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Unveiling the pharmacological potential of guava (*Psidium guajava* L.): A review

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Abstract

Guava, a tropical fruit renowned for its rich nutritional profile, has garnered increasing attention in the field of pharmacology due to its diverse bioactive compounds. This resilient plant flourishes in tropical and subtropical climates, making it well-suited to warm environments. Guavas are climacteric fruits, which means they continue to ripen after being harvested. They are renowned for their nutritional profile, rich in potassium, lycopene, manganese, iron, calcium, fiber and essential vitamins and minerals. The guava plant's fruit and leaves possess a range of edible and medicinal properties. Guava extracts are recognized for their health benefits, which include anticancer, antiobesity, antibacterial, antidiabetic and antihypertensive effects. The presence of phytochemicals in guava leaves, such as caffeic acid, flavonoids and hyperin, enhances their therapeutic potential, particularly in treating respiratory ailments like coughs and colds. Guava's impressive health-promoting qualities have made it a valuable addition to traditional medicine practices. Its fruits are not only delicious but also serve as a natural remedy for various conditions, highlighting the plant's versatility. By incorporating guava into the diet, individuals can benefit from its wide-ranging health advantages, making it a worthwhile fruit to include in daily nutrition. Overall, guava stands out as a powerhouse of nutrients and therapeutic properties, contributing significantly to health and wellness.

Keywords

nutritional benefits; therapeutic properties; bioactive compounds; biological effects

Introduction

Guava (*Psidium guajava* L.) is a well-known tropical tree that is abundantly grown for its fruit. It belongs to the phylum Magnoliophyta, class Magnoliopsida and Myrtaceae family (1). There are about 133 genera and more than 3,800 species within this family (2). *Psidium guajava* is valued for its high vitamin C content, dietary fiber and a wide range of bioactive compounds, including flavonoids, carotenoids and phenolic acids (3). These constituents contribute to its antioxidant, anti-inflammatory and antimicrobial activities, making guava an important fruit for health and nutrition (4).Guava has spread across tropical and subtropical regions worldwide, thanks to its adaptability to various soils and temperatures (Fig. 1, 2). Guava fruits vary in size, typically weighing between 100 to 250 grams and measuring 5 to 10 centimeters in diameter. At the fruit's apex, four fiber-protruding flower remnants are often visible. Depending on the type, guava fruits may have a spherical, ovoid, or pyriform shape and lack visible pubescence on their surface.

Fig. 1. Plant of guava.

While immature fruits exhibit dark green skins, ripe ones can range from light yellow to yellowish-green on the shoulders. The ripe fruit's pulp is smooth and can be white, pink, or salmon-red (Fig. 3, 4). The fruit is characterized by its sweet, aromatic flavor and unique texture, which varies from crisp to creamy depending on the variety (5). Guava is not only consumed fresh but is also used in juices, jams and jellies and serves as an ingredient in various culinary dishes (6). Furthermore, traditional medicine in several cultures has utilized guava leaves and fruit to treat ailments such as diarrhea, respiratory infections and skin disorders (7).

Fig. 3. Fruit of guava (White flesh).

Fig. 4. Fruit of guava (Pink flesh).

The growing interest in functional foods and natural remedies has increased research into the health benefits of guava, leading to its recognition as a valuable dietary component. This review aims to highlight the nutritional benefits, medicinal properties and potential applications of *Psidium guajava* in promoting human health.

Fig. 2. Flower of guava.

Cultivation techniques of guava

Cultivating guava requires specific agronomic practices to ensure healthy growth, high yield and quality fruit.

Climate and soil requirements

Guava thrives in tropical and subtropical climates, preferring warm temperatures ranging from 20 to 30°C. It can tolerate light frosts but is sensitive to prolonged cold temperatures. The ideal soil for guava is well-drained, sandy loam with a pH of 5.5 to 7.0. Soil should be rich in organic matter to support healthy growth (8).

Propagation

Guava can be propagated through seeds, cuttings and grafting. Seed propagation takes longer to yield fruit, while vegetative methods like cuttings and grafting can produce fruit earlier. Grafting is preferred for commercial production due to its advantages in disease resistance and uniformity (9).

Land preparation and planting

Proper land preparation is crucial for successful guava cultivation. The land should be cleared of weeds and debris, followed by plowing and harrowing to ensure a fine seedbed. The soil may be enriched with well-rotted manure or compost to enhance fertility (10).

The optimal planting season for guava is during the rainy season to ensure sufficient moisture. Planting should be done at a spacing of 5 to 7 meters between trees to allow for adequate air circulation and sunlight penetration. Pits of 60 cm x 60 cm x 60 cm should be prepared and the plants should be watered immediately after planting (11).

Irrigation and fertilizer application

Guava requires consistent moisture, especially during the flowering and fruiting stages. Drip irrigation is recommended for efficient water use. In areas with high rainfall, drainage systems should be established to prevent waterlogging (12).

Fertilizer application should be based on soil tests to meet the nutritional needs of the plants. A balanced fertilizer regime, including nitrogen, phosphorus and potassium, is essential. Organic fertilizers such as compost and green manures can also be incorporated (13).

Pest and disease management

Regular monitoring for pests like tea mosquito bugs, fruit flies, aphids and mealybugs is crucial. Integrated Pest Management (IPM) practices, including the use of natural predators, insecticidal soaps and organic pesticides, should be employed.

Guava is susceptible to a range of diseases that can significantly affect the quality and yield of its fruits. The main types of diseases impacting guava plants include fungal, bacterial, viral and nematode infections. Each type of disease can lead to fruit deformities, reduced sweetness, discoloration and other undesirable traits that reduce market value. Common diseases include anthracnose, guava rust, bacterial blight, canker and fruit rot, which can be managed through proper sanitation and fungicide applications. (14).

Harvesting and post-harvest handling

Guava is typically harvested when the fruit attains full size and begins to change color. It is essential to handle the fruit carefully to avoid bruising. Post-harvest treatments, including washing, grading and packaging, should be conducted to maintain quality during storage and transport (15).

Popular names

Various regions around the world have different names for guava. Table 1 lists some of the popular names for guava.

Table 1. Popular names of guava (16)

Country	Popular name
India	Amarood
Philippines	Bayabas
Bengali	Piara
Chinese	Fan shiliu
Arabic	Guwafah
Portuguese	Goiaba
French	Gouyave
Brazil	Araca
Germany	Guavenbaum
Spanish	Guayaba
Thailand	Farang
Cambodia	Trapaeksruk
English	Apple guava

Major species

Guava is a member of the *Psidium* genus and major species are listed in Table 2.

Table 2. Major species of guava (17)

Psidium guajava	*Psidium robustum*
Psidium araaoRaddi	*Psidium harrisianum*
Psidium sartorianum	*Psidium cinereum*
Psidium harrisianum	*Psidium pedicellatum*
Psidium friedrichsthalium	*Psidium galapageium*
Psidium amplexicaule	*Psidium sintenisii*
Psidium spathulatum	*Psidium rostratum*
Psidium incanescens	*Psidium robustum*
Psidium guineense	*Psidium montanum*

Nutritional value

Guava has a rich history of culinary and medicinal use. Its sweet-sour flavor and pleasant aroma make it versatile in various forms such as salads, juices, jams and candies. The nutritional information for 100 grams of guava is provided in Table 3.

Table 3. Nutritional value of guava (18)

Nutrients	Content
Thiamine	0.03-0.04 mg
Fat	0.43-0.7 mg
Carotene	0.046 mg
Calories	77-86 g
Vitamin B3	35 I.U.
Crude fiber	0.9-1.0 g
Vitamin C	36-50 mg
Calcium	17.8-30 mg
Riboflavin	0.6-1.068 mg
Protein	0.1-0.5 mg
Phosphorous	0.30-0.70 mg
Niacin	40 I.U.
Iron	200-400 I.U.
Carbohydrate	9.1-17 mg
Ash	9.5-10 mg
Moisture	2.8-5.5 g

Ethnomedicine values of the guava

Guava has been valued in Central Africa and America for its medicinal properties in treating digestive issues like diarrhea and gastroenteritis due to its antibacterial effects (22). Research has also shown that guava leaves have antibacterial effects and potential therapeutic applications, including cancer treatment (5). Nutritionally, guava is low in calories but rich in vital nutrients such as vitamin C, manganese, carotenoids, phenols and antioxidants, which can help prevent diseases like cancer (2). Its high dietary fiber content in the pulp and peel makes it a natural antioxidant dietary fiber source (6). Different varieties of guava have varying phytochemical compositions, with white-fleshed varieties having higher sugar content but lower levels of certain beneficial compounds compared to red-fleshed ones (5). The ethnomedicine values of the guava are detailed in Table 4.

Antacid and ulcer-preventive action

The antacid and ulcer-preventive action of guava leaves can be attributed to several bioactive compounds such as flavonoids, saponins and other phytochemicals that work synergistically to alleviate hyperacidity and promote ulcer healing. The mode of action involves:

Neutralization of gastric acidity

The natural alkaline properties of guava leaves, particularly through the presence of bioactive flavonoids, help in neutralizing excess stomach acid. This leads to relief from hyperacidity and prevention of further irritation of the gastric mucosa (23).

Cytoprotective activity

The methanolic extract of guava leaves, which contains saponins and flavonoids, has been demonstrated to enhance the production of protective mucus in the stomach lining. This mucus barrier serves as a defense against the harsh acidic environment, thus preventing the formation of ulcers (24).

Reduction of gastric secretions

Flavonoids, especially quercetin present in guava leaves, have been shown to inhibit histamine and gastrin-mediated gastric secretions. This mechanism reduces the overall acid load in the stomach, providing an antacid effect (25).

Healing of ulcers

Studies on animal models, particularly Wister rats, have revealed that guava leaf extract significantly reduces the severity of ethanol-induced ulcers. The ulcer healing effect is mediated by the anti-inflammatory and antioxidant properties of the flavonoids, which promote the repair of damaged gastric tissues and reduce oxidative stress (26).

Table 4. Ethnomedicine usage of the guava

Part of the plant	Compound	Usage in ethnomedicine	References
Seed	Carotenoids, phenolic compounds and glycosides	Antimicrobial efficacy	(19)
Bark	Phenolic	High antibacterial, analgesic and antidiarrheal properties	(20)
Leaves	Flavonoids, epicatechin, gallic acid, phenolic and kaempferol	Neurological activity, antioxidant, anti-inflammatory, antispasmodic, anticancer, antibacterial and anticonservative properties	(21)
Fruit skin	Phenolic	Enhancement of the absorption of food	(20)
Pulp	Carotenoids with ascorbic acid	Antihyperglycemic, antioxidant	(22)

Wound rehabilitation characteristics

The mode of action of guava leaves in wound rehabilitation is attributed to several bioactive compounds present in the leaves, particularly tannins, flavonoids and triterpenoids, which work synergistically to promote wound healing. The mode of mechanism involves:

Antimicrobial activity

The tannins in guava leaves contribute to their antimicrobial properties, which help to prevent infections in wounds. These compounds disrupt the cell membranes of microorganisms, limiting their growth and helping to keep the wound free from infection (23).

Anti-inflammatory effects

Flavonoids present in guava leaves possess strong anti-inflammatory properties. By reducing inflammation, they help to minimize swelling and redness at the wound site, promoting a more conducive environment for healing (27).

Promotion of collagen synthesis

The flavonoids and triterpenoids in guava leaves also promote collagen synthesis, which is crucial for the wound-healing process. Collagen is the primary structural protein in the skin and its increased production helps in wound contraction and the formation of new tissue, thus speeding up the healing process (28).

Antioxidant properties

Guava leaves are rich in antioxidants, which play a role in neutralizing free radicals that can delay the healing process. By mitigating oxidative stress at the wound site, the antioxidants help protect cells and promote faster regeneration (23).

Hemostatic activity

Tannins have been shown to possess astringent properties, which help to constrict blood vessels and promote blood clotting. This aids in controlling bleeding and speeds up the formation of a scab, facilitating the initial stages of wound healing (24).

Improved skin regeneration

The combination of antimicrobial, anti-inflammatory and antioxidant activities, along with enhanced collagen production, supports quicker regeneration of skin tissues and accelerates the overall wound-healing process (28).

Using guava leaves in functional food

Guava leaves exhibit various bioactive properties when used as functional food ingredients, primarily due to their high content of bioactive compounds like flavonoids, polyphenols and other phenolic acids. The mode of action of these compounds can be summarized as follows:

Antioxidant activity

The high content of flavonoids and phenolic compounds, such as quercetin, rutin and gallic acid, are responsible for scavenging free radicals and reducing oxidative stress. These compounds donate electrons to neutralize free radicals, thereby preventing lipid peroxidation and cellular damage (27). The antioxidant properties of guava leaf extracts contribute to overall health, including enhancing egg quality in animals like laying hens by reducing oxidative stress on egg lipids (30).

Antimicrobial properties

Flavonoids, particularly quercetin and guaijaverin, act by disrupting the cell membranes of pathogens, leading to the loss of intracellular contents and bacterial death (31). These compounds have demonstrated strong activity against a variety of pathogenic bacteria, including *Staphylococcus aureus* and *Escherichia coli* (27). This antimicrobial activity can enhance food preservation and reduce spoilage when incorporated into functional foods.

Anti-inflammatory mechanisms

Guava leaf extract inhibits the cyclooxygenase (COX) enzyme, a key mediator in the inflammatory response (30). By inhibiting COX enzymes, especially COX-2, the bioactive compounds, particularly flavonoids, reduce the synthesis of prostaglandins, which are involved in promoting inflammation and pain (29). This mechanism has implications in both food and nutraceutical products designed to manage inflammatory conditions.

Hypoglycemic action

Phenolic compounds, such as gallic acid and epicatechin, regulate blood glucose levels by inhibiting carbohydrate-digesting enzymes, such as alpha-amylase and alpha-glucosidase (29). This results in a slower release of glucose into the bloodstream, which helps in maintaining normal blood sugar levels, making guava leaf extract suitable for managing diabetes and related metabolic disorders in functional foods.

Vascular function enhancement

The bioactive compounds in guava leaves, particularly flavonoids like quercetin, improve endothelial function by increasing nitric oxide (NO) availability. This results in vasodilation and better blood flow, essential in managing vascular conditions like hypertension and atherosclerosis (29).

Sensory and rheological impact

Guava leaf extracts, when used as functional food additives, can maintain or even improve the sensory qualities of foods. Studies show that the extract does not significantly alter the texture, taste, or appearance of foods while providing health benefits (31).

Guava relieves coughs and colds

The effectiveness of guava leaves in treating coughs and colds can be attributed to their high content of iron and ascorbic acid, which play key roles in maintaining respiratory health. These nutrients help reduce excessive mucus production and alleviate lung congestion, supporting the respiratory system. The astringent properties of guava leaves work by tightening the mucous membranes in the throat and lungs, reducing inflammation and clearing microbial pathogens. The mode of action involves:

Iron and ascorbic acid (vitamin c)

These compounds help boost the immune system and reduce oxidative stress in respiratory tissues. Maintaining healthy mucosal surfaces limits the overproduction of mucus and aids in relieving congestion. This action is crucial in managing symptoms of colds and coughs (39).

Astringent properties

Guava leaves contain tannins, which have astringent properties that contract tissues and mucous membranes. This contraction reduces inflammation in the throat and lungs, helping to clear out excess mucus and pathogens. According to Jairarj *et al*. (1999) (39), these properties are key in reducing microbial activity and promoting recovery from respiratory infections.

Anti-microbial and anti-inflammatory effects

Guava leaves possess phytochemicals like flavonoids and polyphenols, which have antimicrobial properties Table 5. These compounds are effective against a variety of pathogens, including those causing influenza and other respiratory illnesses. Kafle *et al*. (2018) (23) found that a water-based guava leaf extract significantly reduced coughing episodes in response to capsaicin-induced irritation, demonstrating the anti-inflammatory and soothing effects of the extract on the respiratory system.

Home remedy use in India

Roasting guava fruits, a common home remedy in India releases volatile oils that can help soothe the throat and reduce coughing by acting on the mucous membranes to ease irritation (23).

Conclusion

Guava (*Psidium guajava* L.) has numerous health benefits, including being rich in antioxidants, having anti-diabetic, antibacterial, anti-diarrheal, antihypotensive, analgesic, anti-inflammatory, anticancer, antihypertensive, antifungal and antipyretic properties. The entire fruit is edible and can be consumed raw or cooked. It can be sliced for salads or desserts and the pulp can be used to make beverages. Additionally, the fruit can make various delicacies such as jam, guava paste and guava cheese. The leaves of the guava plant are also edible and have medicinal properties. It's important to cultivate guava more widely to meet nutritional requirements at a lower cost.

Authors' contributions

RM and RKS conceived the concept and co-wrote the manuscript. RKS provided input for the design of the diagrams and tables, which were created by RM. Both RM and RKS revised and finalized the manuscript. All authors have read and approved the final version.

Compliance with ethical standards

Conflict of interest: The authors declare that there is no competing interest.

Ethical issues: None

Table 5. Pharmacological value of guava

Activity	Pharmacological value	References
Antioxidant	Guava extract, when combined with 65% ethanol at a concentration of 0.47 g/L, has demonstrated the capability to effectively neutralize hydroxyl radicals and prevent the oxidation of lipids.	(33)
Antifungal	Hexane at a concentration of 50 mg/ml shows antifungal activity against *Trichophyton tonsurans* and *Candida parapsilosis*.	(34)
Antimalarial	The solution contains 10-20 mg/ml in water, with fever "teas" made using the leaves as the active ingredient. These leaves are also found in the potted plant used to create steam medicine for malaria. The stem bark extract, containing antimicrobials, flavonoids and terpenoids, has been proven effective in treating malaria.	(31)
Antidiabetic	When extracting guava, 0.2 to 1.0 ml of methanol concentrations are used to find the ideal dose required to get a certain degree of restriction from the α-amylase enzyme.Top of FormBottom of Form	(32)
Antihypertensive	Utilizing water and ethanol with a concentration ranging from 0.6 to 2.0 g/kg (based on body weight) for the extraction of guava, the study demonstrates its antihypertensive properties by effectively managing blood pressure levels throughout the duration of the experiment.	(35)
Antibacterial	The guava extract, dissolved in a 75% methanol/acetone solution with concentrations of 5.0 mg/ml and 2.0 mg/ml, displayed antibacterial properties when tested against *E. coli* and *S. multocida*.	(36)
Anticancer	Research indicates that guava leaf extract and essential oil, when administered at a dosage of less than 1.6 mg per day, demonstrate anti-prostate cancer properties. In an experimental model using mice with transplanted tumors, these extracts were found to lower the levels of prostate-specific antigen in the blood and decrease the incidence of cancer spreading to distant sites in the body.	(37)
Antiobesity	In experiments involving rats with diabetes, researchers administered guava leaves at a dosage of 200 mg per kilogram of the rats body weight. This treatment resulted in improved metabolism of carbohydrates, leading to lower levels of blood glucose and better tolerance to ingested glucose, which is crucial for preventing weight loss. The observed stabilization of insulin levels was attributed to increased activity of hexokinase and glucose-6-phosphate dehydrogenase, along with decreased activity of enzymes involved in glucose production and glucose-6-phosphatase.	(38)

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