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EXPLORING THE MEDICINAL POTENTIAL OF GUAVA (*Psidium guajava*) FOR HEALTH AND WELLNESS

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ABSTRACT
The global escalation of chronic degenerative diseases, often associated with foodborne illnesses, has led to heightened healthcare costs and a diminished quality of life. Consuming foods rich in bioactive substances, such as fruits, vegetables, and seeds, can help reduce the risk factors for developing certain diseases. *Psidium guajava*, well known for its exquisite flavor, has also been the subject of much research due to its possible health advantages. These benefits include anti-inflammatory, anti-cancer, anti-diabetic, antimicrobial, anti-diarrheal, and anti-hypertensive properties. However, using guava as a therapeutic plant has drawbacks and restrictions. This review sheds light on the relevance of guava in promoting health and wellness by emphasizing the necessity of comprehending the medicinal value of guava and its possible uses. Future investigations into the medicinal potential of guava may result in cutting-edge medical tactics.

INTRODUCTION

Navigating a healthy lifestyle in today's modern world is riddled with challenges, primarily due to the presence of harmful chemicals in our food. The interconnected global dynamics of population expansion, technological progress, and the swift industrialization of society compound this issue. Beyond fostering a surge in chronic illnesses, these factors also contribute to escalating healthcare expenses and a general decline in people's overall quality of life. These factors also encourage the growth of chronic degenerative diseases such as metabolic syndrome, diabetes mellitus, dyslipidemia, and cardiac conditions (Sharma and Chandola, 2011; Remington and Brownson, 2011). Fruits, vegetables, and seeds should all be a part of our diets in order to reduce the risk factors associated with these diseases. These foods contain bioactive compounds that can help treat, prevent, and manage various health issues (Barbalho *et al*., 2011; Párraga *et al*., 2011). By consciously choosing these nutrient-rich foods, we can improve our overall well-being and reduce the impact of the challenges posed by the current scenario.The tropical fruit *Psidium guajava* (*P.guajava*) (Fig.1), which has a tart and sweet flavour, is a favourite. Due to its numerous therapeutic benefits in addition to its deliciousness, this fruit has a long history of use in conventional medicine. The comprehensive studies on various parts of the *Psidium guajava tree*, including the leaves, bark, roots, and fruits, have revealed their therapeutic applications for various diseases (Table 1). The abundant flavonoids, carotenoids, tannins, and phenolic chemicals in the plant have been shown in numerous studies to have anti-inflammatory, anti-diabetic, anti-microbial, anti-diarrheal, anti-hypertensive, anti-cancer, and anti-oxidant properties (Carrasco-Castilla *et al*., 2012). Guava is a fruit that originated in the tropics of the Americas, but it has since been widely farmed and dispersed around the world, including South Africa and India (Lima *et al*., 2018). The guava tree, a small tree that belongs to the Myrtaceae family, can thrive in regions with fertile soil and a tropical or subtropical climate. FAOSTAT (Manosroi *et al*., 2006) reports that China and India currently produce the most guava. Depending on the species, guava fruits can be round or oval and range in size from 4 to 12 centimeters (1.6 to 4.7 in). The fruit initially has a faint green tint, then ripens into a yellow color. The tree's leaves are coated with a deep green hue and have an acute point. They range in shape from elliptical to oval (Kumar *et al*., 2021). Apple guava is the guava cultivar that is most frequently bought (Chen and Yen 2007).There is evidence that several plant parts of guava, including the leaves, seeds, bark, and roots, contain antibacterial, anti-inflammatory, antiallergenic, anticar cinogenic, and immunostimulant properties. Its leaves are a rich source of flavonoids, particularly quercetin, which reduces bowel spasms and aids in the anti-diarrheal benefits of guava by relaxing intestinal smooth muscle (Joseph and Priya, 2011; Lok *et al*., 2023). Quercetin also has antimicrobial characteristics.In lab experiments, guava leaf extract has also shown anti-proliferative action, with activity levels greater than vincristine. In addition to quercetin, other polyphenolic substances found in guava that have been linked to its biological qualities include kaempferol, protocatechuic,

ferulic, ascorbic, gallic, and caffeic acids (Kumar *et al.*,2021). These polyphenols function as immunostimulants, possibly enhancing immunity and offering antioxidant advantages (Mittal *et al.*, 2010).Guava is a fruit that is packed with nutrients, including dietary fibre, vitamin- A, vitamins- C, folic acid, and minerals like potassium, copper, and manganese that are crucial for human health (Naseer *et al.*, 2018) (Fig.2). One guava fruit has four times the amount of vitamin - C in it than an orange, and it is a low-calorie but extremely healthy addition to any diet thanks to its wide spectrum of critical components. However, cultivation of guava is significantly affected by wilt disease caused by *Fusarium oxysporum f. sp. psidii* (FOP). Fusarium oxysporum is widely spread and commonly causes wilt diseases in various fruit crops, for example, in tomatoes (by *Fusarium oxysporum f. sp. Lycopersici* - FOL) (Gangaraj *et al.*, 2022; Mesa *et al.*, 2024). In this review, we have highlighted various therapeutic health benefits of consuming guava.

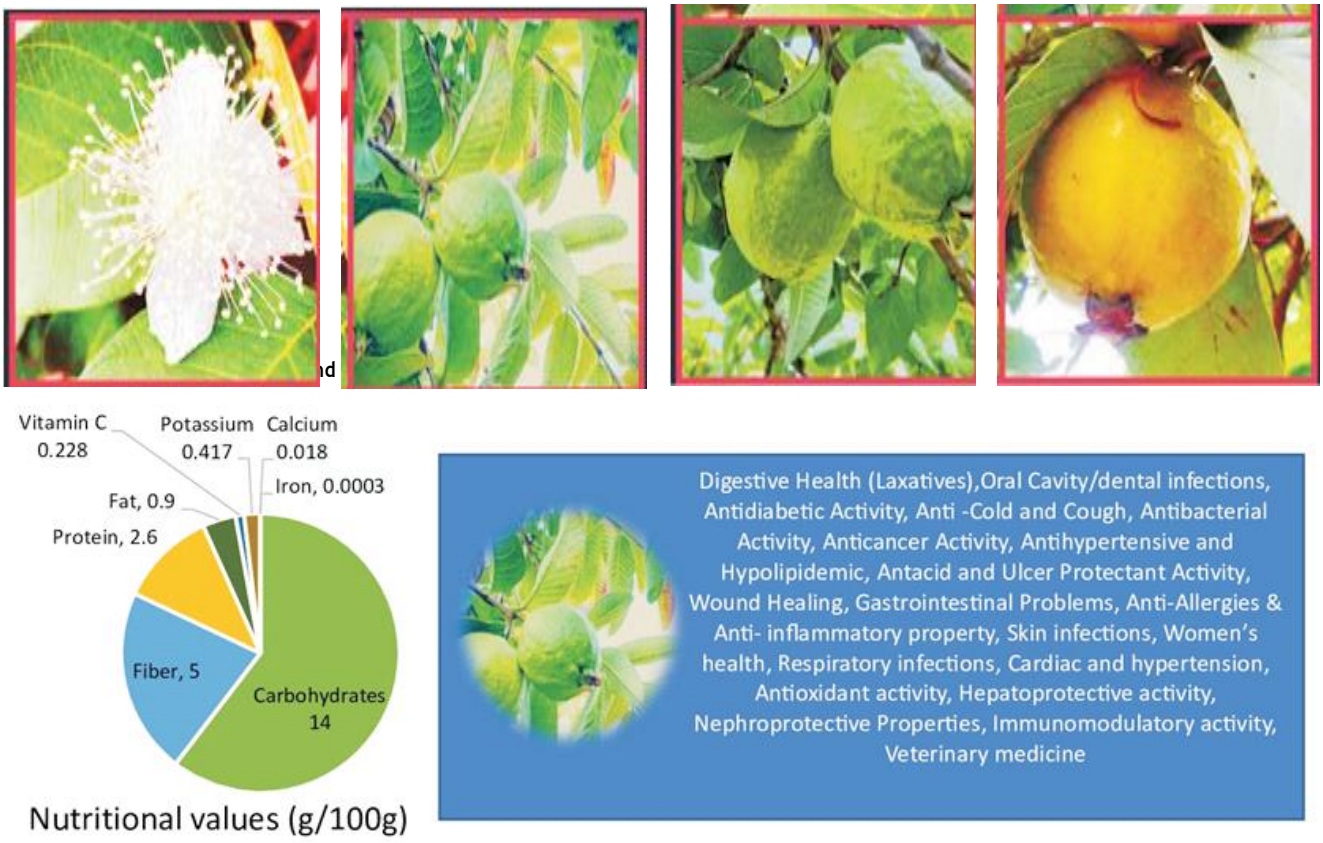


Fig.2 : Nutritional values and therapeutic effects of guava

Health Benefits of Guava

Digestive HeaLth (Laxatives)

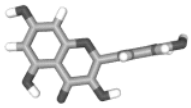
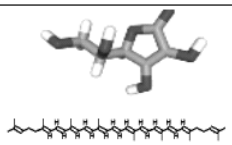
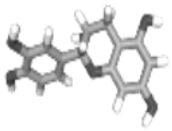
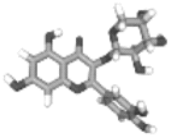
Guava, a fruit recognised for its high nutritional value, contains a significant amount of dietary fibre, making it an effective treatment for constipation. The guava plant's sensitive leaves are very high in fibre, which can both prevent and treat haemorrhoids and constipation. With 36 g of dietary fibre per 100 g of fruit, guava is one of the richest sources of fiber, and its seeds are also high-powered laxatives that can help with persistent constipation and clean up the bowel (Kapoor *et al.*, 2020). In addition, guava is packed with water soluble Vitamin C (ascorbic acid), and just one fruit can provide up to 12% of the recommended daily intake of fibre, making it an excellent choice for promoting digestive health (John *et al.*, 2013).

OraL Cavity/dentaL infections

Guava has been found to be effective in maintaining good oral health. The accumulation of dental plaque is the main cause of periodontitis, a gum disease that can ultimately lead to gingivitis and periodontitis (John *et al.*, 2013). Pathogens such *Porphyromonas gingivalis*, *Aggregatibacter actinomycest emcomitans*, *Fusobacterium nucleatum*, and *Prevotella intermedia* add to the issue (Razak *et al.*, 2006).

However, it has been discovered that the guava's high quercetin content provides antibacterial properties against these infections. In vulnerable microorganisms, it breaks the cell membrane and deactivates essential proteins (Bansal *et al.*, 2012). Thus, guava extract can effectively stop the growth of dental plaques without interfering with the homeostasis of the oral cavity (Shu *et al.*, 2011). Guava is also well recognized for having a lot of vitamin C in it, which makes it a great cure for scurvy and bleeding gums. Due to its astringent properties, guava is useful in treating toothaches and ulcers. According to Nordini Hasnor *et al.* (2013), chewing guava leaves can instantly relieve toothaches, and the guava leaves' folate content can prevent foul breath. Guava is commonly utilized in indigenous medicine all around the world to treat a range of oral disorders. In North Sikkim, guava leaves have been

Table 1: The Pharmacological effect of certain important substance found in gauava

Parts of guava	Compounds	Molecular structure of Important component (source Pubchem)	Effective property	Reference
Leaves	Phenolic chemicals including quercetin, gallic acid, catechin, epicatechin, rutin, naringenin, and kaempferol	 Quercetin (C15H10O7)	Anntimicrobial, Antioxidant and control hypertetion and hyperlipidemia	(Okwu and Ekeke, 2003; Gutierrez-Montiel et al., 2023; Hung-Hui et al., 2011; Ruksiriwanich et al., 2022; Mandal et al., 2022).(Obarzanek et al., 2001; Livingston Raja and Sundar, 2006).
Fruit	Carotenoids (lycopene, beta-carotene, and beta-cryptoxanthin) with ascorbic acid.	 Ascorbic acid (C6H8O6) and Lycopene (C40H56)	Antioxidant, anticancer and maintain healthy digestive system	(Yadav et al., 2010; Teixeira et al., 2003; Gutiérrez et al., 2008; Sharma and Chandola, 2011,Kapoor et al.,2020; Mandal et al., 2022).
Seed	High powdered laxatives, glycosides; Carotenoids, phenolic compounds such as ellagic acid, catechins and quercetin.	 Catechin (C15H14O6)	Antimicrobial and antioxidant activity; prevents the constipation and clean up the bowl; prevents the hypercholesterolemia	(Kapoor et al., 2020; Gutierrez-Montiel et al., 2023; Mandal et al., 2022; Obarzanek et al., 2001.)
Bark	Inorganic phenols such as guaijaverin and luteolin	 Guaijaverin (C20H18O11)	Potential antimicrobial, antioxidant activities anti-inflammatory and anticancer	(Guo et al., 2003; Dorsch et al., 2005; Lok et al., 2023; Gutierrez-Montiel et al., 2023; Ruksiriwanich et al., 2022; Mandal et al., 2022).

utilized to relieve dental pain and mouth sores (Pradhan and Badola, 2008). Guava leaves have also been used to cure mouth ulcers in Andhra Pradesh, India (Lingaiah and Rao, 2013). Guava leaves have been reported to have therapeutic benefits for treating dental and oral diseases, and guava twigs have been discovered to be useful as "chewing sticks" by traditional healers in Cameroon (Agbor and Naidoo, 2015; Okwu and Ekeke, 2003). The antibacterial effects of guava leaf extract against oral infections have been demonstrated in numerous studies. *Streptococcus* strains, such as *Lactobacillus casei* and *Streptococcus oralis*, which are frequently linked to tooth plaque and cavities, have been demonstrated to be significantly resistant to the extract (Ravi and Divyashree, 2014; Vieira *et al.*, 2014; Alves *et al.*, 2009). Additionally, research has shown that guava leaf extract, when administered at a concentration of 1 mg/ml, is particularly helpful in reducing dental plaque and cavities (Razak *et al.*, 2006). Along with other oral pathogens connected to the early phases of plaque development, the bactericidal effects of guava leaf extract in its aqueous form have also been reported against *Streptococcus sanguinis*, *Streptococcus mitis*, and *Actinomyces species*. Guava leaf extract may be utilized as a natural treatment for dental caries and other oral diseases brought on by these bacteria because the minimum inhibitory concentration (MIC) values for these bacteria ranged from 2.61 to 4.69 mg/ml (Razak *et al.*, 2006).

Antidiabetic Activity

It has been discovered that guava may have anti-diabetic benefits. Guava leaves are typically ingested in China on an empty stomach to manage diabetes. Both the fruits and leaves of the guava plant have been demonstrated in studies on mice at the Medicinal Research Laboratory in Allahabad to effectively lower blood sugar levels.The active chemicals present in guava leaves are believed to be responsible for this effect, as they have the ability to inhibit intestinal glycosidases, thereby reducing postprandial hyperglycemia (Grover *et al.*, 2002). Guava is a fruit with a high fibre content that is known to slow down the absorption of glucose from the gastrointestinal tract. As a result, a sharp increase in blood sugar levels following meals is less likely. Studies have shown that drinking guava tea instead of plain water as a control after eating white rice considerably reduces the rise in blood sugar levels (Sharma and Chandola, 2011). Guava has also been demonstrated to lower fasting blood glucose levels. For instance, one study revealed that giving Type 2 diabetics guava leaf decoction to drink with meals for 90 days reduced their fasting blood glucose levels. Guava fruit powder mixed with buttermilk is also a traditional medicine for diabetes in Andhra Pradesh and Tamil Nadu, India. Similarly, in the central part of Togo, guava was enumerated among the most commonly used plants and fruits for diabetes (Shen *et al.*, 2008; Gutiérrez *et al.*, 2008). Studies on both animals and people have investigated the potential of various guava plant sections as a potential antidiabetic medication (Deguchi and Miyazaki,

2010). In a study by Ojewole, it was discovered that both normal and streptozotocin-treated diabetic rats experienced a hypoglycemic response when given aqueous guava leaf extract orally at various doses (50 to 800 mg/kg) (Ojewole, 2005; Uuh-Narvaez *et al.*, 2021). The ability of the guava plant's fruit and bark to reduce blood sugar levels has also been investigated. The fruit extract (125 and 250 mg/kg) demonstrated significant hypoglycemic efficacy in diabetic animals produced by STZ (streptozotocin), whereas the ethanolic stem bark extract (250 mg/kg) was effective in lowering blood glucose levels in alloxan-induced hyperglycemic rats (Mukhtar *et al.*, 2004; Huang *et al.*, 2011).

Numerous cellular-level investigations have also looked at how various guava leaf extracts affect glucose absorption and aldose reductase inhibitory action. Furthermore, insights from Jayachandran *et al.*, and Beidokhti *et al.*, shed light on guava's influence on insulin signaling proteins and glucose uptake efficiency (Jayachandran *et al.*, 2020; Beidokhti *et al.*, 2020). Guava's potential in managing lipid levels, glucose metabolism, and insulin resistance has been a recurring theme in research (Khan *et al.*, 2013; Xu *et al.*, 2020; Zhu *et al.*, 2020). Luo *et al.*, and Shabbir et al., discuss the antidiabetic attributes of polysaccharides and polyphenols derived from guava leaves, with the latter also exploring the effects of extracts from guava pulp and seeds (Luo *et al.*, 2019; Shabbir *et al.*, 2020). Such antidiabetic effects, as Tella *et al.*, suggests, may be attributed to guava's ability to enhance glycogen synthase levels and restrict the activity of the enzyme glycogen phosphorylase (Tella *et al.*, 2019). Research extends beyond mere observation of glucose level regulation. Cellular studies have delved deep to understand the influence of various guava leaf extracts on glucose absorption and aldose reductase inhibitory action. Such detailed insights collectively suggest the therapeutic potential of guava components like leaves, fruit, and bark in antidiabetic medication and call for intensified research in this direction (Anand *et al.,* 2016).

Anti-CoLd and Cough

Due to its high content of iron and vitamin C, guava has been suggested as a potential treatment for cold and cough. These components have been found to alleviate congestion, reduce mucus formation in the respiratory tract, and help combat harmful pathogens. Reports claimed that these components in Guava act like a miracle in curing influenza (Jaiarj *et al.*, 1999). Guava leaves, particularly the young and tender ones, can be used as a decoction to relieve cold and cough symptoms. The fruit itself, whether raw or cooked, has also been found to have benefits. Its astringent properties can help inhibit microbial activity and loosen cough by breaking down mucus polymers. Guava fruit, which contains a lot of vitamin C (ascorbic acid), has also been shown to be useful against viral or bacterial illnesses. Cooked (roasted) ripe guava is a traditional remedy for severe cough and obstruction in several Indian regions. Recent studies have also shown that hydroextracts of guava leaves can significantly reduce coughing frequency induced by irritants like capsaicin aerosol Diving deeper into its anticough attributes, Jaiarj *et al.* (1999) probed into the anticough potential of guava leaf extracts, specifically on rats and guinea pigs. The researchers employed a dose of 30μmol of capsaicin to elicit cough in the animals. The subjects in the experimental groups received intraperitoneal doses of the extracts at concentrations of 1, 2, and 5 g/kg. The data gleaned from this study underscored that the extracts, when administered, curtailed cough frequency in a dose-proportional manner. Such findings reinforce the therapeutic prowess of Guava in managing cough-related ailments.

AntibacteriaL Activity

Guava extracts have been discovered to have antibacterial effects against both Gram-positive and Gram-negative species of bacteria. Studies have shown that guava leaves and bark extracts exhibit strong antibacterial activity against multidrug-resistant *Vibrio cholera*, indicating their potential in controlling epidemics of cholera. In some cultures, natural remedies like young and tender guava leaves are preferred for the treatment of infections in children as they exhibit good activity against intestinal microbes, including *Vibrio cholera*. Guava extracts have also been found effective against bacteria such as *E. coli*, which are otherwise resistant to many antibiotics. The antibacterial impact of the majority of essential oils and different guava leaf extracts has been examined using methanolic extract, demonstrating the effective inhibition of bacterial growth, particularly against *Staphylococcus aureus* (*S.aureus*) (Shu *et al.*, 2011; Prabu *et al.*, 2006).

The extraction of benzyl isocyanate from the methanolic extract of guava leaves, which shown inhibitory effect against *S. aureus*, is a remarkable mention by Dutta *et al.*, (2020). *P. aeruginosa*, *C. violaceum*, *S. aureus*, and *S. marcescens* were only a few of the bacteria whose virulence was found to be reduced by extracts from guava leaves (Patel *et al.*, 2019). Human pathogenic bacteria and plant pathogenic fungi, specifically C. lunata and F. chlamydosporum, were suppressed by the essential oil of P. guajava's senescent leaves (Chaturvedi *et al.*, 2021). The antibacterial effectiveness of guava extracts was demonstrated by Silva et al. (2018) against bacterial strains including *S. salivarius*, *Streptococcus* mutans: *Streptococcus mitis*, *Streptococcus sanguinis*, and *Streptococcus sobrinus*. According to a study, the essential oils from guava were tested for their antibacterial activity against *Enterococcus faecalis* and *S. aureus* at a range of concentrations, including 125, 250, 500, and 1000 g/ml (Weli *et al.*, 2019). Strong antibacterial effects were found by Morais-Braga *et al.* (2016b) against bacteria such *E. coli, Pseudomonas aeruginosa*, and *S. aureus*, with the extract exhibiting significant activity and having a MIC value of 256 g/mL. The chemicals identified from guava that inhibited the growth of *S. aureus*, *S. epidermidis*, and *Mycobacterium smegmatis* were further clarified by Huang *et al.* (2021).

Anticancer Activity

The presence of the antioxidant lycopene in guava makes it an effective shield in preventing and fighting cancer, especially breast and prostate cancer. Lycopene scavenges free radicals and prevents further formation of them. In cell line models, research has shown that guava leaf extracts have anti-prostate cancer activity, making them a promising anti-androgen-sensitive prostate cancer agent. It also contains carotene, which can help prevent lung and oral cancers (Yadav *et al.*, 2010; Ruksiriwanich *et al.*, 2022; Mandal *et al.*, 2022).

A recent comprehensive review of available literature has explored the potential anticancer properties of guava through laboratory investigations. The review suggests that guava may have various anticancer properties, including the ability to regulate gene expression, modulate cellular signalling pathways, repair DNA damage, and impact cell proliferation and apoptosis (Correa *et al.*, 2016; Lok *et al.*, 2023; Mandal *et al.*, 2022).

Taking MCF-7 cells as a model, Lin and Lin (2020) evaluated the effects of guava seed polysaccharides. The outcomes showed that MCF-7 cell viability was significantly and dose-dependently inhibited. Similarly, dos Santos *et al.* (2018) investigated the anticancer effects of red guava extracts. Their results demonstrated the potency of an extract from guava high in lycopene, with an IC50 value of 29.85 at 5.964 g/mL. Guava was shown to have particular chemicals that had anticancer effects on HCT116 and HT29 cells, according to Zhu *et al.* (2019). Guava has been shown to have potent inhibitory activity against cancer cells by Ashraf *et al.* (2016), as shown by an IC50 value of less than 30 mg/ml. Tetracosane, vitamin E, and g-sitosterol, three of the guava's bioactive components, are thought to be the source of the fruit's anticancer effects (Ryu *et al.*, 2021).

Bazioli *et al.* (2020) looked into the P. guajava extracts' antiestrogenic properties. Studies on 17- β -estradiol injected MCF7 BUS cells and female Wistar rats were conducted in vitro and in vivo, respectively. One million MCF7 BUS cells per milliliter in the presence of 10-9M 0.3, 0.6, 1.25, and 2.5 µg/mL of fractionated P. guajava extracts were used to treat 17- β -estradiol. The rats in the experiment were given 0.3 mg/kg of 17- β -estradiol as an injection, and they were given extracts fractionated from P. guajava at doses of 12.5, 25, and 50 mg/kg for three days. The findings from experiments conducted in vitro and in vivo demonstrated that the injection of extracts inhibited the proliferative activity of 17- β -estradiol, indicating its antiproliferative properties.

AntidiarrheaL property

Guava leaves have been found to possess strong antidiarrheal properties. Consuming 6-10 fresh and tender guava leaves boiled in warm water on an empty stomach can effectively control diarrhoea. The leaves contain high levels of flavonoids, which contribute to their antimicrobial activity against pathogens responsible for diarrhoea, such as *giardia* and *rotavirus* (Birdi e*t al.*, 2010; Gutierrez-Montiel *et al.*, 2023). Guava bark has been traditionally used as a treatment for diarrhoea in children due to its astringent properties. On the other hand, a tea made from guava leaves or an extract of guava leaves in warm water can help promote bowel movement. A study found that guava leaf extract may be helpful for lowering the severity and frequency of rat castor oil-induced diarrhea. According to Lozoya *et al.* (2002), these results were attributed to the extract's influence on intestinal peristalsis. A study by Koriem *et al. (*2019) looked at how guava extracts helped rats with osmotic diarrhea that was caused by a lactose-containing diet. Desmopressin served as the reference medication, and the rats received daily doses of 50 and 100 mg/kg of the extract. Getting the serum electrolytes and urine output back to normal showed that the extract could stop diarrhea. Moreover, the level of lipid peroxidation dropped.The antidiarrheal properties of guava extracts in rats against enteropathogenic *Escherichia coli* were examined in a different study by Hirudkar *et al.* (2020). The study's findings demonstrated that giving the subjects the extract reduced their weight, frequency of feces, and overall frequency of diarrheal stools. By examining the recovery of WBC, Hb, and platelet values, this experiment further demonstrated the extract's antidiarrheal capabilities.

Antihypertensive and HypoLipidemic

Guava is well known for its beneficial effects on heart disease, hypertension, and hyperlipidemia. Its high potassium level aids in blood vessel relaxation, which lowers blood pressure. Due to its greater potassium and fiber content, regular eating of guava fruit has been demonstrated to considerably lower blood pressure and blood lipids. Guavas have a high amount of pectin, which has been discovered to slow down food absorption and significantly lower blood lipid levels as well as the risk of cardiovascular diseases (Singh *et al.*, 1993).

Gallic acid, catechins, epicatechins, rutin, naringenin, and kaempferol are among the compounds found in guava leaves that have been demonstrated to inhibit the pancreatic cholesterol esterase enzyme, lowering blood levels of lipids (including cholesterol). One of these compounds that is essential for avoiding hypercholesteremia is catechins (Deguchi and Miyazaki, 2010). Guava's quercetin has also been linked to a lower risk of cardiac and stroke mortality brought on by hypertension and hyperlipidaemia (Obarzanek *et al.*, 2001). Guava's modest potassium content is what gives it its capacity to strengthen heart health and prevent stroke.

Antacid and ULcer Protectant Activity

Guava has long been utilised as a homoeopathic treatment for ulcers and hyperacidity. Guava leaves are good at reducing stomach hyperacidity due to their alkaline composition. Young guava leaves are boiled in water in many areas to make guava tea, which is then served hot to reduce acidity. Research has shown that the methanolic extract of guava has antacid and ulcer healing properties, with the highest efficacy observed *in vitro* (Livingston Raja and Sundar, 2006).

Flavonoids and saponins present in both guava fruit and guava leaves have been found to counteract acidity and prevent ulceration of the stomach. The methanolic extract of guava leaves (500 mg and 1000 mg/kg body weight) significantly lowers ulcer index in ethanol-induced ulcers, according to studies in rats (Uduak *et al.*, 2012).

Wound HeaLing

For centuries, Guava leaves have been used as a traditional remedy for wound healing. Ancient people in India and China would grind the leaves and made into paste with water or oil content and apply it directly to the wound. Studies have shown that the tannins and flavonoids in Guava leaves can promote faster healing of wounds when applied topically in the form of a methanolic extract. In fact, ointments made from Guava leaves have been found to be more effective than commercially available wound care products. To produce the ointment, guava leaves are first washed, ground, and extracted with oil. The resulting extract is then mixed with a vehicle, which is

typically melted candle wax, to improve absorption. The resulting compound can be applied twice daily for four days to treat wounds (Okoli *et al.*, 2009).

GastrointestinaL ProbLems

Guava leaves contain quercetin and flavonoids that have been shown to effectively treat a range of gastrointestinal issues (Arima and Danno, 2002). The alkaline properties of guava discourage the growth of harmful microbes that can cause gastroenteritis. Both the fruit and leaves of the guava plant can help alleviate diarrhoea by inhibiting the growth of microbes and binding loose stools. Furthermore, guava is rich in vital vitamins and minerals like vitamin C, potassium, and carotenoids, which help maintain a healthy digestive system (Arima and Danno, 2002; Teixeira *et al.*, 2003). Consuming guava leaves on an empty stomach can aid in the removal of extra mucus from the large intestine, while occasionally sipping guava leaf tea can help control the consistency and degree of stiffness of the stools. Guava has long been a well-liked traditional treatment for gastrointestinal illnesses such diarrhoea, dysentery, indigestion, and stomach aches (Gutiérrez *et al.*, 2008). For instance, in Mexico, guava was mentioned as one of the species used to cure gastrointestinal diseases, while in India, local traditional healers advise drinking hot water with guava bark powder to treat blood-associated diarrhoea (Heinrich *et al.,* 1998). Guava leaves have been used to treat diarrhea in Maharashtra and South Assam (Tetali *et al.*, 2009; Choudhury *et al.*, 2015). There have been a lot of laboratory studies on the potential medical use of guava leaves. By inhibiting diarrheal bacteria, regulating intestinal motility, lowering the frequency of stools, and promoting gastric emptying, guava leaves have been demonstrated to have antidiarrheal efficacy in both in vitro and animal experiments.

Guava leaf extracts at 5% and 10% concentrations are very effective against pathogens like *Shigella flexneri* and *Vibrio cholerae* that cause bacterial diarrhea (Birdi *et al.*, 2010; Birdi *et al.*, 2011). Tona *et al.* (1998) also found that guava leaf extracts stop *Entamoeba histolytica* from growing and lessen the contractions caused by acetylcholine and/or KCl solution. Guava leaf extracts are able to postpone the onset of diarrhoea, lessen the frequency of faeces, and lessen the severity of the condition, according to tests conducted on animals. Furthermore, they reduce the rate at which rats move charcoal food and block prostaglandin E2 enteropooling (Lin *et al.*, 2002). Guava leaf decoction (1%, 5%, and 10%) has been found to inhibit colonization of bacteria on the epithelial cells, toxin production, and inflammatory response (Brijesh *et al.*, 2011) and has been shown to promote gastric ulcer healing and reduce capillary permeability in the abdominal cavity (Livingston Raja and Sundar, 2006). Although quercetin is a significant component in guava leaf, it has been discovered that the crude guava decoction has greater antidiarrheal efficacy than quercetin by itself (Birdi *et al.*, 2010). As a result, guava leaves show potential for treating both acute and chronic diarrhoea brought on by a variety of bacterial infections.

Anti-ALLergies

The possible anti-allergy effects of Psidium guajava leaves have been studied recently. The activation of T regulatory cells from CD^{4+} splenocytes of C57BL/6 mice by IL-10 and the release of histamine by mast cells can both be inhibited by the methanol and aqueous extracts of the leaves, according to studies. Furthermore, it has been found that the extracts reduce T regulatory cell activity, which shifts the Th1/Th2 balance to a Th1-dominant state.Guava leaf extracts have been demonstrated in animal experiments to lessen allergy reactions brought on by T cells. According to these findings, guava leaves may be helpful in the treatment of allergies (Seo *et al.*, 2005).

Anti- InfLammatory

In traditional medicine, guava leaves have been used to treat inflammatory conditions including rheumatism (Gutierrez *et al.*, 2008). Studies have demonstrated that guava leaf extracts, whether in methanol or aqueous form, have anti-inflammatory and antipyretic activities. In an experiment involving rats with carrageenan-induced paw edema, the methanol extract of guava leaves displayed anti-inflammatory benefits at dosages of 50, 100, and 200 mg/kg (Olajide *et al.*, 1999). Similar to this, an aqueous extract of guava leaves was given to rats with fresh egg albumin-induced edema via IP (50–800 mg/kg), which decreased acute inflammation (Han *et al.*, 2011). Guava leaves have an extensive tradition of use in India as rheumatism medication. In addition, mice with yeast-induced hyperpyrexia were given guava leaf methanol extract at doses of 50, 100, and 200 mg/kg, which had antipyretic effects similar to those of regular indomethacin (5 mg/kg) (Olajide *et al.*, 1999).

Skin infections

Many cultures have a long history of using guava as a traditional remedy for skin problems. In the Philippines, for instance, natives use guava leaves to cure scabies (Ong and Kim, 2014), and Tahiti and Samoa have used guava shoots as a skin tonic (Han, 1998). Other countries with a history of employing various guava portions for skin-related illnesses include Panama, Bolivia, Venezuela, Fiji, and Senegal, according to Gupta *et al.* (2011). Studies have shown that guava leaves have antibacterial properties and are effective against clinical isolates of bacteria like *Proteus mirabilis*, *Streptococcus pyogenes*, *E. coli*, *S. aureus*, and *Pseudomonas aeruginosa*, which are frequently linked to surgical wounds, burns, and skin and soft tissue infections (Abubakar , 2009). Atopic skin lesions in mice brought on by 2,4-dinitrochlorobenzene have been successfully treated with cream containing guava leaf extract (Choi *et al.*, 2012) and guava leaf extract in the form of ethyl acetate has shown to be efficient in treating atopic dermatitis (Han *et al.*, 2011).

Women's heaLth

In traditional medicine, guava has a long history of use for female health-related ailments. Tahiti, for example, has utilized guava to treat early labor, uterine bleeding, painful menstruation, and miscarriages in women (Han, 1998). Guava has been identified as a treatment for blennorrhea, irregular menstrual cycles, and postpartum bleeding in a study (de Boer and Cotingting, 2014). Guava leaf decoction has been used to treat menstrual irregularities in Durgapur, Bangladesh (Khan *et al.*, 2015). A double-blinded, randomized clinical trial including 197 women with primary dysmenorrhea was conducted to evaluate the effectiveness of guava leaf extract. Ibuprofen (1200 mg/day), guava leaf extract (3 mg and 6 mg flavanol/day), and placebo (3 mg/day) were given to each of

the four experimental groups. To measure how much the stomach discomfort diminished during the study, a visual analogue scale was employed. According to Dougova *et al*. (2007), the group receiving 6 mg/day of guava leaf extract experienced significantly decreased overall pain.

Respiratory infections

Guava leaves have long been utilised as a cough treatment in a number of places, including Guerrero, Mexico, Malaysia,

South Africa, Arunachal Pradesh, and North Sikkim, India (Daswani *et al*., 2017; Namsa *et al*., 2011; Pradhan and Badola, 2008). Guava has been used to cure tuberculosis traditionally in various parts of the world. For instance, guava bark has been used for this purpose in Nigeria, while guava leaves have been used to treat HIV-AIDS , tuberculosis in Tanzania (Ogbole and Ajaiyeoba, 2009; Kisangau *et al*., 2007). Animals may benefit from aqueous guava leaf extract as a cough suppressant. In guinea pigs and rats, oral administration of the extract at doses of 2 g/kg and 5 g/kg considerably reduced cough frequency by 35% and 54%, respectively (Jaiarj *et al*., 1999). Additionally, *Cryptococcus neoformans*, *Klebsiella pneumonia, Moraxella catarrhalis*, *Mycobacterium smegmatis*, and *S. aureus* have been demonstrated to be eliminated by guava leaf extract and dichloromethane-methanol extract (York, 2012). Although additional research is required to prove the plant's efficacy and safety, these traditional applications of guava raise the possibility that it may have therapeutic promise for the treatment of tuberculosis.

Cardiac and hypertension

Guava leaves have been used to treat hypertension for centuries in several nations, including Cuba, Nigeria, and Togo (Mesa, 2014; Borokini and Clement , 2013; Karou *et al.,* 2011). In laboratory tests, aqueous guava leaf extract was shown to have cardio preventive benefits and to drastically lower blood pressure and heart rates in hypertensive rats (Ojewole, 2005). Furthermore, rats' intracellular calcium release has been shown to be inhibited by guava leaf extracts, and the aorta rings are markedly constricted in a dose-dependent manner (0.25–2 mg/ml) (Belemtougri *et al*., 2006; Olatunji Bello *et al*., 2007). Clinical studies have shown that guava fruit consumption can have positive benefits on cardiovascular health. The consumption of guava fruit has been shown to improve high-density lipoprotein cholesterol levels while decreasing serum total cholesterol, triglycerides, and blood pressure in treated patients (Singh *et al*., 1992). In another clinical research, hypertension patients were given a potassium- and fibre-rich diet that included 0.5–1 kg of guava per day for four weeks (Singh *et al.,* 1993). These patients' diastolic and systolic blood pressures improved. Additionally, 400 gm of guava fruit per day for nine weeks was found to reduce oxidative stress and blood cholesterol levels in a clinical experiment conducted in Malaysia (Rahmat *et al*., 2004). These suggest that guava fruit may be a valuable dietary intervention for improving cardiovascular health.

Antioxidant activity

Recent research has shown that guava possesses exceptional antioxidant qualities (Okwu and Ekeke, 2003; Kapoor *et al*., 2020; Mandal *et al*., 2022). The methanolic extract of guava leaves exhibits strong antioxidant activity. Quercetin, quercetin-3-O-glucopyranoside, morin, ascorbic acid, carotenoids, and polyphenols are only a few of the advantageous phytochemicals that contribute to this activity. These substances are essential for preventing oxidative stress and neutralising dangerous free radicals in the body (Jimenez-Escrig *et al.,* 2001).

The Guava plant's antioxidant potential emphasises its relevance as a great source of naturally occurring antioxidants with possible health benefits.Tan *et al*. (2020) embarked on research to compare the antioxidative capacities of extracts from red and white Guava fruits using varying drying procedures. Their study highlighted that the red Guava powders obtained via vacuum drying exhibited the most significant antioxidant activity. Sobral-Souza *et al*. (2018) focused on the antioxidative capabilities of flavonoids derived from Guava extracts. In another study, Luo *et al*. (2019) revealed the impressive antioxidant properties of polysaccharides from guava leaves. These polysaccharides augmented the overall antioxidant activity and the action of the superoxide dismutase (SOD) enzyme while simultaneously reducing MDA (malondialdehyde) activities in diabetic mice induced by STZ. Moreover, a methanolic extract of Guava leaf was shown to possess antioxidant qualities (Khedr *et al*. (2021).

According to Zahin *et al*. (2017), guava fractionated in methanol has greater antioxidant activity than guava fractionated in other solvents such gasoline, benzene, acetone, and ethyl acetate. From guava, Feng et al. (2015) extracted a number of chemicals and evaluated their antioxidant capacities. When tested using a DPPH (2,2- diphenyl -1-picrylhydrazyl) assay, the substances guavinoside C, guavinoside F, quercetin, quercetin-3-O-a-L-arabinofu ranoside, and quercetin-3-O-a-L-arabinopyranoside were discovered to possess potent antioxidative properties. According to Hartati *et al*. (2020), the guava extracts' strong antioxidant activity may be largely related to their high phenolic component content.

Hepatoprotective activity

The leaves of guava have been found to possess a hepatoprotective activity (Roy *et al*., 2006). In an experiment, the aqueous extract of these leaves was shown to protect healthy clone 9 liver cells from injury induced by a 5% alcohol concentration for 30 minutes. Among various extracts tested, hot water extracts exhibited high hepatoprotective effects with lower cytotoxicity. These findings suggest the potential use of guava as a natural remedy for protecting the liver (Hung-Hui *et al*., 2011; Luiza and Gustavo, 2017).

Studies have shown that Psidium guajava extract has hepatoprotective properties at dosages of 250 and 500 mg/ kg. The aqueous leaf extract was found to significantly reducehigh levels of alanine aminotransferase, alkaline phosphatase, bilirubin, and aspartate aminotransferase when administered orally to rats with acute liver injury brought on by hepatotoxins (Roy *et al*., 2006). Guava leaf extract could be employed as a drug to treat and protect the liver. These imply that Psidium guajava extract may be helpful in the treatment of hepatic diseases. Vijayakumar *et al*. (2020) also evaluated the hepatoprotective properties of guava against liver damage brought on by carbon tetrachloride in rats. Carbon tetrachloride (CCl4) at the amount of 1.5 mL/kg was intentionally given to

these rats to cause hepatotoxicity. The liver biomarkers (ALT, AST, ALP, and GGT) that were raised as a result of the CCl4 exposure were decreased after the extract was taken orally every day for 21 days. Additionally, Saber *et al*. (2018) investigated how Guava and P. cattleianum worked together to protect rats' livers from liver toxicity brought on by paracetamol. They discovered that giving the extract at doses of 250 and 500 mg/kg significantly decreased the increased levels of liver enzymes, hence reducing hepatotoxicity. In a separate study, Vijayakumar *et al*. (2018) found that administering guava extract to rats with liver damage brought on by exposure to CCl4 at doses of 100, 200, and 300 mg/kg, bw, and 20 mg/kg of the quercetin component resulted in a reduction in lipid metabolism. The capacity of triterpenoid-enriched guava leaf extract to lower blood ALT (alanine transaminase) and AST (aspartate transaminase) levels, as well as liver ROS (reactive oxygen speices)and MDA in mice exposed to acetaminophen, was emphasized by Li *et al*. in (2021). Furthermore, according to Li *et al*. (2020), giving mice which suffered liver damage as a result of acetaminophen exposure 100 mg/kg/day of Guavinoside B, derived from guava fruit, significantly improved both serum and hepatic biochemical markers.

Nephroprotective Properties

Extraction from Guava has nephroprotective qualities. The ability of guava extracts to prevent kidney impairment brought on by some medications and medical disorders has been shown in studies utilising animal models. For instance, ethanolic extracts of guava leaves were reported to prevent renal impairment brought on by paracetamol when given orally and to maintain blood urea, blood creatinine, urine sodium, and creatinine in a dose-dependent manner when given at 200 and 400 mg/kg. The study of histopathology corroborated this observation (Patel *et al.*, 2011). In a similar way, the extracts were reported to shield rats against cisplatin-induced nephrotoxicity (Patel *et al.*, 2012). Additionally, research on diabetic rats has revealed that guava fruit extract can prevent kidney damage (Lin and Yin, 2012).

ImmunomoduLatory activity

In one study, it was found that a decoction of guava leaves successfully killed a strain of *E. coli* that generates a heat-stable toxin in the murine monocytic cell line J774 by stimulating macrophages (Birdi *et al.*, 2014). In antigen-stimulated mast cells, the ethyl acetate fraction of guava leaves reduced COX-2 expression, cytokine secretion, degranulation, and FceRI-mediated signaling (Han *et al.*, 2011). In an in vitro model system utilizing Labeo rohita head kidney macrophages, a flavonoid fraction of guava leaf extract also demonstrated promise in regulating nuclear factor KB activation (Sen *et al.*, 2015).

Veterinary medicine

Guava leaves and buds have been found to possess antidiarrheal activity and have been used in veterinary medicine (Lans *et al.*, 2000). For treating diarrhoea in rumin ants, sheep, and goats, Javan farmers use various guava plant spieces. In particular, guava leaves are used to treat diarrhoea in ruminants, while sheep and goats are treated for the same ailment with the plant's root and stem bark (Mathias-Mundy and Murdiati ,1990). In Trinidad, for horses suffering from diarrhoea, a mixture of boiled guava leaves, young fruits, and/ or buds is prepared with mash or bran (Lans *et al.*, 2006). Meanwhile, in the Philippines, adding dried and ground guava leaf meal to pig diets in proportions of 5% and 10% has been found to be effective in reducing diarrhoea in piglets . In Thailand, supplementing the diet of weaned piglets with ground guava leaves has been observed to prevent post-weaning diarrhoea (Tartrakoon *et al.*, 2005). Furthermore, guava has demonstrated antibacterial activity against pathogenic bacteria in pigs.

Downsides of Guava Consumption

Guava intake, like any other food, has some downsides to consider. Allergic responses to guava are uncommon but possible, so people with documented fruit allergies should proceed with caution (Cubero *et al.*, 2005). Guava's oxalates content, which can help cause kidney stones in those who are sensitive, is one cause for concern (Moein *et al.*, 2015). Further, the vitamin K concentration in guava may interact with anticoagulant drugs, reducing their effectiveness (Alqahtani *et al.*, 2016). Another factor to consider is that the mild acidity of guava can lead to dental enamel loss and tooth discomfort if ingested in large quantities (Al-Dlaigan *et al.*, 2017).

CONCLUSION

Over the past decade, substantial studies have proven the ethnomedicinal uses of Guava leaves, establishing their promise as a cure for many common ailments worldwide. Guava leaves contain quercetin, catechin, gallic acid, peltatoside, hyperoside, isoquercitin, and guaijaverin, which offer health advantages. Guava skin contains polyphenols, vitamins A and C, iron, phosphorus, calcium, and other minerals. It harbours anti-cancer phenolic chemicals that reduce skin aging. Guava leaves act as antioxidants, bacteriostatic, and fungistatic. Due to these traits, Psidium guajava can treat and prevent several diseases. Public health is increasingly burdened by chronic degenerative diseases such as diabetes, dyslipidemia, metabolic syndrome, and cardiovascular disease. Researchers are studying the bioactive chemicals present in *P.guajava* leaves, bark, and seeds to address this rising concern. Medicinal plants like guava may reduce disease risk factors and offer alternative treatments, considering the high expenses associated with allopathic therapies.

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