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Methods For Isolation Of Bioactive Compounds From Guava Leaves

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ABSTRACT: In several engineering domains, the properties of bioactive chemicals derived from guava (Psidium guajava L.) leaf extract, their biological activity, and their technological uses are crucial subjects. Guava leaf extract contains a variety of bioactive substances, like alkaloids, terpenes, tannins, flavonoids, phenolic acids, etc. Guava leaf bioactive chemicals show significant synergistic effects in antibacterial, anti-inflammatory, and enzyme inhibition. Although the use of natural bioactive chemicals is promising, their sensitivity and fragility during storage make them complex. Although the use of natural bioactive chemicals is promising, their sensitivity and fragility during storage make them complex. Consequently, sophisticated methods like encapsulation, microemulsion, and a promising method may be the nanosuspension of such naturally occurring bioactive substances. These techniques are especially crucial for the creation of additive agents—natural preservatives—that have substantial industrial applications. To promote the functional advantages of guava leaf extract and make a health claim about it, however, adequate scientific proof is needed. Recent studies on guava leaf extract and its technical applications are the main topic of this review. Along with their analytical techniques, nutritional bioavailability, biological activity and synergistic effects, bioactive substances' chemical structures are demonstrated. Additionally, this review study takes into account the techniques for safeguarding the technical advancements and active ingredients in food, medicine, and cosmetics.

Keywords: bioactive compounds; Psidium guajava; guava leaf extract; biological activity; technological applications

1.INTRODUCTION

Guava, or Psidium guajava L., is mostly grown in tropical and subtropical locations throughout a number of nations. Guava is well renowned for its ability to heal a variety of medical conditions, including diabetes, vertigo, skin issues, jaundice, and cerebral disorders. It contains a lot of vitamins, essential oils, tannins, triterpenoids, flavonoids, phenolics, and sesquiterpene alcohols, glycosides, and saponins. referred to for their beneficial antimicrobial, antioxidant, and anti-inflammatory properties, rutin, naringenin, gallic acid, catechin, epicatechin, kaempferol, isoflavonoids, and flavonoids like quercetin and guaijaverin are the main components of guava leaves[1].Therefore, guava leaves extract are used to treat dysentery, diarrhea, stomachaches, gastroenteritis, indigestion, diabetes, hypertension, inflammation, rheumatism, fever, lung illnesses, and ulcers are thus treated with preparations made from the leaves of Psidium guajava[1]. The study of several secondary metabolites that are isolated from Psidium guajava leaves has drawn more attention in recent years in an effort to comprehend their mechanisms of action, accurately assess their efficacy, maximize their use, and avoid adverse effects.

To increase the yield, purity, and bioavailability of bioactives like flavonoids, tannins, and phenolic acids, advanced extraction techniques for bioactive compounds from plant materials are currently being used, including enzyme-assisted, ultrasound-assisted, and microwave-assisted methods[2]. Because they shield these delicate substances from deterioration while guaranteeing their regulated release and stability in a variety of matrices, encapsulation techniques like spray drying, microencapsulation, and nanoencapsulation are gaining popularity[3]. These encapsulated bioactives have been successfully added to a variety of food systems, such as meat products, baked goods, and functional beverages, proving their capacity to improve nutritional content, prolong shelf life, and offer health advantages[3].One of the main methods for obtaining bioactive compounds from naturally occurring plant sources is extraction. Based on variations in solubility, this method is described as a separation process. A solvent is used to separate and solubilize a solute from other substances that are less soluble in it. Solid-liquid extraction and liquid-liquid extraction are the two categories of extraction processes that are frequently distinguished. Using the guava leaf extract method, bioactive substances are mass transferred from a solid to a liquid state[4].

2.BIOACTIVE COMPOUNDS FOUND IN GUAVA LEAVES

In addition to its nutritional benefits, guava (Psidium guajava L.) is well-known for its abundance of phytochemicals, which can result in a variety of pharmacological effects. The plant's medicinal potential is influenced by its rich and varied phytochemical compositions, and the potential varies depending on the plant's components (leaves, fruits, bark, and roots). Numerous investigations have proven that flavonoids, tannins, saponins, carotenoids, alkaloids, essential oils, and phenolic acids are physiologically active substances. Pharmacological characteristics of these components include anti-inflammatory, anti-oxidant, antibacterial, antidiabetic, anticancer, and most importantly, antiulcer[5].

Flavonoids

One prominent class of phytochemicals, particularly those found in P. guajava leaves, is flavonoids. Quercetin, the most well-known flavonoid molecule, is a potent antioxidant with potent antibacterial and anti-inflammatory properties. Quercetin plays a significant role in antiulcer therapy since it is highly dependent on Helicobacter pylori, stomach inflammation, and mucosal protection. Kaempferol, rutin and morin are the other significant flavonoids; they function as vascular protectants, enzyme inhibitors, and free radical scavengers. Additionally, these substances work in concert to increase the pharmacological effect of guava extracts overall[6].

Tannins

High levels of astringent polyphenolic chemicals, or tannins, are found in guava leaves and bark. Gallic and ellagic acids are the two primary forms found in P. guajava. These hydrolyzable tannins are responsible for the plant's antibacterial and antidiarrheal properties. One of the key mechanisms of guava's antiulcer effect is its capacity to establish a protective layer over the stomach mucosa and precipitate proteins due to the presence of tannins. Additionally, they can bind to their viral proteins and enzymes, which are particular to gastrointestinal infections, and so impede the growth of bacteria[7].

Saponins

Saponins are glycosidic chemicals that are recognized for their ability to form complexes with cholesterol and for their foaming properties. P. guajava's saponins are responsible for its immunomodulatory and anti-inflammatory properties. They play a part in immune response modulation, mucus secretion, and stomach mucosal damage prevention. By altering intestinal permeability, saponins may also enhance the absorption of some medications and nutrients[8].

Terpenoids

Terpenoids, sometimes referred to as isoprenoids, make up the biggest class of secondary metabolites found in plants. Terpenoids are divided into monoterpenes, sesquiterpenes, and diterpenes based on isoprene units.Tetraterpenes, triterpenes. They have a variety of functions in plants, including pollination of seed crops, wound scaling, thermotolerance, and defense. Additionally, terpenoids give fruits their flavors and flowers their fragrances. They are also in charge of the quality of agricultural products[9].

Glycosides

Plant secondary metabolites known as glycosides are composed of two parts: aglycone, a non-carbohydrate component, and glycone, a carbohydrate component. Typically, the former part contains one or more glucose units, and the latter might be any of the secondary metabolites of terpenoids, phenolics, or alkaloids found in plants. The pharmacological significance of anthraquinone glycosides, steroidal (cardiac) glycosides, and coumarin glycosides is not restricted to these glycosides alone[10].

3.BIOLOGICAL PROPERTIES AND SYNERGY EFFECT

Guava leaf extracts contain chemicals with a variety of biological activity, such as hypoglycemic, anticancer, and antioxidant properties. Antimicrobial properties, specifically antibacterial, antiviral, and antiplasmodial actions, form the basis of the second group. The third category delves deeper into the impacts of metabolism and inflammation, including antihyperglycemic, anti-inflammatory, and activities that prevent diarrhea[11].

Anti-inflammatory

Inflammation is the cause of numerous acute and chronic illnesses, including gastrointestinal disorders, cardiovascular diseases, asthma, arthritis, and many more. It has been discovered that P. guajava extracts, particularly those from the leaves and bark, have strong anti-inflammatory properties.Ellagic acid, quercetin, and saponins limit the expression of certain enzymes, including COX 2 and iNOS, and inhibit several proinflammatory cytokines, including TNF-α, IL-1β, and IL-6. It accomplishes these via reducing inflammation and pain through elimination, supporting the historic use of guava leaves for rheumatism, wounds, and sore throats[12].

Anti-microbial

Numerous organic and inorganic antioxidants, together with anti-inflammatory substances, are thought to be responsible for the antibacterial qualities of guava leaves. Strong antibacterial activity against Pseudomonas aeruginosa, Escherichia coli, Streptococcus faecalis, Staphylococcus aureus, and Bacillus subtilis is demonstrated by the essential oils of guava leaves[13].

Anti-cancer

Psidium guajava contains a number of compounds with anticancer and chemopreventive qualities.Quercetin, lycopene, and other polyphenols are to stop tumor cells from proliferating, limit angiogenesis (the formation of new blood vessels), and induce apoptosis (programmed cell death).Guava extracts have been shown in several trials to protect against cervix, colon, prostate, and breast cancers. PI3K/Akt, MAPK, and NF-κB are among the signaling pathways that are hypothesized to be modulated in the anticancer impact. Even if the majority of research is preclinical, it raises the prospect of creating anticancer medications based on guava[14].

Anti-oxidant

Numerous organic and inorganic antioxidants, together with anti-inflammatory substances, are thought to be responsible for the antibacterial qualities of guava leaves. Strong antibacterial activity against Pseudomonas aeruginosa, Escherichia coli, Streptococcus faecalis, Staphylococcus aureus, and Bacillus subtilis is demonstrated by the essential oils of guava leaves[15].

4. ADVANCES IN EXTRACTION TECHNOLOGY

Extraction techniques are separating procedures based on differences in solubility.A solvent is used to separate and solubilize a solute from other substances that are less soluble in it. Bioactive components are mass transferred from solid to liquid form using the GLEprocess.Conventional extraction methods like maceration, decoction, and Soxhlet extraction are frequently distinguished from sophisticated extraction methods like ultrasound-assisted extraction,enzyme-assisted extraction,vacuum-assisted extraction , microwave-assisted extraction. A traditional extraction method called maceration relies on the organic diffusion of soluble compounds from plant materials into a solvent[16].

Use of a concentration gradient, the solvent dissolves the target compounds after penetrating the plant cell walls. Maceration is less effective and time-consuming than modern methods. Plant materials are extracted for 24 to 72 hours at room temperature (25 °C) using solvents such as ethanol solution, n-butanol, ethyl acetate, or chloroform.

The decoction technique is a conventional extraction method that releases bioactive components into the aqueous phase by breaking down plant cells through heat treatment.Water's ability to effectively remove polar and hydrophilic compounds makes it a common solvent.The use of only water and high temperatures, which restricts the extraction to water-soluble chemicals, is blamed for the lower yield.Soxhlet extraction is a continual reflux process, the solvent constantly draws out the bioactive ingredients from plant materials.This method uses heat to improve diffusion and solubility.Soxhlet extraction used Soxhlet apparatus to perform continuous extraction for 48 hours.UAE breaks cells and enhances the transport of intracellular chemicals into the solvent by using ultrasonic waves to produce cavitation bubbles in a liquid that collapse and produce strong shear stresses.UAE is particularly well-suited for heat-sensitive materials because it is effective and time-efficient.MAE is a successful technique that quickly heats the solvent and plant material using microwaves to produce intracellular pressure.Because of the disintegration of cell walls caused by this pressure, bioactive compounds are released into the solvent[17].

5.TRENDS AND EMERGING TECHNOLOGY

ENCAPSULATION TECHNOLOGY: Psidium guajava are regarded as a rich source of bioactive substances. These chemicals can be protected, stabilized, and made more bioavailable using encapsulation procedures**.** With a size range of 10 nm to 800 µm, the capsule/core shell encapsulates the material inside a protective barrier. This process keeps the substance's useful qualities intact, inhibits deterioration, and regulates release[18].

MICROEMULSION TECHNOLOGY: Lipid nanoparticles, also known as microemulsions, are innovative blends of water, oil, and amphiphiles that efficiently encapsulate essential oils.The fundamental structure of these lipid nanoparticles is a liquid matrix stabilized by the combination of surfactants in an aqueous media.Application of microemulsion to enhance skin penetration; systems that combine water and oil penetrate deeper than those that combine water and oil[19].

NANOSUPENSION TECHNIQUES: Nanosuspension requires fewer dosages than traditional formulations, it is frequently suggested for herbal medications.

The surface area and solubility of nanoparticles typically lead to increased absorbability and bioavailability of bioactive substances[20].

TECHNOLOGICAL APPLICATION

Food industry:GLE has been suggested as a natural preservative that provides the best alternative to artificial preservatives that could be harmful to human health.GLE is used in food packaging, namely as a polymer that forms edible films. These films or coatings help reduce plastic pollution, food waste, and provide environmentally friendly food preservation options without sacrificing quality.Due to its high polyphenol (15.81 mg GAE/g) and flavonoid (6.99 mg QE/g) content, GLE helps lower liquid oxidation and peroxide levels in the film.They highlighted the film's physical-mechanical qualities, antioxidant qualities, and antibacterial activity[21].

Pharmaceutical industry: Although the leaves of Psidium guajava have long been used in traditional medicine, they have only recently been used in the pharmaceutical business, where research has shown great promise.GLE added to herbal toothpastes demonstrated strong antibacterial activity against oral infections such Staphylococcus aureus and Streptococcus mutans. The main product characteristics, including pH, abrasiveness, and foaming capacity, were also thoroughly examined to ensure they satisfied human safety and effectiveness standards . GLE's safety, non-carcinogenic qualities, and significant medical benefits were highlighted in the research study, which ultimately strongly advocated its use in toothpaste[22].

Cosmetic industry:

Combining the extract with silk fibroin nanoparticles is a recent development in the use of GLE in cosmetic goods, as shown by Pham et al.Phenolic compounds are protected by silk fibroin nanoparticles coated with ethanolic extract from Psidium guajava.These substances demonstrated stability when encapsulated in silk fibroin nanoparticles, even when subjected to challenging conditions such high temperatures (70 °C) for 24 hours.Furthermore, the particles' dual-phase release mechanism allowed for the extended use of phenolic chemicals for a minimum of 210 minutes, which is ideal for preserving their antioxidant properties in cosmetic formulas.The leaf of Psidium guajava contains beneficial chemicals that have a wide range of uses.It is also utilized in skin care products and in nanoparticles that are added to improve cleanliness and reduce perspiration[23].

6.CHALLENGERS IN THE BIOLOGICAL ACTIVITY OF GUAVA LEAF EXTRACT COMPOUNDS AND THEIR TECHNOLOGICAL APPLICATIONS

Despite the encouraging outcomes associated with GLE, several issues warrant additional exploration. To begin with, differences in the source of the plants and their growth conditions may result in varying molecular compositions of GLE, which can affect the precision of its extraction methods and scalability. Furthermore, the lack of standardized procedures for assessing key bioactive compounds (such as quercetin and gallic acid) hinders reliable quality control.In terms of approach, prior research has predominantly employed response surface methodology (RSM) for modeling the optimization of extraction parameters. Nevertheless, alternative machine learning models like artificial neural networks and convolutional neural networks, which have the ability to reduce error variance and enhance prediction accuracy have yet to be thoroughly investigated in this area[24].

The presence of chemicals in processing and storage diminishes their efficacy in commercial applications. Additionally, from a regulatory standpoint, the endorsement of GLE-based treatments faces obstacles due to a lack of toxicological information and concerns regarding potential allergenicity or interactions with other medications.Ultimately, the scientific data gathered from current studies is not enough to provide a clear understanding of the mechanisms involved and the nutritional benefits. It is also crucial to highlight that complex diseases present significant challenges for researchers investigating practical applications of GLE. While the potential therapeutic effects of bioactive compounds have been explored through both in vitro studies and animal models, there is still a lack of clinical research confirming their safety, effectiveness, and the appropriate dosages of GLE for human consumption.Crucially, recent research has presented mixed findings regarding the potential long-term adverse effects of GLE-based products. Addressing these uncertainties could enable future studies to fully explore the benefits of bioactive compounds extracted from GLE[25].

7.FUTURE DIRECTIONS

The recovery of bioactive chemicals presents excellent prospects for more study. The mechanics of the GLE-derived components that provide health advantages are still not well understood.Developments in protective encapsulation technologies are crucial for industrial applications because they preserve the stability and biochemical characteristics of medicinal plant components throughout processing and storage. The development of scalable and reasonably priced microemulsion and nanosuspension techniques is essential.In the end, applying recent discoveries from preclinical research to human trials will support the creation of fresh strategies and medication therapies aimed at metabolic diseases and other long-term conditions. Future study might clearly show the potential of GLE in the food, cosmetic and pharmaceutical industries by tying lab work to practical uses.

CONCLUSION

The plant-derived metabolites of GLE that may have functional and health-enhancing qualities as well as therapeutic potential are the focus of this review study.This study examines the bioactive substances found in Psidium guajava L., including alkaloids,tannins,terpenoids,saponins and flavonoids,phenol and glycosides.Compared to traditional processes like maceration, decoction, or Soxhlet extraction, it is a more effective approach. Methanol, ethanol and chloroform are the most often utilized extraction solvents, and the temperatures range from 40 to 60 °C and the durations range from 20 to 60 minutes.Metabolites from Psidium guajava L. leaves are crucial for tackling global health issues like the treatment of chronic diseases, antibiotic resistance, and practical uses in food, cosmetics, and medicine.

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