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Pharmacological Properties of Guava (*Psidium guajava* L.): An Overview

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ABSTRACT

Psidium guajava L. is an important crop plant belonging to the family Myrtaceae, commonly known as guava. *P. guajava* fruit is considered a poor man's apple due to its immense nutritious properties and wide distribution in tropical and sub-tropical countries around the world. Different parts of the plant have been used for the treatment of myriad ailments since ancient times in different parts of the world, including Latin America, Africa, China and India. Traditionally the plant is known for the treatment of diseases like diabetes, dysentery, diarrhoea, gastroenteritis, hypertension, wounds, reducing fever and pain, etc. Recent pharmacological studies support a wide variety of its pharmacological properties, including anti-diarrhoeal, anti-inflammatory, anti-microbial, hypoglycaemic, hepatoprotective, antioxidant, anti-cancerous, etc. While some pharmacological properties have been studied for decades leading to clinical trials, some studies are at a preliminary stage limited to *in vitro* and few *in vivo* studies. This review is aimed at recent developments on the pharmacological properties of P. guajava plant and its future prospects in the field ofdrug development. *P. guajava*.

Keywords: *Anti-Diabetic; Anti-Diarrheal; Anti-Microbial; Anti-Oxidant; Pharmacological Property; Psidium Guajava*

Introduction

Psidium guajava L. (Family: Myrtaceae), commonly known as guava for its nutritious fruits, is widely distributed and consumed throughout the world in tropical and sub-tropical areas. Botanically, the plant can be described as a dicotyledonous small tree with opposite and entire leaves. Flowers are white in colour, large, solitary, with 4 to 5 sepals, connate in bud stage in an urceolate or ovate calyx with valvate aestivation. Corolla is white in colour, consisting of 4 to 5 free petals. Stamens are many in number, inserted in several series on a wide disc, ovary is inferior with numerous ovules. Fruit is globose, ovoid or pyriform berry with persistent calyx (Fig. 1). Numerous seeds with hard testa are present in the fruit pulp (Prain, 1908).

Guava is considered a poor man's apple due to its immense nutritional value, delicious taste and traditional therapeutic use in tropical and sub-tropical nations (Anand *et al.*, 2016). The species *P. guajava* can grow in various soil types and adapt to dry as well as humid environmental conditions. The adaptability and resilience of the plant species have contributed to widespread cultivation around the world. Countries including China,

India, Mexico, Brazil, Thailand and Indonesia lead global production of guava. Apart from the utilisation of fruits of *P. guajava* as food, different countries, including Latin America, China, India, Africa and many more countries, have been utilising different parts of the plant species, including leaves, bark, seeds and roots, for treatment of numerous diseases, including diabetes, cough, dental problems, pain management, amenorrhoea, hepatic diseases, microbial infection, etc. (Barbalho *et al*., 2012). Several parts of the plant *P. guajava* including leaves, stem bark, fruit pulp, seeds and fruit peels, are known to produce myriad phytochemicals. Pharmacological investigations have confirmed several biological activities in the plant extracts and its important secondary metabolites. This review is aimed at recent developments on the pharmacological properties of *P. guajava* plant and its future prospects in the field of drug development.

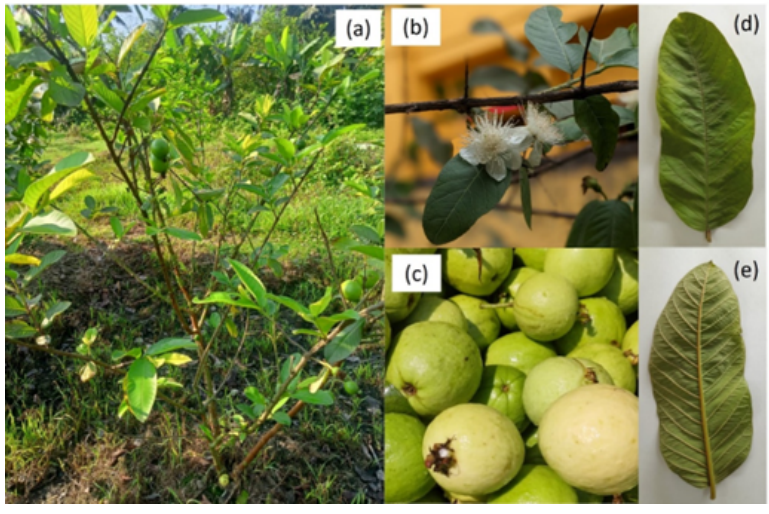

Figure 1. (a) Plant body, (b) Flower, (c) Fruits, (d,e) Single leaf (dorsal surface) and (ventral surface) respectively of Psidium guajava L. (Myrtaceae).

Phytochemical Profile

Qualitative phytochemical analyses have shown a wide array of secondary metabolites present in the different parts of *P. guajava*, mainly in the leaves and barks of the plant in addition to its fruit. Leaf extracts of guava plant are reported to show the presence of different alkaloids, anthraquinones, cardiac glycosides, flavonoids, glycosides, phytosteroids, polyphenols, saponins, steroids, tannins and terpenoids (Barbalho et al., 2012; Porwal, Singh & Gurjar, 2012; Krishnarathi, Issac & Kannan, 2014; Thenmozhi & Rajan, 2015; Oncho, Ejigu & Urgessa, 2021; Adamu, 2021). The major bioactive compound identified in the leaves is the phenolic compound quercetin. Other bioactive compounds reported in leaf extracts of *P. guajava* include catechin, epicatechin, gallic acid, rutin, avicularin, isoquercitrin, apigenin, guaijaverin, kaempferol, hyperin, and myricetin (Wang, Du & Song, 2010; Liu *et al*., 2014; Wang *et al*., 2017a,b). Several

essential oils are found in the leaves of guava, with 1,8-cineole and trans-caryophyllene as the major compounds identified, along with more than 50 other compounds, including limonene, eucalyptol, caryophyllene oxide, caryophyllene, and nerolidol (Lee *et al*., 2012; Mandal *et al*., 2022). Similarly, a plethora of phytochemicals are detected in the bark extracts as well, namely, alkaloids, anthraquinones, carboxylic acids, cardiac glycosides, coumarin, flavonoids, quinines, resins, saponins, steroids, tannins and terpenoids (Barbalho *et al*., 2012; Velmurugan *et al*., 2012; Abdulhamid *et al.*, 2014; Oncho, Ejigu & Urgessa, 2021). Atik *et al*. (2019) reported a range of secondary metabolites in the fruit extracts of *P. guajava*, including flavonoids, tannins, quinones, saponins, and triterpenoids/steroids. Recently, more than 550 secondary metabolites have been identified in the fruit's pulp by modern instrumentation techniques like MS/UPLC-ESI-MS. Metabolic profile of the fruit varies with different coloured pulps and revealed a type of anthocyanin (cyanidin-3-O-sophoroside) to act as the primary pigment responsible for variance in fruit pulp colour along with some co-pigments, namely, chlorogenic acid, myricetin, myricitrin, quercetin, and quercitrin (Zheng *et al*., 2020).

Pharmacological Properties

Psidium guajava plants are not only known to the world for its palatable fruit, but it is also known all over the world for its wide range of medicinal uses. Different parts of the world, namely, Asia, Africa, Mexico and Central America, are known to employ plant parts of *P. guajava* for treatment of different ailments. Traditional use of the plant is known for the treatment of diseases like diabetes, dysentery, diarrhoea, gastroenteritis, hypertension, wounds, reducing fever and pain, etc. Recent pharmacological studies support a wide variety of its pharmacological properties, including anti-diarrhoeal (Birdi *et al*., 2020), anti-inflammatory (Oktavia, 2021), anti-microbial (Rayjade Meghana, Bhambar & Attarde Daksha, 2021), anti-hyperglycaemic (Zhu *et al*., 2020), hepatoprotective (Alves *et al*., 2023), anti-oxidant (Gomes August *et al*., 2025), anti-cancerous (Lok *et al*., 2023), etc. The following section elaborates on the various pharmacological activities reported in different plant parts of *P. guajava*.

Anti-microbial Property

Different parts of the plant *Psidium guajava* have been reported to possess antimicrobial properties against a wide range of micro-organisms, including Gram-positive bacteria, Gram-negative bacteria fungi, etc. (Naseer *et al.*, 2018). Leaf, root and bark extracts of *P. guajava* are reported to be active against Gram-positive bacteria, including *Staphylococcus aureus* and *Bacillus subtilis* (Sanches *et al*., 2005). The study showed ethanol:water (7:3) extracts of the leaf, root and bark to be more active than aqueous extracts of the same against the tested bacterial strains. Phytochemical analyses of the leaf extracts in the same study suggested flavonoids to be the active secondary metabolite to be involved in the antibacterial property of the plant (Sanches *et al.*, 2005). Later on, the effect of five different flavonoids extracted from the leaves of *P. guajava* for antimicrobial activity was studied by Metwally *et al*. (2010). In addition to

different leaf extracts and its fractions, quercetin and its glycosides were observed to exhibit strong antimicrobial activity against *S. aureus* (Gram-positive bacteria), *Escherichia coli* and *Pseudomonas aeruginosa* (Gram-negative bacteria) and the fungus *Candida albicans* (Metwally *et al.*, 2010). Crude extracts of *P. guajava* leaves are reported to be active against Gram-positive bacterial species like *Streptococcus pneumoniae* and *Staphylococcus aureus* (Gashe, Belete & Gebre-Mariam, 2010). Essential oils freshly extracted from leaves of *P. guajava* are reported to have antibacterial effects against Gram-positive bacteria, namely, *B. cereus* and *Lactobacillus lactis*, Gram-negative bacteria, viz., *Enterobactor aerogenes* and *Glucanobactor oxidans* (Joseph *et al*., 2010). Huang *et al.* (2021) separated seven different compounds, including flavonoids, from ethanolic extract of guava leaves and reported Psidinone to exhibit strong antimicrobial activity against *S. aureus*, *S. epidermidis* (Gram-positive bacteria) and *Mycobacterium smegmatis* (Acid-fast bacterium). Rayjade Meghana, Bhambar and Attarde Daksha (2021) reviewed in detail the antimicrobial activity of guava leaf extracts and found the extracts to be active against a wide range of microbes, including *B. cereus, S. aureus*, (Gram-positive bacteria), *E. coli, Salmonella enteritidis, Vibrio* and *Aeromonas* species (Gram-negative bacteria), *Aspergillus niger, Saccharomyces cerevisiae* (fungi) as well as against periodontal pathogens. In addition to the above-mentioned microbial species, extracts from different parts of *P. guajava* (leaf, bark, fruits, peels, etc.) are reported to be active against a plethora of Gram-negative bacteria like Klebsiella pneumoniae, Salmonella typhi, Shigella dysenteriae, Shigella flexneri, Vibrio cholerae, Salmonella enteritidis and fungi including Aspergillus niger (Dona & Rajapakse, 2024). The findings support the traditional use of different parts of the guava plant in the treatment of microbial diseases like diarrhoea and periodontal diseases.

Anti-diarrheal Property

Diarrhoea is one of the world's major health concerns in developing as well as economically developed countries. It is the third leading cause of death among children less than 5 years old, with 4.44 lakh child deaths per year, and is estimated to remain a global health concern for the upcoming decades (Meyrowitsch & Bygbjerg, 2007; World Health Organisation, 2024). Diarrhoea may be the result of infection by a number of causal organisms, including viruses, bacteria or protozoa. Medicinal plants have been employed traditionally for the treatment of infectious diarrhoea around the world, including the use of different parts of *Psidium guajava*. The extracts of *P. guajava* plants have been found to have antidiarrheal activity in vitro (Vieira *et al*., 2001) as well as in vivo (Lu *et al.*, 2020). Anti-diarrhoeal activity of the plant has been tested in animal models as well as preclinical and clinical trials are reported with positive results as reviewed in detail recently by Garrido *et al.* (2024) and Liu, Jullian and Chassagne (2024). The antidiarrheal property of this plant is mainly attributed to the anti-microbial property of its extracts, including some microbes responsible for diarrhoea (as discussed above). Furthermore, different extracts of guava leaf have been reported to

have positive effects on gastrointestinal propulsion in animal models by increasing absorption of water and lowering ingested food movement rate. The inhibitory rate of gastrointestinal function by these leaf extracts is reported to be comparable to loperamide, an FDA-approved anti-diarrhoeal medicine (Liu, Jullian & Chassagne, 2024). Multiple reports thus support and scientifically validate the traditional use of guava leaves in the treatment of diarrhoea and possible mechanisms of action. However, more investigations are required to standardise the dosage and extraction procedure for safe application of the plant in treatment of diarrhoea.

Anti-diabetic Property

Extracts of guava leaves have been employed in the treatment of diabetes since ancient times in east Asia and other countries. Pharmacological investigations have confirmed extracts of this plant to exhibit antidiabetic properties at various levels, including *in vitro* and *in vivo* studies (Oh *et al*., 2005; Mukhtar *et al*., 2006; Basha & Kumari, 2012; Zhu *et al.*, 2020; Tella, Masola & Mukaratirwa, 2022; Rahman *et al*., 2023). Ethanolic extract of the plant bark showed significant anti-hyperglycaemic activity in alloxan-induced diabetic mice subjects (Mukhtar *et al.*, 2006). However, the maximum number of reports are available for leaf extracts to possess anti-diabetic properties. In *Leprdb/Leprd*b diabetic mice, methanolic leaf extract of *Psidium guajava* showed significant reduction in blood sugar level after intraperitoneal injection of the extract (Oh *et al*., 2005). Guava leaf extracts have been reported to show significant antidiabetic properties in vitro analysis as well. Basha and Kumari (2012) observed that methanolic extracts of the plant leaf show significant inhibition of glucose diffusion in vitro. Anti-diabetic activity of *P. guajava* leaf extracts against Type 2 diabetes in a mouse model is suggested to be mediated by the inhibition of the enzyme tyrosine phosphatase1B which acts as a negative regulator in insulin signalling (Oh *et al*., 2005). Zhu *et al*. (2020) reported leaf flavonoids (namely, Guaijaverin and avicularin) of *P. guajava* to have active antidiabetic effects on a streptozotocin-induced diabetic mice model by decreasing insulin resistance, fasting plasma glucose and glucose tolerance on flavonoid supplementation. Tella, Masola and Mukaratirwa (2022) observed after studying the effect of aqueous leaf extract on streptozotocin-induced diabetic rat models that the anti-diabetic property of the plant extract is mediated by modification of glycogen metabolism pathways enzymes. The group further attributed the anti-diabetic property of the plant to its phenolic compounds and triterpenes present in the leaf extract (Tella, Masola & Mukaratirwa, 2022). Oral treatment with aqueous leaf extracts has shown positive results for the anti-diabetic effect on neonatal streptozotocin-induced diabetic rat models as well (Rahman *et al.*, 2023). Rahman *et al.* (2023) demonstrated oral treatment with leaf extract to increase insulin secretion and promote glycogen synthesis in the diabetic rats, thus contributing to potential anti-diabetic natural drug development.

Anti-inflammatory Property

Inflammation plays an important role in a large number of diseases, including diabetes,

pulmonary diseases, cancer, arthritis, etc. Different plants are reported to possess anti-inflammatory properties, including *Psidium guajava*. Pharmacological investigations have revealed the presence of anti-inflammatory properties in different parts (fruit and leaf extracts) of *P. guajava* plant in both *in vitro* and *in vivo* studies (El-Ahmady, Ashour & Wink, 2013; Oktavia, 2021; Yu *et al.*, 2022; Singh *et al.*, 2023; Mohan *et al*., 2024). Extracts of *P. guajava* are reported to demonstrate anti-inflammatory properties in different carrageenan-induced oedema in mice model studies as well as in lipopolysaccharide-activated macrophage cell lines of mice (Oktavia, 2021). Study conducted with dechlorophyllised ethanolic extract of *P. guajava* leaves showed anti-inflammatory effects against macrophage cells stimulated with lipopolysaccharides (Singh *et al*., 2023). Oils isolated from both the leaf (*β*-caryophyllene and selin-7(11)-en-4α-ol) and fruit (β-caryophyllene and limonene) of the guava plant are also reported to have anti-inflammatory properties by evaluation of inhibition of 5-lipoxygenase (El-Ahmady, Ashour & Wink, 2013). Psidial F, a monoterpenoid identified from leaf extracts of the guava plant, is observed to show anti-inflammatory activity (Yu *et al*., 2022). Fermented *P. guajava* fruits with *Lactiplantibacillus* sp., FSA-4, showed enhanced activity by significantly alleviating inflammatory responses in *in vitro* conditions due to the presence of a distinct group of flavanols supporting the traditional use of fermented food for overall well-being (Mohan *et al*., 2024). Oktavia (2021) suggested the anti-inflammatory property of the plant is mainly mediated by inhibition of PGE2, COX-2, NO, iNOS, ERK1/2, leukocyte cell migration, and suppression of oedema and paw withdrawal latency and by membrane stabilisation.

Hepatoprotective Property

Guava extracts are long known for their hepatoprotective nature. Oral administration of aqueous extract of *Psidium guajava* leaves (200 mg/kg bw) did not show significant improvement in histological and biochemical parameters for liver function in male and female rat models; however, an increase in RBC, haematocrit and haemoglobin was noted by Uboh, Okon and Ekong (2010). On the contrary, ethanolic extract of *P. guajava* leaves (200, 400 mg/kg) and its phospholipid complex (100 mg/kg) are reported to exhibit significant hepatoprotective activity against paracetamol overdose-induced hepatic damage in rats (D'mello & Rana, 2010). D'mello and Rana (2010) further deduced phospholipid complexes isolated from the leaves to show better activity compared to crude extracts, which was comparable to the standard drug silymarin. Ethanolic extract of guava leaves is also reported to restore liver functional markers to normal levels in CCl_4-induced rats (Vijayakumar *et al*., 2020). The authors observed that quercetin, isolated from leaves of *P. guajava*, had better hepatoprotective activity compared to crude ethanolic extract. Fruits of *P. guajava* are also reported to possess hepatoprotective properties in pharmacological investigations. Aqueous extract of raw fruit peel of guava when administered orally to streptozotocin-treated rats at a dose of 400 mg/kg, showed a significant decrease in all parameters for liver function after 21 days (Rai, Mehta & Watal, 2010). Intra-peritoneal administration of guava fruit puree at

doses of 200 and 400 mg/kg for 21 days showed significant hepatoprotective activity in alloxan monohydrate-treated rats without any toxicity up to 5000 mg/kg in addition to anti-diabetic properties (Joshua *et al*., 2022). Lycopene extract from P. guajava ameliorated liver degenerative changes in a hamster model on oral administration without any cytotoxic effects, although it did not improve blood markers for liver function (Alves et al., 2023). Guavinoside B, a major benzophenone glycoside in the fruits of *P. guajava*, showed positive hepatoprotective properties both *in vitro* and *in vivo*, significantly reducing serum and hepatic biochemical markers (Li *et al*., 2020).

Anti-oxidant Property

Metabolic processes result in the production of free radicals, which play a key role in different diseases. Plant secondary metabolites, particularly phenolic compounds like flavonoids, are capable of scavenging free radicals, contributing to natural anti-oxidants. Different plant parts of *P. guajava* are rich in varied types of phenolic compounds (as discussed above), contributing to its anti-oxidant property. Role of such compounds isolated from *P. guajava* plant parts demonstrating antioxidant properties has been reported in a number of studies (Zahin, Ahmad & Aqil, 2017; Ruksiriwanich *et al.*, 2022; Gomes August *et al.*, 2025). Methanolic fraction of guava leaf extract, with a high amount of phenolics, showed maximum anti-oxidant activity, comparable to that of ascorbic acid in four different biochemical assays (Zahin, Ahmad & Aqil, 2017). Ethanolic extract of guava leaves was reported to be rich in phenolic compounds namely, catechin, gallic acid and quercetin, which showed anti-oxidant activity in both DPPH and ABTS radical scavenging assays (Ruksiriwanich *et al*., 2022). The vanillic acid, ascorbic acid, flavonoids and tannins present in the leaf extract of P. guajava were correlated with anti-oxidant activity of the plant (Gomes August *et al*., 2025). In addition, the leaf extracts were observed to produce a constant amount of total phenolics and exhibited stability in maintaining its anti-oxidant and photo-protective activity across the seasons for years (Gomes August *et al*., 2025). It is evident from the various scientific reports that P. guajava, especially its leaf extracts, is a potent anti-oxidant which can be utilised in the future with proper safety measures.

Anti-cancerous Property

The International Agency for Research on Cancer (IARC), a World Health Organisation (WHO) unit, has recently estimated an incidence of 19.97 million cancer cases worldwide, causing 9.74 million deaths in 2022. Among the different types of cancers, the maximum number of death cases is reported to be caused by lung cancer, followed by colorectal, liver, breast, stomach cancers, etc. (Ferlay *et al.*, 2024). In addition to traditional therapeutic strategies like chemotherapy, radiation therapy and surgery, recent focus has been included in the area of alternative potential anti-cancer agents derived from natural products. Systematic review focusing on scientific evidence of potentially anti-cancerous plants covered more than fifty plant species, with their secondary metabolites playing an important role against different types of cancer in

both *in vitro* and *in vivo* studies (Chandra *et al*., 2023). In the last two decades, extensive reports have been available on anti-cancerous properties of different parts of *Psidium guajava* plant, including leaf, fruit, seed, bark and root extracts against different human cancer cell lines as well as some in vivo animal models, as reviewed extensively by Lok *et al*. (2023). Leaf extracts of the plant are extensively reported to have anti-proliferative activity against a number of different cancer cell lines, including lung cancer, breast cancer, colon cancer, prostate cancer, leukaemia cancer, kidney cancer, ovarian cancer, etc. Among the phytochemicals tested, Guajadial, a monoterpenoid isolated from guava leaves, shows anti-neoplastic properties against cell lines of lung cancer, breast cancer, and cervical cancer in vitro as well as against some cancers like lung cancer *in vivo*. Other compounds reported from *P. guajava* leaves to be active against cancer cells include guavinoside C, F, quercetin (a flavonoid), against gastric cancer cell lines. Quercetin is suggested to work via inhibiting cancer cell proliferation and inducing apoptosis in different cancer cell lines. Compounds having strong anti-oxidant activity are believed to be one of the most important contributing factors in the fight against cancer. Polyphenol-rich fractions of P. guajava leaf extracts are known to limit the growth of human colon cancer cell lines in addition to inhibiting prostaglandin H synthase, thus limiting cancer cell adhesion, migration and invasion. Aqueous and ethanolic extracts of guava leaves were also found to be inhibiting vascular angiogenesis in colon cancer cell lines. Fruit extracts and its important phytochemicals, including guajadial A, D, psiguadial D, lycopene, apigenin, and resveratrol, are also reported to show anti-cancerous properties against various cancer cell lines in vitro like, leukaemia, liver cancer, breast cancer, skin cancer and prostate cancer cell lines (Lok *et al*., 2023; George, Thangasamy & Geetha, 2025). Limited number of reports are available for guava plant parts against cancer in vivo studies in mouse models, including skin melanoma, prostate cancer cell line grafted mouse tumours, breast cancer and adenocarcinoma. Hence, booming research to date suggests anti-cancerous potential of different parts of *P. guajava* plant in numerous in vitro studies against impressive cancer cell lines and a few in vivo studies in animal models. Further clinical trials are necessary to validate the potentially anti-cancerous phytochemicals to be used as drugs in cancer treatment in the future.

Conclusion

Psidium guajava, a nutritionally rich fruit plant, is traditionally used for the treatment of various diseases. The plant is known for the presence of myriad phytochemicals in different plant parts, which contribute to various pharmacological properties. Numerous scientific studies support the use of various plant parts of *P. guajava* for the treatment of microbial diseases, including diarrhoea and periodontal diseases, due to its diverse anti-microbial properties against bacteria (both Gram positive and Gram negative) as well as various strains of fungi. Maximum number of such studies are reported for leaf extracts of the plant and flavonoids extracted from it. Anti-diarrheal property of the plant is not only due to its anti-microbial property, but a recent study suggests its role in gastrointestinal

propulsion, thus contributing to the inhibitory rate of gastrointestinal function comparable to FDA-approved drugs like Loperamide. However, a very limited number of clinical trials are available to date. Thus, more investigations on safe dosage are required for future implementation of the plant extract in diarrhoeal control. Anti-diabetic properties of the plant parts and its compounds have been reported in various in vivo studies in animal models on both oral application and intraperitoneal injection by decreasing insulin resistance, increasing insulin secretion, promoting glycogen synthesis and decreasing plasma glucose, thus contributing to potential anti-diabetic drug development in the future. Different in vivo reports are available suggesting anti-inflammatory and antioxidant properties of *P. guajava* extracts and its bioactive compounds, specifically flavonoids. Different extracts of the plant, including fruit pulp and its major glycosides, are reported to improve liver function parameters without any cytotoxic effects contributing to hepatoprotective properties. Research in the last two decades has highlighted the anti-cancerous property of the plant against different types of cancer in numerous in vitro cancer cell line studies as well as some *in vivo* studies. *P. guajava* extracts and various secondary metabolites isolated from the plants are reported to exhibit anti-proliferative properties and promote apoptosis in cancerous cells, inhibit cell adhesion, migration, invasion and angiogenesis. Further clinical trials in the area will help in drug development against the different diseases for which pharmacological activities are established through numerous studies.

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