high potential antioxidant value among plant foods[19]. As these pigments produce the fruit skin and flesh color, guavas that are red-orange have more pigment content as polyphenol, carotenoid and pro-vitamin A, retinoid sources than yellow-green ones.

Guavas contain both carotenoids and polyphenols like (+)-gallocatechin, guaijaverin, leucocyanidin and amritoside[41]. It was reported that the leaves of *P. guajava* contain an essential oil rich in cineol, tannins and triterpenes. In addition three flavonoids (quercetin, avicularin, and guaijaverin) have been isolated from the leaves[42]. The leaves of guava are rich in flavonoids, particularly quercetin. The bark of guava tree contains considerable amounts of tannins (11-27%), and hence is used for tanning and dyeing purposes.

Leucocyanidin, luectic acid, ellagic acid and amritoside have been isolated from the stem bark. Five constituents, including one new pentacyclic triterpenoid: guajanoic acid and four known compounds beta-sitosterol, uvaol, oleanolic acid and ursolic acid, have been recently isolated from the leaves of *P. guajava* by Begum *et al.*[32]. The essential oil contains alpha pinene, caryophyllene, cineol, D-limonene, eugenol, and myrcene. The major constituents of the volatile acids include (E)-cinnamic acid and (Z)-3-hexenoic acid[43]. The guava fruit has high water content with lesser amounts of carbohydrates, proteins and fats. The fruit also contains iron, vitamins A and C, thiamine, riboflavin, niacin and manganese. The characteristic fruit odor is attributed to carbonyl compounds. Unripe fruits are high in tannins. The major constituent of the fruit skin is ascorbic acid, largely destroyed by canning and processing[17].

Active factors of *P. guajava* fruits involve ursolic acid, oleanolic acid, arjunolic acid and glucuronic acid[44]. In comparison, huge amounts of β-sitosterol glucoside, brahmic acid, and polyphenolics including gallic acid, ferulic acid, and quercetin[45] and triterpenoids[46], exist in guava leaves[45]. Thus, it is clear that *P. guajava* contains many components reported to display efficacy against various diseases.

Pharmacology

Pharmacology of extracts:

The aqueous extract of *P. guajava* leaves exhibited good antibacterial activity against various test cultures. Report says that flavanoids extracted from guava leaves believed to be responsible for antibacterial activity[47]. The microbicidal activity of *P. guajava* is also attributable to guajaverine and to psydiolic acid[48]. Joseph *et al*[40] reported that guava leaf essential oil contains more terpenoids and that can strongly inhibit human cervical cancer cells. The leaf extract was found to possess anticestodal[49], analgesic, anti-inflammatory properties[50], antimicrobial[51], hepatoprotective and antioxidant activities[52]. In addition, the leaf extract is used in many pharmaceutical preparations as a cough sedative[53]. It has demonstrated antibacterial and anti-diarrheal effects and is able to relax the intestinal smooth muscle and inhibit bowel contractions. Guava has antioxidant properties attributed to polyphenols found in its leaves. The presence of the metabolites such as cardiac glycosides, saponins, tannins, alkaloids in *P. guajava* may be responsible for its potential use as a drug against pathogenic bacteria[54,55]. Alkaloids, flavonoids are phenolics structure containing one carbonyl group complexes with extracellular and soluble protein and with bacterial cell wall[56], thus exhibits antibacterial activity through these complexes.

In the pharmacological action guava leaf extracts have also been indicated to inhibit disturbances of the central nervous system: insomnia, convulsions and epilepsy[57,58]. In addition, anti-rotavirus activity has also been reported to exist in these extracts[59]. Bark and leaf extracts were shown to have *in vitro* toxic action against numerous bacteria. Water and chloroform extracts of guava were effective in activating the mutagenecity of *Salmonella typhimurium*[60]. It was shown that *P. guajava* leaf extracts might be beneficial in treating acne especially those that have anti-inflammatory activities[61].

In several studies, guava showed significant antibacterial activity against common diarrhea causing bacteria such as *Staphylococcus*, *Shigella*, *Salmonella*, *Bacillus*, *E. coli*, *Clostridium* and *Pseudomonas*, which was concluded that guava has good curative effect on infantile rotaviral enteritis[62]. In a study carried out with leaf extract of the plant, inhibition of gastrointestinal release of acetylcholine by quercetin present in extract was suggested as a possible mode of action in the treatment of acute diarrheal disease[57]. Guava fruit and leaf showed antioxidant and free radical scavenging capacity[52]. Its leaf extract possess anticough activity by reducing the frequency of cough induced by capsaicin aerosol[63]. Leaf extract of guava had inotropic effect on guinea pig atrium[64]. Another study investigated that the hypoglycemic and hypotensive effects of *P. guajava* leaf aqueous extract in rats showed hypoglycemic activity. The hypoglycemic effect of plant extract was examined in normal and diabetic rats, using streptozotocin (STZ) induced diabetes mellitus model[65]. In the study, i.p. treatment with 1 g/kg guava juice produced a markable hypoglycemic action in normal and alloxan-treated diabetic mice[66]. The anti-stress and adaptogenic activity exhibited by ethanol extract of *P. guajava* possess anti-stress property. It may be useful in the treatment of several disorders caused by stress by its immunostimulating, immunomodulating properties and also by enhancing the homeostatic mechanisms. Aqueous extract of *P. guajava* budding leaves has been shown to possess anti-prostate cancer activity in a cell line model. Guava leaf essential oil has been shown to possess cytotoxic effect on human cervical cancer cell lines[46,67].

The leaf extract has an excellent capacity to form coloured complex with iron. Iron chelation therapy has been shown to be anti-parasitic especially in African trypanosomiasis. Furthermore, decreasing of free-radicals has antioxidizing effect in the body, meaning that polyphenols can prevent arterial sclerosis, thrombosis, cataract and inhibit senescence of the body and skin[68]. In other animal studies,

guava leaf extracts have shown central nervous system (CNS) depressant activity[69]. It can also be used as antihypertensive and antidiarrhoeal agents in traditional medicine, by inhibiting intracellular calcium release[70]. *P. guajava* is reputed for its medicinal use in hyperactive gut disorders[71]. In a recent study with guinea pigs Brazilian researchers reported that guava leaf extracts have numerous effects on the cardiovascular system which might be beneficial in treating irregular beat (arrhythmia). Previous research indicated guava leaf provided antioxidant effects beneficial to the heart, heart protective properties, and improved myocardial function. Guava leaf extracts decreased spasms associated with induced diarrhea in rodents.

The *P. guajava* infusion at the higher concentration caused a statistically significant inhibition of cellular division in the onion root-tip cells[72]. During various episodes of screening of medicinal plants, extract from *P. guajava* leaves exhibited significant inhibitory effect on the protein tyrosine phosphatase1B (PTP1B).
In a study including 17 Thai medicinal plants on anti-proliferative effects on human mouth epidermal carcinoma and murine leukemia cells using MIT assay, guava leaf showed anti-proliferative activity, which was 4.37 times more than vincristine[73].

Pharmacology of pure compounds:

Gallocatechin isolated from the methanol extract of guava leaf showed antimutagenic activity against *E. coli*[74]. The active flavonoid compound quercetin-3-Oalpha-l-arabinopyranoside (guaijaverin) extracted from leaves has high potential antiplaque activity by inhibiting the growth of *Streptococcus mutans*[75]. Lectin chemicals in guava were shown to bind to *E. coli*, preventing its adhesion to the intestinal wall and thus preventing infection and resulting diarrhea[76]. Quercetin has several pharmacologic actions; it inhibits the intestinal movement, reduces capillary permeability in the abdominal cavity[77] and possesses dose-dependent antioxidant properties[78].

Clinical trials

In two randomized human studies, the consumption of guava fruit for 12 weeks was shown to reduce blood pressure by an average 8%, decrease total cholesterol level by 9%, decrease triglycerides by almost 8% and increase HDL cholesterol by 8%. The effects were attributed to the high potassium and soluble fiber content of the fruit. A randomized, single-blind, controlled trial was conducted to examine the effects of guava fruit intake on blood pressure and blood lipids in patients with essential hypertension. It is possible that an increased consumption of guava fruit can cause a substantial reduction in blood pressure and blood lipids without decreasing HDL-cholesterol level[79,80]. A double-blind clinical study of the effects of a Phytodrug (QG- 5) developed from guava leaf showed a decrease in duration of abdominal pain, which is attributed to antispasmodic effect of quercetin present in leaf extract[20]. The fruit or fruit juice has been documented to lower blood sugar levels in normal and diabetic animals and humans. Most of these studies confirm the plant's many uses in tropical herbal medicine systems[64]. In a clinical study with 62 infants with infantile rotaviral enteritis, the recovery rate was 3 days in those treated with guava, and diarrhea ceased in a shorter period than controls. It was concluded in the study that guava has 'good curative effect on infantile rotaviral enteritis'[62].

CONCLUSION

Psidium guajava (Linn.) is popularly known as 'poor man's apple of the tropics', has a long history of traditional use for a wide range of ailments. The fruit as well as its juice is freely consumed for its great taste and nutritional benefits. Much of the traditional uses have been validated by scientific research. Toxicity studies in mice and other animal models as well as controlled human studies show both leaf and fruit are safe without any side effects. The plant has been extensively studied in terms of pharmacological activity of its major components, and the results indicate potent anti-diarrheal, antihypertensive, hepatoprotective, antioxidant, antimicrobial, hypoglycemic and anti-mutagenic activities. A number of chemicals isolated from plants like quercetin, guaijaverin, flavonoids and galactose-specific lecithins have shown promising activity in many human trials. In recent years, emphasis of research has been on utilizing traditional medicines that have a long and proven history of treating various ailments. Quite a significant amount of work has been done on the pharmacological and biological activity and possible application of chemical compounds from whole part of the plant. Hence extensive investigation on its pharmacodynamics, kinetics, and proper standardization and clinical trials is needed to exploit their therapeutic utility to combat various diseases.

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