



Psidium guajava Linn: Current Research and Future Prospects

Girish Kumar Gupta*, Jagbir Chahal, Deeksha Arora

*Maharishi Markandeshwar College of Pharmacy, Mullana, Ambala, Haryana-133203

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ABSTRACT

In recent times, the use of herbal products has increased tremendously in the Western world as well as in developing countries. *Psidium guajava* L. is a medium sized tree, belonging to the family Myrtaceae found throughout the tropics. It is popular in an indigenous system of medicine like Ayurveda, Siddha, Unani and Homeopathy. Traditionally guava is used for the treatment of various ailments like diarrhoea, wounds, rheumatism, lung problems, ulcers etc. *Psidium guajava* L. contains a number of major bioactive constituents like flavonoids, guayavolic acid, guavanoic acid, guajadial, guajaverin and so many others. The present review summarises our current knowledge of major phytoconstituents, clinical studies with major emphasis on traditional and pharmacological activities. This plant reported to display various biological activities like anti-diarrhoeal, antimicrobial, antitussive, hepatoprotective, and antioxidant, anticancer and antistress activity. In view of its wide pharmacological and biological activities, it seems to be having a great therapeutic potential.

Key words: *Psidium guajava*, Myrtaceae, Traditional uses, Pharmacological activities

INTRODUCTION

Psidium guajava L. commonly known as guava, of the family Myrtaceae, is a native plant of tropical America, but now cultivated throughout the tropics. Wherever the climate is suitable the plant has become naturalized. Different parts of the plant are used in the indigenous system of medicine for the treatment of various human ailments such as wounds, ulcers, bowels and cholera.^[1] Pharmacological investigations indicated that its bark, fruit and leaves possess antibacterial, hypoglycaemic, anti-inflammatory, antipyretic, spasmolytic and central nervous system depressant activities.^[2] The synonyms of *Psidium guajava* are guava, goiaba, guayaba, goavier, perala, guave, guayave, bayabas, pichi, posh, enand. The *Psidium guajava* is found in Kingdom: Plantae, Division: Magnoliophyta, Class: Magnoliopsida, Sub class: Rosidae, Order: Myrtales, Family: Myrtaceae, Sub family: Myrtoideae, Tribe: Myrteae, Genus: Psidium and Species: guajava.^[3] *Psidium guajava* is a medium sized tree with evergreen, opposite, aromatic short-petioled leaves. The inflorescence axillary, 1-3 flowered. The bark is reddish brown, thin, smooth continuously flaking. The roots are very extensive and superficial. The fruit may be round, ovoid or pear-shaped with strong, sweet, musky odour.^[4]

HABITAT

The *Psidium guajava* L. thrives well at an altitude of 2740 m above sea level. It prefers full sun but requires at least partial sunlight. The plant grows best in average summer temperatures of over 15°C, but cannot withstand intense heat. Only light frost can be tolerated. It produces more fruit in areas with distinct winter season. The annual rainfall required is between 1000 to 20000 mm, although it is drought tolerant. Tolerates many different soil types, but prefers slightly acidic soils with good drainage. It tolerates soil pH of 4.5-9.4, but prefers a range of 5-7.^[5]

TRADITIONAL USES

The *Psidium guajava* L. is used traditionally for a number of ailments since a long time in history. The part of the plant used maximum is the leaves, and then comes the fruits, bark and then the roots. Sometimes the plant as a whole is also used for a number of reasons. Some of the traditional uses of the plant are compiled here according to the part of the plant used.

Guava leaf

The decoction or infusion of leaves is used as febrifuge, antispasmodic and for rheumatism in India.^[6] They are also used to treat diarrhoea and stomach ache in Columbia, Mexico, Maya, Nahuatl, Zapotec, USA and Mozambique. In USA, the leaves are also used as antibiotic. The leaves are used in the form of poultice or decoction for wounds, ulcers and tooth ache.^[7-9] In South Africa and Caribbean, they are used to manage diabetes and hypertension. In Latin America, Central and West Africa and South East Asia, the leaves are also used in the form of decoction

*Corresponding author.

Girish Kumar Gupta
Maharishi Markandeshwar College of Pharmacy,
Mullana, Ambala, Haryana-133203
Tel.: +91-9896188905
E-mail: girish_pharmacist92@rediffmail.com

as gargle for sore throats, laryngitis and swelling of the mouth, and it is used externally for skin ulcers, vaginal irritation and discharge.^[10-15] The leaves are used for bacterial infections, blood cleansing, diarrhea and dysentery in Trinidad. In Cook Islands, the leaves are used in sores, boils, cuts and sprains. The leaves are used in the form of boiled preparation in New Guinea, Samoa, Tonga, Niue, Futuna and Tahiti for itchy rashes caused by scabies. The leaves are also used as an astringent and also in lung problems. The *Psidium guajava* leaves are applied externally on inflammations in Panama, Cuba, Costa Rica, Mexico, Nicaragua, Venezuela Mozambique, Guatemala and Argentina. In Uruguay, a decoction of the leaves is used as a vaginal and uterine wash, especially in leucorrhoea.^[16-18]

Bark

In Philippines, the bark is used as an astringent, in the treatment of ulcers, wounds and diarrhea in the form of decoction and poultice. The bark is also used in dysentery and in bath to treat skin ailments in Panama, Bolivia and Venezuela.^[16] The bark is used as antiamebic in Kinshasa and Congo as an infusion or decoction or tisane.^[17] In Mexico, the bark along with the leaves in the form of decoction and poultice is used as a febrifuge, to expel the placenta after childbirth, in cold, cough infections of the skin, caries, vaginal hemorrhage, wounds, fever, dehydration and respiratory disturbances.^[18]

Roots

In Fiji and Senegal, the roots are used as a juice or decoction for diarrhea, coughs, stomachache, dysentery, toothaches, indigestion and constipation. In Philippines, the roots are used in the form of decoction and poultice as an astringent, in ulcers, wounds and in diarrhea.^[18]

Fruits

In Brazil and Fiji, the ripe fruits are used in anorexia, cholera, diarrhea, digestive problems, dysentery, indigestion, constipation, gastric insufficiency, inflamed mucous membranes, laryngitis, mouth (swelling), skin problems, sore throat, ulcers, vaginal discharge in the form of mashed and decoction.^[18]

Whole plant

In Tahiti and Samoa, the whole plant or shoots are used in the form of infusion, decoction and paste as a skin tonic, beneficial in painful menstruation, miscarriages, uterine bleeding, premature labour in women, wounds.^[18]

BIOLOGICAL ACTIVITIES

The *Psidium guajava* L. plant is used for a number of ailments in traditional history. Due to this widespread use of the plant traditionally, we compiled here its all reported pharmacological activities.

Antidiarrhoeal Effect

About 2.2 million people in developing countries are suffering from diarrhea.^[30] Aqueous extract of the leaves of *Psidium guajava* L. were assessed for the anti-diarrhoeal activity in male Sprague-Dawley rats with morphine as the standard

PHYTOCHEMISTRY

| PLANT PART | CONSTITUENTS | REFERENCES |
|-------------|---|---------------------------------|
| Fruits | Carbohydrates(13.2%), Fats (0.53%), Proteins(0.88%), Water content(84.9%), Macronutrients like Mn, Fe, P and Ca, S, vitamins, Cytokinins like Zeatin, Zeatin riboside, Zeatin nucleotide. Flavonoids, Saponins, Oleanolic acid, Nerolidiol, Ursolic acid, Crategolic acid, Guayavolic acid, Essential oils like β -Caryophyllene, α -pinene, 1,8-cineole, Tannins, Guavanoic acid, 2-a-hydroxy ursolic acid, lleletifol, Isoneriucoumaric acid, Guajadial, 2a-hydroxyoleanolic acid, Morin-3-O-a-L-arabopyranoside, Quercetin, hyperin, Myricetin-3-O- β -D-glucoside, Quercetin-3-O- β -D-glucuronopyranoside, 1-O-galloyl- β -D-glucose, Diguajadial | [12-16] [1,2], [17], [19-24] |
| Leaves | Ascorbic acid | [17] |
| Fruit peels | Tannins, Resin, Crystals of Calcium oxalate. | [18] |
| Bark | Tannins, Leukocyanidins, Sterols, Gallic acid, Carbohydrates and Salts. | [25] |
| Roots | Proteins, Starch oil, Phenolic and Flavonoid compounds, Linoleic acid. | [26, 27] |
| Seeds | Quercetin, Myricetin, Luteolin, Kaempferol and Apigenin. | [28] |
| Floral buds | Calcium, Magnesium, Phosphorus, Potassium, Sodium, Fluoride, | [29] |
| Twigs | Copper, Iron, Zinc, Manganese and Lead, Flavonoids, Sesquiterpene alcohols and Acid triterpenoids. | |

drug (dose: 0.2 ml/kg).^[31] Quercetin and quercetin-3-arabinoside, extracted from the buds and leaves of *Psidium guajava* L. at concentrations of 1.6 μ g/ml showed a morphine like inhibition of acetylcholine release in the coxially stimulated ileum together with an initial increase in muscular tone, followed by a gradual decrease. It is also reported that the Asiatic acid, extracted from the leaves showed dose dependent (10-500 μ g/ml) spasmolytic activity in spontaneously contracting isolated rabbit jejunum.^[32] In a study carried out with methanol extract from leaves (8 μ g/ml) of *Psidium guajava* showed activity against simian (SA-11) rotavirus 93.8% inhibition.^[33] In addition, galactose specific lectin in guava was shown to bind to *Escherichia coli* (a common diarrhea causing organism), preventing its adhesion to the intestinal wall and thus preventing infection resulting diarrhea.^[34]

Antimicrobial Activity

Different extracts of *Psidium guajava* leaves were tested for their antibacterial potential against *Staphylococcus aureus*, *Streptococcus mutans*, *Pseudomonas aeruginosa*, *Salmonella enteritidis*, *Bacillus cereus*, *Proteus spp.*, *Shigella spp.* and *Escherichia coli*, causal agent of intestinal infections in humans.^[35,36] The methanol root extract consists of quercetin and was found to be fungicidal.^[37] In another study, aqueous and methanol extracts of the leaves are found to be effective inhibitors of growth spore formation, and enterotoxin production of *Clostridium prefringens* type A.^[38] The bark tincture showed fungicidal activity at different concentrations but exhibited only fungistatic property in case of *Candida albicans*.^[39,40] The *in vitro* antibacterial activity of *Psidium guajava* L. leaf extract on *Staphylococcus aureus* was possibly due to protein degrading activity of the extracts.^[41] The active flavonoid compound –guajaverin extracted from leaves is reported to have high potential antiplaque activity.^[42,43] The aqueous extracts were more potent in inhibiting the growth of pathogenic *Proteus mirabilis*, *Streptococcus pyogenes*, *Escherichia coli*, *Staphylococcus aureus* and *Pseudomonas aeruginosa* than the organic extracts. The gram negative bacteria were less susceptible to the effects of the crude drugs.^[44] The *Psidium guajava* leaf extracts have trypanocidal activity which may be attributed mainly due to the broad antimicrobial property of the flavonoids and the iron chelating property of tannins.^[45,46] Four antibacterial compounds were isolated from the leaves of *Psidium guajava* and the flavonoids extracted from guava leaves were found to be active against the several strains of spoilage and food borne pathogenic bacteria.^[47] In a study carried out with the leaf extracts of *Psidium guajava* have shown potent antimicrobial activities against *Propionibacterium acnes* and may be beneficial in treating acne.^[48] The γ -terpinene and α -pinene obtained by hydro distillation show antimicrobial activity against *Propionibacterium acnes*. (MIC = 9.38 mg/ml)^[49]

Effect on Dental Plaque

The adhesion of early settlers of dental plaque to the tooth surface has a role in the initiation of the development of dental plaque. The treatment of the early plaque settlers with 1mg/ml aqueous extract of *Psidium guajava* L. reduced the cell surface hydrophobicity of *S. sanguinis*, *S. mitis* and *Actinomyces sp.*^[50,51]

Antimalarial / Antiparasitic Activity

The aqueous leaf, stem bark and fruit extracts of *Psidium guajava* L. were used to examine anti-plasmodial activity via *in vitro* parasite lactate dehydrogenase assay method.^[52] In another study, leaves and stem bark of *Psidium guajava* inhibited *Entamoeba histolytica* growth.^[53]

Antitussive Activity

The water infusion from *Psidium guajava* leaves decreased the frequency of

coughing induced by capsaicin aerosol as compared to the control, within 10 minutes after injection of the extract.^[54] These results suggest that guava leaf extract could be recommended as a cough remedy.

Hepatoprotective Activity

Research using a Wistar rat demonstrated that aqueous leaf extract of *Psidium guajava* is having hepatoprotective effect. The leaf extract at doses of 500 mg/kg produced significant hepatoprotection.^[55] Pretreatment with asiatic acid (a triterpenoid extracted from *Psidium guajava* L. leaves and fruit at doses of 25 mg/kg, 50 mg/kg or 100mg/kg significantly blocked the LPS (lipopolysaccharide) and (D-galactosamine) D-GalN-induced increases in both serum aspartate aminotransferase and serum alanine aminotransferase levels, showing improved nuclear condensation, ameliorated proliferation and less lipid deposition.^[56] The hepatoprotective activity of ethanol extract of *Psidium guajava* L. and the phospholipid complex of the extract was evaluated.^[57]

Antioxidant, Free Radical Scavenger and Radio protective Activities

Cellular damage or oxidative injury arising from free radicals or reactive oxygen species (ROS) now appears to be the fundamental mechanism underlying a number of infections, human neurodegenerative disorders, diabetes, inflammation, viral infections, autoimmune pathologies and digestive disorders. Free radicals are generated through normal metabolism of drugs, environmental chemicals and other xenobiotics as well as endogenous chemicals especially stress hormones.^[58] *Psidium guajava* L. has been used as health tea.^[59] Its leaf contains copious amounts of phenolic phytochemicals which inhibit peroxidation reaction in the living body, and therefore, can be expected to prevent various chronic diseases such as diabetes, cancer and heart diseases.^[60] The decrease of free radicals have antioxidising effect in the body, meaning that the guava leaf polyphenols can prevent arterial sclerosis, thrombosis, cataract and inhibit senescence of the body and skin.^[61] In another study, the antioxidant activity of lyophilized leaf extracts was determined using free radical DPHH (2,2-diphenyl-1-picrylhydrazyl) scavenging. The results obtained showed that ascorbic acid was a substantially more powerful antioxidant than the extracts from guava leaf.^[62] These antioxidant properties are associated with its phenolic compounds such as protocatechonic acid, ferulic acid, quercetin and guavin B,^[63] ascorbic acid, gallic acid and caffeic acid.^[64] Guava leaf extracts and fruits are a potential source of natural antioxidants.^[65] Several studies revealed that guava fruits also exert antioxidant action, collagen formation and radio protective activity in the assay with technetium-99m.^[66]

Antigenotoxic and Antimutagenic Effects

Generation of DNA damage is considered to be an important initial event in carcinogenesis. A considerable number of assays exist for the detection of different genotoxic effects of compounds in experimental systems, or for investigations of exposure to genotoxic agents in environmental or occupational settings. Treatment with an aqueous whole plant extracts of *Psidium guajava* L. afforded protection.^[67] Detailed studies have revealed that pre-treatment with an aqueous guava leaf extract was found to be effective in inactivating the mutagenicity of direct acting mutagens 4-nitro-*o*-phenylenediamine and 2-aminofluorine in the tester strains of *Salmonella typhimurium*. Therefore results showed promising antigenotoxic/antimutagenic activity.^[68] Gallocatechin isolated from the methanol extract of guava leaf also showed antimutagenic activity against *E.coli*.^[69]

Anti-allergic Effects

Apart from these above mentioned activities *Psidium guajava* also showed anti-allergic effects. An aqueous and methanolic extract of *Psidium guajava* L. were reported to cause potent inhibition of histamine release from mast cells. *Psidium guajava* L. leaf extracts also showed anti-allergic activity on T cell immunity in mice.^[70]

Anticancer Effects

Some recent reports have indicated that *Psidium guajava* possess anticancer activity. An aqueous extract of *Psidium guajava* leaves inhibited the viability of the cancer cell line DU-145 in a dose dependent manner. At 1.0 mg/ml, the extract reduced the viability of Pca DU-145 (the androgen independent Pca cells) to 36.1% and 3.6%, respectively after 48h and 72h of incubations.^[71] Essential oil extracted from leaves of *Psidium guajava* L. was highly effective in reducing the growth of human mouth epidermal carcinoma (KB) and murine leukemia (P388). Guava leaf oil showed the highest antiproliferative activity with an IC50 value of 0.0379mg/ml (four times more potent than vincristine) on P388 cell lines.^[72,73] A chemopreventive effect was also demonstrated in another study of a methanol leaf extract on mice, in case of induced cancer inoculated with B16 melanoma cells. The jacoumaric acid (isolated from guava seeds) was evaluated for its antitumor effect; it was found to significantly reduce the incidence of tumors.^[74] Phytochemical investigations of an acetone extract of *Psidium guajava* seeds has

led to the isolation of phenyl-ethanoid glycosides(1-O-3,4-dimethoxy-phenylethyl-4-O-3,4-dimethoxycinnamoyl-6-O-cinnamoyl-beta-D glucopyranose and 1-O-3,4-dimethoxy-phenylethyl-4-O-3,4-dimethoxy cinnamoyl-6-O-cinnamoyl-beta-D-glucopyranose) which showed cytotoxic activities *in vitro* against Ehrlich Ascites Cells(EAC) and leukaemia P3888 cells.^[75] These findings suggested that *Psidium guajava* L. extracts have the potential to be developed as new chemotherapeutic agent to prevent or to inhibit the growth of tumours and cancers.

Cardiovascular System Effects

Psidium guajava has been reported to have action on the heart. In a study of an aqueous leaf extract, *Psidium guajava* L. exhibited cardioprotective effects against myocardial ischaemia-reperfusion injury in isolated rat hearts. Ojewole, (2005) showed that an aqueous leaf extract caused hypotension in the experimental animal model used via cholinergic mechanisms. The acute intravenous administrations of the leaf extract produced dose dependent, significant reductions in systemic arterial blood pressures and heart rates of hypertensive. Belemtougri *et al* (2006) found that an aqueous and ethanolic leaf extracts of *Psidium guajava* L. inhibits intracellular calcium release.^[76-78] An Aqueous leaf extract of *Psidium guajava* L. significantly and dose-dependently (0.25-2mg/ml) contracted the aorta rings. The sensitivity of the aortic rings to cumulative doses of *Psidium guajava* L. was significantly enhanced in the presence of phentolamine suggesting that the effect of *Psidium guajava* L. was to a large extent mediated by activation of an alpha-adrenoceptor and to a lesser extent by activating via calcium ion channels.^[79] The antihypertensive effect was also observed on the pink guava puree.^[80]

Antihyperglycemic Activity

The rapidly increasing diabetes mellitus is becoming a serious threat to human health in all parts of the world. With the distinctive traditional medical opinions and natural medicines mainly originated in herbs, traditional medicine offers good clinical opportunities and shows a bright future in the therapy of diabetes mellitus and its complications. During various episodes of screening of medicinal plant extract from *Psidium guajava*, it exhibited anti-diabetic effect.^[81] The decoction of leaves was screened for hypoglycaemic activity in alloxan induced diabetic rats. In both acute and sub acute tests, the extract showed statistically significant hypoglycaemic activity.^[82] Apart from these the treatment with *Psidium guajava* L. aqueous leaf extract (0.01-0.625 mg/ml) also showed significant inhibition on LDL glycation in a dose-dependent manner. Tannins, flavonoids, pentacyclic triterpenoids, guajaverin, quercetin and other chemical compounds present are speculated to account for the observed hypoglycaemic and hypotensive effects of the leaf extract.^[83,84] Whatever the case may be, the undisputable truth is that this subject requires further investigations. *Psidium guajava* is an excellent anti-LDL glycative agent whose potential therapeutic uses can be extended to the prevention of a variety of cardiovascular and neurodegenerative diseases associated with glycations.^[85] Some investigators suggested that the hypoglycaemic components of guava fruits might involve ursolic acid, oleanolic acid, arjunolic acid and glucuronic acid.^[86] The antiglycation activities of guava fruit were relevantly and directly related to its polyphenolic content (extractable polyphenols 2.62-7.79%), yet it seemed to us that fruit of *Psidium guajava* L. also possess specific and somewhat different degree of free radical scavenging ability.^[87] Anti LDL glycative agents were investigated using an aqueous extract of *Psidium guajava* and was found potential antiglycative agent.^[88]

Effect on Muscular System

Degenerative muscular diseases such as muscular dystrophy have been the target of regenerative cell therapy. Although satellite cells play central role in skeletal muscle regeneration that occur intrinsically after muscle injury, their application to cell therapy is confronted with difficulties.^[89] Water and methanolic leaf extracts from *Psidium guajava* L. showed antagonistic effects on caffeine induced calcium release from the sarcoplasmic reticulum of rat skeletal muscle cells in a dose-dependent-manner showed a clear calcium antagonistic effect. An aqueous leaf infusion of *Psidium guajava* could block the L-type calcium membrane channels. Guava may therefore be beneficial for patients with muscular dystrophy.^[90]

Anti-inflammatory / Analgesic / Antinociceptive Effect

A decoction of *Psidium guajava* L. leaves was used worldwide for the treatment of various inflammatory ailments including rheumatism. The anti-inflammatory property of an aqueous leaf extract was investigated in rats, using fresh egg albumin induced paw edema, while the analgesic effect of the plant extract was evaluated by the hot plate and acetic acid test models of pain in mice.^[91] An anti-inflammatory and analgesic activities of 70% ethanol extract of leaves were also investigated in rats. Extracts which exhibited an anti-inflammatory activity were

screened for analgesic activity using the Randall-Selitto method in rats. *Psidium guajava* L. leaves showed significant anti-inflammatory activity at a dose of 300 mg/kg, p.o. with an inhibition of 58%. The essential oil 0.8 mg/kg significantly reduced edema formation induced by carrageenan while at 0.4 mg/kg and 0.8 mg/kg the oil also significantly reduced granuloma formation induced by cotton pellets.^[92-96] The hexane, ethyl acetate and methanol extracts of *Psidium guajava* L. leaves exhibited most antinociceptive effects in chemical and thermal tests of analgesia. The extracts also produced dose-dependent prolongation of pentobarbitone-induced sleeping time.^[97] It was also reported in another study that the leaf essential oil from *Psidium guajava* L. and its constituent, α -pinene produced a significant antinociceptive effect in the formalin test probably mediated by endogenously released adenosine.^[98]

Central Nervous System Related Activity

The sesquiterpenes isolated from hexane extract of *Psidium guajava* leaves have depressant activities in mice. The relaxant properties of the *Psidium guajava* L. hexane extract are largely due to the presence of terpenes, especially caryophyllene-oxide and β -selinene, which potentiated pentobarbital sleeping time and the latency of convulsions induced by leptazol in mice.^[99]

Wound Healing

The wound healing properties of a methanol leaf extract of *Psidium guajava* L. were determined using the excision wound model. More than 90% wound healing was observed after 14 days post-surgery, whereas 72% healing was observed in the distilled water treated group.^[127]

Antistress Activity

An ethanolic extract of the *Psidium guajava* L. were investigated for anoxia stress tolerance test and swimming endurance test in Swiss mice and showed significant adaptogenic activity against the stress models.^[102]

TOXICOLOGY

The toxicology study was performed on the leaves of *Psidium guajava* L. calculating mean lethal dose in Swiss mice and alternative toxicology in Wistar rats. No deaths were observed in the toxicological results of the two experimental models in the dose range using up to 2g/kg body weight. Acute toxicity tests in rats and mice have proven the LD50 of guava leaf extracts to be more than 5g/kg.^[18]

CLINICAL TRIALS

The clinical trials of *Psidium guajava* were performed for various activities like cardiovascular effects, infantile rotaviral enteritis, infectious gastroenteritis, hypoglycaemic effect and dysmenorrhoea. The phytodrug based on *P.guajava* folia, produced a useful and most-likely spasmolytic effect, clearly recognised in the group under treatment and that decreased the duration of abdominal pain, this although no significant changes were detected in the consistency and frequency of liquid stools compared with the control group. The clinical trial on the efficacy of a chemically standardised extract from *Psidium guajava* showed a decrease in intensity of menstrual pain during each treatment cycle compared with baseline, the difference was not statistically significant.^[103-107] A double-blind clinical study also done to investigate the effect of a Phytodrug (QG-5) developed from guava leaf showed decrease in duration of abdominal pain, which is attributed to antispasmodic effect of quercetin present in the leaf extract.^[108,109]

CONCLUSION

In a decade of extensive research, great progress has been achieved in the discovery of potential pharmacological agents from natural sources. A number of natural products have been used as lead compounds because of its specific activity and low toxicity. This review presented numerous evidences of its strong antidiarrhoeal, antimicrobial, antioxidant and other so many activities. *Psidium guajava* L. has received much attention in the literature over the past 10 years and a variety of potential beneficial effects have been elucidated. The fruit as well as its juice is freely consumed for its great taste and nutritional benefits however, it is imperative that more clinical and pharmacological studies should be conducted to investigate the unexploited potential of this plant.

REFERENCES

1. Begum S, Hassan SI, Siddiqui BS, Two new triterpenoids from the leaves from *Psidium guajava*, *Phytochemistry*, 2002, 61, 399-403.
2. Begum S, Hassan SI, Siddiqui BS, Two new triterpenoids from the fresh leaves of *Psidium guajava*, *Planta medica*, 2002, 68, 1149-1152.
3. Ahmed SS, Introduction *Psidium guajava*, Screening of edible plants for Urease inhibitors and chemical structures of the inhibitors, 2010, 24.
4. Morton J, Miami FL, Guava In: Fruits of warm climates 1987, 356-363.
5. Weber E, Invasive plant Species of the world: A reference guide to Environmental weeds, CAB International, Wallingford, UK, 2003.
6. Hernandez DF, Plants of the Philippines, M&L Licudine Enterprises, First Printing Philippines,

- University of the Philippines, Chairman, Consuelo, 1971, 678-680.
7. Pontikis C, Psidium guajava L. Guava, Biotechnology in Agriculture and Forestry, 1996, 35, 309-319.
 8. Heinrich M. Plants as anti-diarrhoeals in medicine and diet. In: Proceedings from a Joint Meeting of the Society for Economic Botany and the International Society London, Royal Botanic Gardens, Kew, UK, 1998, 17-30.
 9. Leonti M, Vibrans H, Sticher O, Heinrich M, Ethnopharmacology of the Popoloca, Mexico: an evaluation, Journal of Pharmacy and Pharmacology, 2001, 53, 1653-1669.
 10. Oh WK et al., Antidiabetic effects of extracts from Psidium guajava, Journal of Ethnopharmacology, 2005, 96, 3, 411-415.
 11. Ojewole JA, Hypoglycemic and hypotensive effects of Psidium guajava Linn (Myrtaceae) leaf aqueous extract, Methods and Findings in Experimental and Clinical Pharmacology, 2005, 27, 689-695.
 12. Rouseff RL, Onagbola EO, Smoot JM, Stelinski LL, Sulfur volatiles in Guava (Psidium guajava L.) leaves: Possible Defense mechanism, Journal of Agricultural and Food Chemistry, 2008, 56, 8905-8910.
 13. Yang XL, Hsieh KL, Liu JK, Guajadial: An unusual monoterpenoid from guava leaves, Organic Letters, 2007, 9, 24, 5135-5138.
 14. Idstein H, Schreier P, Volatile constituents from guava (Psidium guajava L.) fruit, Journal of Agricultural and Food Chemistry, 1985, 33, 1, 138-143.
 15. Nagar PK, Rao Raja T, Studies on endogenous cytokinins in Guava (Psidium guajava L.) Annals of Botany, 1981, 48, 845-852.
 16. Conway P, Tree Medicine: A Comprehensive Guide to the Healing Power of Over170 Trees, Judy Piatkus (Publishers) Ltd, 2002, 2173-2177.
 17. Geidam YA, Ambali AG, Onyeyili PA, Preliminary Phytochemical and Antibacterial Evaluation of crude aqueous extract of Psidium guajava leaf, Journal of Applied Sciences, 2007, 7, 4, 511-514.
 18. Rosa M, Perez G, Sylvia M, Rosario VS, Psidium guajava: A Review of its traditional uses, phytochemistry and pharmacology, Journal of Ethnopharmacology, 2008, 117, 1-27.
 19. Sofahy SM, Metwalli AM, Harraz FM, Omar AA, Quantification of flavonoids of Psidium guajava L. preparations by planar chromatography, Phcog Magazine, 2009, 5, 61-66.
 20. Zhongguo ZY, Studies on chemical constituents of leaves of Psidium Guajava, Medline, 2009, Mar, 34, 5, 577-579.
 21. Yang XL, Hsieh KL, Liu JK, Diguajadial: A dimer of the monoterpenoid from the leaves of Psidium guajava (Guava), Chinese Journal of Natural Medicines, 2008, 6, 5, 333-335.
 22. Cybele E, Almeida MG, Kamikowski RF, Baldissierotto B, Analysis of anti-diarrhoeic effect of plants used in popular medicine, Revista de Saude Publica, 1995, 29, 56-59.
 23. Zakaria MM, Traditional Malay medicinal plants, Penerbit Fajar Bakti Sudan Berhad, 1994, 129-132.
 24. Arima H, Danno G, Isolation of antimicrobial compounds from guava (Psidium guajava L.) Bioscience, Biotechnology and Biochemistry, 2002, 66, 1727-1730.
 25. Quisumbing E, Medicinal plants of the Philippines, Katha publishing Company JMC Press Quezon City, Philippines, 1978, 321-324.
 26. Prasad NBL, Azeemuddin G, Characteristics and composition of guava (Psidium guajava L.) seed and oil, Journal of the American Oil Chemists Society, 1994, 71, 4, 457-458.
 27. Michael HN, Salib JY, Acylated flavonol glycoside from Psidium guajava L., Seeds, Pharmacy, 2002, 47, 145-151.
 28. Dolores VA et al., Kinetics of accumulation and distribution of flavonoids in guava (Psidium guajava), Agrobiencia, 2006, 40, 109-115.
 29. Okwu DE, Ekeke O, Phytochemical screening and mineral composition of chewing sticks in South Eastern Nigeria, Global Journal of Pure and Applied Sciences, 2003, 9, 235-238.
 30. Tona L, Kambu K, Mesia K, Cimanga K, Vlietinck AJ, Antiamoebic and Phytochemical Screening of traditional preparations from some medicinal plants used as anti-diarrhoeal in Kinshala, Cong, Phytomedicine, 1998, 6, 59-66.
 31. Lutterodt GD, Inhibition of Microlox induced experimental diarrhoea with narcotic like extracts of Psidium guajava leaf in rats, Journal of Ethnopharmacology, 1992, 37, 151-157.
 32. Zhang WJ, Chen BT, Wang CY, Zhu QH, Mechanism of quercetin as an anti-diarrhoeic agent, Di Yi Jun Yi Xue Xue Bao, 2003, 23, 1029-1031.
 33. Goncalves JL et al., In vitro anti-rotavirus activity of some medicinal plants used in Brazil against diarrhoea, Journal of Ethnopharmacology, 2005, 99, 403-407.
 34. Rocio CR, Pedro HC, Hector GR, Lectins in fruits having gastrointestinal activity: their participation in the hemagglutinating property of Escherichia coli O157:H7, Archives of Medical Research, 2001, 32, 251-257.
 35. Chah KF, Eze CA, Emuelosi CE, Esimone CO, Antibacterial and wound healing properties of methanolic extracts of some Nigerian medicinal plants, Journal of Ethnopharmacology, 2006, 104, 164-167.
 36. Nair R, Chanda S, In-vitro antimicrobial activity of Psidium guajava L. Leaf extracts against clinically important pathogenic microbial strains, Brazilian Journal of Microbiology, 2007, 38, 452-458.
 37. Prabu GR, Gnanamani A, Sadulla S, Guajaverin a plant flavonoid as potential antiplaque agent against Streptococcus mutans, Journal of Applied Microbiology, 2006, 101, 487-495.
 38. Garcia S, Araiza M, Gomez M, Heredia N, Inhibition of growth, enterotoxin production, and spore formation of Clostridium perfringens perfringens by extracts of medicinal plants, Journal of Food Protection, 2002, 65, 1667-1669.
 39. Dutta BK, Das TK, In vitro study on antifungal property of common fruit plants, Biomedicine, 2000, 20, 187-189.
 40. Estrada-Luna AA, Davies FT, Egilla JN, Mycorrhizal fungi enhancement of growth and gas exchange of micropropagated guava plantlets (Psidium guajava L.) during ex vitro acclimatization and plant establishment, Mycorrhiza, 2000, 10, 1-8.
 41. Belemtougri RG, Constantin B, Cognard C, Raymond G, Sawadogo L, Effects of two medicinal plants Psidium guajava L. (Myrtaceae) and Diospyros mespiliformis L. (Ebenaceae) leaf extracts on rat skeletal muscle cells in primary culture, Journal of Zhejiang University Science, 2006, 7, 56-63.
 42. Brotz-Oesterhelt H et al., Dysregulation of bacterial proteolytic machinery by a new class of antibiotics, Nature Medicine, 2005, 11, 1082.
 43. Limsong J, Benjavong Kulchai E, Kuvataanasuchati J, Inhibitory effects of some herbal extracts on adherence of S. mutans, Journal of Ethnopharmacology, 2004, 92, 2-3, 281-289.
 44. Abubakar EM, The use of Psidium guajava L. in treating wound, skin and soft tissue infections, Scientific Research and Essay, 6, 2009, 605-611.
 45. Adeyemi, Stephen O, Akanji AM, Oguntayo SA, Ethanolic leaf extract of Psidium guajava: Phytochemical and trypanocidal activity in rats infected with Trypanosoma brucei brucei, Journal of Medicinal Plants Research, 2009, 3, 5, 420-423.
 46. Pongsak R, Parichat P, Contents and antibacterial activity of flavonoids extracted from leaves of Psidium guajava, Journal of Medicinal Plants Research, 2010, 4, 5, 393-396.
 47. Akangi MA, Adeyemi OS, Oguntayo SO, Sulyman F, Psidium guajava extract reduces trypanosomiasis associated lipid peroxidation and raises glutathione concentrations in infected animals, EXCLI Journal, 2009, 8, 148-154.
 48. Qadan F, Thewaini AJ, Ali DA, Afifi R, Elkhawad A, Matalka KZ, The antimicrobial activities of Psidium guajava and Juglans regia leaf extracts to acne developing organisms, American Chinese Medical, 2005, 33, 197-204.
 49. Athikomkulchai S et al., The development of anti-acne products from Eucalyptus globulus and Psidium guajava oil, Journal of Health Research, 2008, 22, 3, 109-113.
 50. Razak FA, Othman RY, Rahim ZH, The effect of Piper betle and Psidium guajava extracts on the cell surface hydrophobicity of selected early settlers of dental plaque, Journal of Oral Science, 2006, 48, 71-75.
 51. Fathilah AR, Rahim ZH, Oathman Y, Yusoff M, Bacteriostatic effect of Piper betle and Psidium guajava extracts on dental plaque and bacteria, Pakistan Journal of Biological Sciences, 2009, 12, 6, 518-521.
 52. Ponce MM, Navarro AI, Martinez GMN, Alvarez CR, In vitro effect against Giardia of 14 plant extracts, Revista de Investigacion Clinica, 1994, 46, 343-347.
 53. Nundkumar N, Ojewole JA, Studies on the antiparasmodial properties of some South African medicinal plants used as antimalarial remedies in Zulu folk medicine. Methods and findings in Experimental and Clinical Pharmacology, 2002, 24, 397-401.
 54. Jaiar P et al., Anticough and antimicrobial activities of Psidium guajava Linn Leaf extract, Journal of Ethnopharmacology, 1999, 67, 203-212.
 55. Roy CK, Kamath JV, Asad M, Hepatoprotective activity of Psidium guajava Linn., Indian Journal of Experimental Biology, 2006, 44, 305-311.
 56. Gao J, Chen J, Tang X, Pan L, Zhao L, Xu Q, Mechanism underlying mitochondrial protection of asiatic acid against hepatotoxicity in mice, Journal of Pharmacy and Pharmacology, 2006, 58, 227-233.
 57. Priscilla DM, Milan R, Hepatoprotective activity of Psidium guajava extract and its phospholipid complex in paracetamol induced hepatic damage in rats, International Journal of Phytomedicine, 2010, 2, 85-93.
 58. Masuda T et al., Evaluation of the antioxidant activity of the Environmental plants: Activity of the leaf extracts from the sea shore plants, Journal of Agricultural and Food Chemistry, 2003, 51, 1831-1838.
 59. Antonio J, Mariela R, Raquel P, Fulgencio Saura-Calixto, Guava fruit (Psidium guajava L.) as a new source of antioxidant dietary fibre, Journal of Agricultural and Food Chemistry, 2001, 49, 11, 5489-5493.
 60. Kimura S, Tamaki T, Aoki N, Acceleration of fibrinolysis by the N-terminal peptide of alpha 2-plasmin inhibitor, American Society of Hematology, 1985, 66, 1, 157-160.
 61. Okuda T et al., Ellagitannins of the casuarinaceae, stachyuraceae and myrtaceae, Phytochemistry, 1982, 21, 12, 2871-2874.
 62. Qian H, Nihorimbere V, Antioxidant power of phytochemicals from Psidium guajava Leaf, Journal of Zhejiang University Science-A, 2004, 5, 676-683.
 63. Thaipong K, Boonprakob U, Cisneros-Zevallos L, Byrne DH, Hydrophilic and lipophilic antioxidant activities of guava fruits, Southeast Asian Journal of Tropical Medicine Public Health, 2005, 36, 254-257.
 64. Jimenez EA, Rincon M, Pulido R, Saura CF, Guava fruit(s) as a new source of antioxidant dietary fibre, Journal of Agricultural and Food Chemistry, 2001, 49, 49, 5489-5493.
 65. Yan LY, Teng LT, Jhi TJ, Antioxidant properties of guava fruit: Comparison with some local fruits, Sunway Academic Journal, 2006, 3, 9-20.
 66. Abreu PR et al., Guava extract (Psidium guajava) alters the labelling of blood constituents with technetium-99m, Journal of Zhejiang University Science - B, 2006, 7, 429-435.
 67. Bartolome A et al., SOS-red fluorescent protein (RFP) bioassay system for monitoring of antigenotoxic in plant extracts, Biosensors and Bioelectronics, 2006, 21, 2114-2120.
 68. Grover IS, Bala S, Studies on antimutagenic effects of guava (Psidium guajava) in Salmonella typhimurium, Mutation Research, 1993, 300, 1-3.
 69. Matsuo N, Hanamura, Koyoko SY, Nakamura, Tomita I, Identification of (+) galloocatechin as a bio-mutagenic compound in Psidium guajava leaves, Phytochemistry, 36, 4, 1994, 1027-1029.
 70. Seo N et al., Antiallergic Psidium guajava extracts exert an anti-tumor effect inhibition of T regulatory cells and resultant augmentation of Th1 cells, Anticancer Research, 2005, 25, 3763-3770.
 71. Chen KC et al., Brain derived prostate cancer DU-145 cells are effectively inhibited in vitro by guava leaf extracts, Nutrition and Cancer, 2007, 58, 93-106.
 72. Chen KC et al., Action mechanism and signal pathways of Psidium guajava L. Aqueous extract in killing prostate cancer LNCap cells, Nutrition and Cancer, 2010, 62, 2, 260-270.
 73. Manosroi J, Dhumtanom P, Manosroi A, Antiproliferative activity of essential oil extracted from Thai medicinal plants on KB and P388 cell lines, Cancer Letter, 2006, 235, 114-120.
 74. Numata A et al., Cytotoxic triterpenes from Chinese medicine, Goresi, Chemical and Pharmaceutical Bulletin, 1989, 37, 648-651.
 75. Salib JY, Michael HN, Cytotoxic phenylethanol glycosides from Psidium guajava seeds, Phytochemistry, 2004, 65, 2091-2093.
 76. Yamashiro S et al., Cardioprotective effects of extracts from Psidium guajava L. and Limonium wrightii, Okinawan medicinal plants, against ischaemia-reperfusion injury in perfused rat hearts, International Journal of Experimental and Clinical Pharmacology, 2003, 67, 128-135.
 77. Chiesi M, Schwaller R, Reversal of phospholamban-induced inhibition of cardiac sarcoplasmic reticulum Ca-ATPase by tannin, Biochemical and Biophysical Research Communications, 1994, 202, 1668-1673.
 78. Apisariyakul A, Chaichana N, Takemura H, Dual effects of quercetin on contraction in cardiac and skeletal muscle preparations, Research Communications in Molecular Pathology and Pharmacology, 1999, 105, 129-138.
 79. Olatunji BI, Oduyanya AJ, Raji I, Ladipo CO, Contractile effect of the aqueous extract of Psidium guajava leaves on aortic rings in rat, Fitoterapia, 2007, 78, 241-243.
 80. Ayub MY, Norazmir MN, Mamot S, Jeeven K, Hadjah H, Antihypertensive effect of pink guava (Psidium guajava) puree on spontaneous hypertensive rats, International Food Research Journal, 2010, 17, 89-96.
 81. Rai PK, Singh SK, Kesari AN, Watal Geeta, Glycaemic evaluation of Psidium guajava in rats, Indian Journal of Medical Research, 2007, 126, 3, 224-227.
 82. Mukhtar HM, Ansari SH, Bhat MA, Naved T, Bhat ZA, Effect of water extract of Psidium guajava on alloxan-induced diabetic rats, Pharmazie, 2004, 59, 734-735.
 83. Wang B, Liu HC, Ju CY, Study on the hypoglycaemic activity of different extracts of wild Psidium guajava leaves in Panzhihua area, Sichuan Da Xue Xue Bao Yi Xue Ban, 2005, 36, 858-861.
 84. Chen KC et al., The polyphenolics in the aqueous extract of Psidium guajava kinetically reveal an inhibition model on LDL glycation, Pharmaceutical Biology, 2010, 48, 1, 23-31.
 85. Hsieh CL et al., Kinetic analysis on the sensitivity of glucose- or glyoxal-induced LDL glycation to the inhibitory effect of Psidium guajava extract in a physiologic system, Biosystems, 2007, 88, 92-100.
 86. Cheng JT, Yang RS, Hypoglycaemic effect of guava juice in mice and human subject, American Journal of Chinese Medicine, 1983, 11, 74-76.
 87. Liu CH et al., Polyphenolics-rich Psidium guajava Budding Leaf extracts can reverse Diabetes-induced functional impairment of cavernosal smooth muscle relaxation in rats, Research Journal of Medical Sciences, 2010, 4, 1, 25-32.
 88. Hsieh CL et al., Inhibitory effect of some selected nutraceutical herbs on LDL glycation induced by glucose and glyoxal, Journal of Ethnopharmacology, 2005, 102, 357-363.
 89. Endo T, Stem cells and plasticity of skeletal muscle cell differentiation: potential application to cell therapy for degenerative muscular diseases, Regenerative Medicine, 2007, 2, 243-256.
 90. Lamb GD, Excitation-contraction coupling in skeletal muscle: comparison with cardiac muscle, Clinical Experimental Pharmacology and Physiology, 2000, 27, 216-224.
 91. Ojewole JA, Antiinflammatory and analgesic effects of Psidium guajava Linn. Leaf aqueous extract in rats and mice, Methods and findings in Experimental and Clinical Pharmacology, 2006.
 92. Kavimani S, Karagam RI, Jayka B, Anti-inflammatory activity of volatile oil of Psidium guajava, Indian Journal of Pharmaceutical Sciences, 1997, 59, 142-144.
 93. Olajide OA, Awe SO, Makinde JM, Pharmacological studies on the leaf of Psidium guajava,

- Fitoterapia, 1999, 70, 25-31.
94. Winter CA, Riskey EA, Nuss GW, Carageenan-induced oedema in hind paw of the rat as an assay for anti-inflammatory drugs, *Proceedings of the Society for Experimental Biology and Medicine*, 1962, 111, 544.
95. Hess SM, Milong RC, Lepow IH, Ward PA, *Inflammation, mechanisms and Control*, New York: Academic Press, 1972, 1-12.
96. Koster R, Anderson M, De Beer EJ, *Fed Proc Beer EJ Fed Proc*, 1959, 18, 412.
97. Shaheen HM, Ali BH, Algarawi AA, Bashir AK, Effect of *Psidium guajava* leaves on some aspects of the central nervous system in mice, *Phytotherapy Research*, 2000, 14, 107 -111.
98. Santos FA, Rao VS, Silveira ER, Investigations on the antinociceptive effect of *Psidium guajava* leaf essential oil and its major constituents, *Phytotherapy Research*, 1998, 12, 24-27.
99. Meckes M, Calzada F, Tortoriello J, Gonzalez JL, Martinez M, Terpenoids isolated from *Psidium guajava* with depressant activity on central nervous system, *Phytotherapy Research*, 1996, 10, 600-603.
100. Lakshmi BVS, Sudhakar M, Screening of *Psidium guajava* leaf extracts for antistress activity in different animal models, *Pharmacognosy Research*, 2009, 1, 1, 6, 359- 366.
101. Wei LZ, Chen B, Clinical study on treatment of infantile rotaviral enteritis with *Psidium guajava* L, 2000, 20, 893-895.
102. Lozoya X et al., Intestinal anti-spasmodic effect of a phytodrug of *Psidium guajava* folia in the treatment of acute diarrheic disease, *Journal of Ethnopharmacology*, 2002, 83, 19-24.
103. Echemendia CE, Moron RFJ, Tinture of Leaves of *Psidium guajava* L., in patient with common acute diarrhoea, *Revista Cubana de Plantas Medicinales*, 2004, 9, 340-356.
104. Singh RB, Rastogi SS, Singh R, Ghosh S, Niaz MA, Effects of guava intake on serum total high-intensity lipoprotein cholesterol levels and on systemic blood pressure, *American Journal of Cardiology*, 1992, 70, 1287-1291.
105. Vladislavovna SD et al., Effect of *Psidium guajavae* folium extract in the treatment of primary dysmenorrhoea: a randomised clinical trial, *Journal of Ethnopharmacology*, 2007, 110, 305-310.
106. Yusof RM, Said M, Effect of high fibre fruit (*Guava-Psidium guajava* L.) on the serum glucose level in induced diabetic mice, *Asia Pacific Journal Clinical Nutrition*, 2004, 13, 135.
107. Chiwororo witness DH, Ojewole JAO, *Journal of Smooth Muscle Research*, 2009, 45, 1, 31-38.
108. Akah PA et al., Studies on the gastrointestinal properties of *Ficus exasperata*, *Fitoterapia*, 1997, 68, 17.
109. Lutterodt GD et al., Inhibition of gastrointestinal release of acetylcholine by quercetin as a possible mode of action of *Psidium guajava* leaf extracts in the treatment of acute diarrhoeal disease, *Journal of Ethnopharmacology*, 25, 3, 1989, 235-247.

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