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A Mini Review of the Antioxidant and Antimicrobial Activities and photoprotective properties of *Psidium guajava* L.

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ABSTRACT

Psidium guajava L. popularly known as a poor man's apple is not just a tropical plant that provides delicious fruit but also offers numerous benefits for mankind across various disciplines due to its rich pool of phytochemicals with bioactive properties. Many scientific investigations confirmed that guava leaves, fruit pulp, peel, and seeds are rich in compounds with nutritional, pharmacological, medicinal, and cosmeceutical properties. The objective of this comprehensive review is to compile the data on photoprotective properties (ultraviolet protection), antioxidants, and antimicrobial activities of *Psidium guajava* L. published in the last two decades and to discuss how these properties are advantageous for potential photoprotective cosmeceutical industrial applications.

Keywords: Antioxidant, Antimicrobial, *Psidium guajava* L, Ultraviolet.

INTRODUCTION

Guava, scientifically known as *Psidium guajava* L. is a small tree of the Myrtaceae family[1]. It mostly grows in tropical and subtropical areas in the world[2,3]. The major phytochemicals of guava are flavonoids, phenols, tannins, terpenes, saponins, alkaloids, glycosides, coumarins, etc[4-6] which exhibit varieties of properties that are very useful to human health as herbal medicine, and a cosmeceutical ingredient[7,8].

Guava (*Psidium guajava* L.) stands as a year-round fruit tree with antioxidant-rich fruits[9]. Its fruit, leaves, and seeds have garnered attention due to their substantial antioxidant potential[10,11], attributed to their robust polyphenolic and flavonoid contents[12]. Guava boasts a repertoire of food and nutritional values along with potent bioactive properties, including antioxidative[7,9,13], antidiabetic[14,15], antimicrobial[16-18], anti-inflammatory[14,20], anticancer[20,21], anti-diarrheal[22,23], antimutagenic[24,25], hepatoprotective[26,27], anti-hemolytic[28,29], antimalarial[30,31], antitussive[32,33], antigenotoxic[34,35], wound healing[36,37] and cardiovascular protective effects[38,39].

Guava is known to be rich in a diverse range of phytochemicals, including alkaloids, steroids, flavonoids, quinones, oils, fats, phenolics, starch, tannins, terpenoids, glycosides, saponins,

vitamin C, carotenoids, and more[40-42]. Lutein and zeaxanthin protect the retina from UV-induced oxidative damage. Polyphenols also demonstrate photoprotective effects[43,44]. One standout example is Epigallocatechin-3-gallate (ECGC), a polyphenol that effectively combats UV-associated maladies[45]. Studies have shown that guava fruits are rich in bioactive compounds, particularly ellagic acid, kaempferol glycosides, quercetin derivatives, catechins, and proanthocyanidins[46-51]. These compounds contribute to the fruit's antioxidant properties. Additionally, guava fruits contain citric acid, oleanolic acid, and various anthocyanidins[9,42]. The leaves are also a valuable source of phytochemicals, including essential oils like carvone, fatty acids, and terpenoids such as β-caryophyllene, eugenol, and α-copaene[20]. Furthermore, guava leaves contain flavonoids, phenolic acids, and other antioxidants, such as gallic acid, rutin, and ferulic acid[19]. The peel is particularly abundant in ellagic acid, tannins, triterpenoids, and flavonols, enhancing its health benefits[18].

The awareness of the potential risks associated with continuous sun exposure has led to a significant increase in the use of sunscreen creams over the past few decades[52]. As people become more informed about the harmful effects of UV radiation, especially UV-B and UV-A, they seek protective measures to mitigate these risks[53]. Sunscreens, specifically designed to shield the skin from the adverse effects of UV radiation, have become a vital societal awareness in skin protection[54]. While visible light (with wavelengths ranging from 400 to 740 nm) and infrared radiation (wavelengths above 760 nm) affect the skin[55], UV radiation poses the most immediate and significant threat to skin health. The harmful impact of UV radiation, including sunburn, photoaging, and an increased risk of skin cancer, underscores the importance of effective sun protection measures[56,57].

In light of these concerns, there is an ongoing effort to develop herbal-based sunscreens that offer effective UV protection while minimizing potential adverse effects on the skin[58]. This has led to an increased interest in exploring natural sources of photoprotective compounds, such as those found in plant and fruit extracts, which may provide a safer and more sustainable alternative for sun protection cosmetics[59]. Indeed, the use of natural bioactive substances in sun protection cosmetics has gained significant attention due to their potential to provide effective photoprotection while offering additional benefits for the skin's overall health and appearance[60]. Natural compounds often possess a range of bioactivities, including antioxidant, antimicrobial, and anti-aging properties. These properties can work synergistically to counteract the adverse effects of UV radiation and promote healthier skin[61,62].

Many herbal cosmeceuticals incorporate a range of natural components, each contributing to the overall benefits of the product[63]. One notable advantage is the presence of natural antioxidants and other secondary metabolites, which bring nutritional and antimicrobial properties to the formulation[64]. Additionally, these products often contain vitamins that provide supplementary protection to the skin. Importantly, this combination of elements contributes to achieving enhanced skin protection while minimizing potential side effects, a characteristic that stands in contrast to synthetic cosmetic products[65].

Furthermore, the antimicrobial properties of certain natural compounds can help protect the skin from harmful microorganisms that may thrive under UV exposure[66]. This can contribute to maintaining the skin's health and integrity, preventing potential infections or irritations caused by microbial activity[67]. Additionally, the anti-aging properties of some natural compounds can aid in maintaining the skin's youthful appearance and minimizing the effects of UV-induced aging[68]. These compounds can support collagen production, skin elasticity, and overall skin health, helping mitigate the negative impact of long-term sun exposure[69]. Given the potential benefits of natural bioactive substances, the cosmeceutical industry has been increasingly incorporating herbal products into sunscreen formulations[70]. Many cosmeceutical products now include one or more natural agents as active ingredients alongside primary sun protection components[71]. This approach aims to offer consumers effective sun protection and the potential for improved skin health and appearance.

In the field of phytocosmetics, plant extracts with antioxidant potential are of significant interest since they include compounds that might neutralize reactive oxygen species, improve skin homeostasis, and avoid erythema and premature skin aging[72].

Nowadays, a wide variety of extracts of plant species are included in sunscreen formulations[73]. These include extracts of Aloe-vera (*Aloe barbadensis miller*), lemon (*Citrus limon* L.), cucumber (*Cucumus sativus* L.), green tea (*Camellia sinensis*), Eastern prickly pear cactus (*Opuntia humifusa*), African tulip tree (*Spathodea campanulata* L.), tomatoes (*Solanum lycopersicum*), Indian beech tree (*Pongamia pinnata* L.), Dendropanax morbifera and pomegranate (*Punica granatum*)[74]. They serve as biological agents in sun protection cosmetics by moisturizing, preserving, smoothing, and emulsifying for skin protection[75].

Data Collection and Analysis

A comprehensive literature search was undertaken using search engines and databases including Sci-finder, Google Scholar, Research Gate, PubMed, and Science Direct to locate publications discussing the bioactivities of *Psidium guajava* L. that are important for the development of sunscreens using Guava extracts. The keywords used for the relevant literature search were antioxidant, antimicrobial, cosmeceuticals, *Psidium guajava* L. and ultraviolet. These keywords were chosen due to the plant material (*Psidium guajava* L.), and properties (antioxidant, antimicrobial, and photoprotective) that give significant contributions to the scope, and the search was done individually and using keywords as a combination. This review extensively encompasses findings from a total of 101 research papers, spanning from last two decades. Even though the keyword search gave 3,070 articles, only those published in English and relevant to the scope of this review were considered.

Antioxidant properties of Guava

Guava, which has a unique collection of phytochemicals, has attracted attention as a potent anti-aging agent with strong antioxidant effects to be used as a cosmeceutical ingredient[76]. They reduce oxidative skin damage by preventing the generation of reactive oxygen species induced by external (UV radiations) and endogenous factors[77]. The antioxidant potential of the different plant parts of the *Psidium guajava* is summarized in Table 1. It further summarizes the methods used to extract the chemical constituents from different plant parts and the antioxidant assays conducted to determine their antioxidant activities. The assays that have been used to determine the antioxidant activity of the plant parts include, 2,2-Diphenyl-1-picrylhydrazyl (DPPH), 2,2'-azino-bis (3-ethylbenzothiazoline-6-sulfonic acid ($ABTS^+$), Ferric ion reducing antioxidant power (FRAP), thiobarbituric acid (TBA) and Ferric Thiocyanate (FTC).

Moreno *et al.,* (2014) investigated that not only the guava fresh fruit but also the flour obtained from acetonic guava fruit has a considerable amount of antioxidant potential by analyzing the ethanolic, and aqueous extracts of fresh guava juice, fresh guava fruit, and its flour using an improved ABTS method[17]. This study revealed that all the extracts of guava fruit flour have a higher potential for antioxidant activity than fresh fruit and juice. According to Milani *et al.,* (2018) antioxidant properties of extract of guava waste which is generated in agricultural industries are higher than the standard ellagic acid[46]. These findings proved that not only the original plant materials but also its waste in agricultural industries have sufficient antioxidant properties. Araújo *et al.,* (2014) discovered that the co-product (discarded fruit material in industry) of guava has high antioxidant activity compared to the standard BHT[85].

A study by Shabbir *et al.,* (2020) revealed that the highest DPPH scavenging activity was found in guava pulp methanolic extract than in guava leaf and seed methanolic extracts[14]. They suggested that because guava pulp contains Vitamin C, it may be the reason for the higher DPPH scavenging activity. According to the study conducted by Yousaf *et al.,* (2020), the antioxidant activity of guava fruits varies in different indigenous guava cultivars[81]. Guo *et al.,* (2003) showed that guava exhibits robust antioxidant activity in fruit, peel, and seed fractions and their antioxidant activities were determined by the FRAP assay[83]. Marina and Noriham (2014) reported the antioxidant activity of guava peel extract by using DPPH, FRAP, TBA, and FTC assays[82]. Research conducted by Liu *et al.,* (2018) found that compared to guava fruit and seed ethanol aqueous extracts, guava peel extract shows significant antioxidant potential compared to other samples in both DPPH, $ABTS^+$, and FRAP assays[18]. The studies conducted by researchers showed that guava leaves are a great source for phytochemicals with antioxidant properties[4,28,50,78-80,84].

Table 1: Antioxidant activities of guava plant parts

Plant part	Solvent/s used for extraction	Type of assay	Results	References
Leaves	The material was submerged in 70% ethyl alcohol and then subjected to boiling in a water bath at 100 °C for 10 minutes	DPPH, ABTS+	The DPPH assay yielded a comparable result (444.05 ± 1.01 mg TE/g extract) to the outcome obtained in the ABTS assay (424.80 ± 31.05 mg TE/g extract)	50
Leaves	Soxhlet extraction was performed using methanol and hexane as solvents	DPPH, nitric oxide radical-scavenging activity and superoxide radical-scavenging activity	In comparison to the methanolic extract, the hexane extract from Psidium guajava L. leaves exhibited reduced effectiveness in scavenging oxidation, as indicated by diminished activity against 1,1-diphenyl-2-picrylhydrazyl (DPPH), nitric oxide, superoxide, and α-glucosidase inhibitory activity	28
Leaves	The guava leaves were boiled with distilled water, followed by filtration. Subsequent extractions using ethanol and methanol were carried out through maceration.	DPPH, ABTS+, Reducing power assay, nitric oxide radical-scavenging activity and nitrite-scavenging activity	The guava leaves exhibited higher scavenging activity against DPPH• and ABTS•+ radicals, as well as stronger reducing power in the water extract compared to pure ethanol and methanol extracts	78
Leaves	Essential oil (EO) from guava leaves was re-dissolved in methanol (MeOH)	DPPH	Exhibited a moderate antioxidant effect, with an IC_{50} value of 460.37 ± 1.33 µg/mL	79
Leaves	Macerated into 95% ethanol	DPPH	The IC_{50} value was determined to be 53.2 µg/ml	80
Leaves	Sonication (E1), Soxhlet extraction (E2), agitated maceration (E3), and heated agitated maceration (E4)	FRAP, DPPH	The extraction method E4 exhibited the highest total antioxidant capacity (432.57 ± 0.51 mg Trolox Eq/g), while the DPPH radical scavenging assay demonstrated the lowest IC_{50} value in E3 (273.81 ± 0.07 ppm)	4
Fruit	The pretreated sample was extracted using methanol that was acidified with concentrated hydrochloric acid	DPPH and ABTS+	The antioxidant activity obtained from DPPH assay and ABTS assay in values of 5.22–5.62 TEAC 100 g–1 dried weight and 17.63–18.74 TEAC 100 g–1 dried weight, respectively	47
Fruit	Macerated using 80% methanol (80:20 methanol-water, v/v, 200 ml)	DPPH	The DPPH inhibition percentage ranges from 36.8% to 71% across different guava cultivars	81
Peel	Macerated into water	DPPH, FRAP, TBA Assay, FTC assay	The reduction in DPPH radicals followed the sequence: guava peel > Butylated hydroxyanisole (BHA)/Butylated hydroxytoluene (BHT) > ascorbic acid. At a concentration	82

				of 200 ppm, the reductive potential of the samples decreased in the order: ascorbic acid (Abs=4.9803) > BHA/BHT (Abs= 1.5050) > guava peel (Abs=1.0120). In the TBA assay, guava peel exhibited higher absorbance compared to BHA/BHT and ascorbic acid. As determined by the FTC assay, the antioxidant activity of guava peel extract was measured at 58.91%.	
Peel, pulp and seed	The material was ground in a mortar following the addition of distilled water (1:9 w/v), then centrifuged. Theresulting supernatant was collected and utilized	FRAP		Guava exhibits robust antioxidant activity in both fruit peel and seed fractions	83
Peel, pulp and leaves	Cold extracted into methanol	DPPH		The guava leaf extract displayed the most substantial DPPH activity with an IC_{50} value of 89.56 ± 0.97 µg/mL, whereas the pulp extract exhibited the lowest antioxidant potential with an IC_{50} of 119.72 ± 0.55 µg/mL	84
Co-products (discarded fruit material) from the processing of guava	The dry co-product was stirred with ethanol, followed by centrifugation to obtain the supernatant, which was then filtered with ethanol and subsequently diluted	DPPH, FRAP and β-carotene/ linoleic acid system		The guava co-products exhibited antioxidant activity comparable to BHT (butylated hydroxytoluene) at a concentration of 20 µg/mL	85

Antimicrobial activity of Guava

Guava emerges as a promising candidate, brimming with the source of robust antibacterial agents[2,19,84]. Investigations have unveiled the antibacterial prowess inherent in various components of the guava plant, including its leaves, fruits, and peels, displaying efficacy against both *Gram-positive* and *Gram-negative* bacterial strains[86,87]. Growther and Sukirtha (2018) evaluated the antimicrobial activity of petroleum ether, benzene, chloroform, ethanol, and methanol extracts of guava bark and leaves against *Staphylococcus aureus*, *Klebsiella pneumoniae*, *Salmonella typhi*, *Shigella dysenteriae*, *Escherichia coli*, *Pseudomonas aeruginosa* and *Candida albicans* using the agar well diffusion method[7]. This study showed that both guava leaf methanol extract and bark ethanol extract have significant antimicrobial activity against the tested bacterial and fungal strains.

According to Birdi *et al.,* (2010) *Psidium guajava* leaves from different areas were used to prepare a decoction extract, which inhibited two bacterial strains including *Shigella flexneri* (EC_{50} = 0.98% ± 0.2%) and *Vibrio cholerae* (EC_{50} = 2.88% ± 0.36%)[22]. Another study by Biswas *et al.,* (2013) reported that leaf methanolic and ethanolic extracts of guava showed the highest inhibition activity against Bacillus cereus (8.27 mm and 6.11 mm were the respective mean inhibition zones) and *Staphylococcus aureus* (12.3 mm and 11.0 mm were the respective mean inhibition zones) which are foodborne and spoilage *Gram-positive* bacteria[86]. However, the guava leaf extracts didn't show any antimicrobial effect against gram-negative bacterial organisms. In this study solvents, n-hexane, methanol, ethanol, and boiling distilled water were used as the extraction solvents and the well-diffusion method against *Escherichia coli* and *Salmonella enteritidis* which represent *Gram-negative* bacteria and *Staphylococcus aureus* and *Bacillus cereus* which represent *Gram-positive* bacteria were used. Abdelmalek *et al.,* (2016) reported that peel aqueous extract of *Psidium guajava* L. could be used as a natural preservative due to its high antibacterial activity. An aqueous extract of the peel at a concentration of 10% or higher was effective against coagulase-positive *Staphylococcus aureus* and methicillin-resistant *Staphylococcus aureus* (MRSA), while a concentration of 1% or higher was effective against coagulase-negative staphylococci[19].

This study showed that guava fruit is not only rich in nutrients but also has good antimicrobial potential in its peel. Das & Goswami (2019) investigated that guava leaf methanolic extract has a significant inhibition against *Bacillus subtilis*, *Saccharomyces cerevisiae*, and *Aspergillus niger*[2]. However, it showed very little inhibition against *Escherichia coli*. In this study, they determined the antimicrobial effect of the guava leaf extract against *Gram-positive* (*Bacillus subtilis*), *Gram-negative* bacteria (*Escherichia coli*), yeast fungal strain (*Saccharomyces cerevisiae*), and mold fungal strain (*Aspergillus niger*).

Ekeleme *et al.,* (2017) determined the antibacterial activity of ethanolic, methanolic, and aqueous crude extracts using Cup-plate agar diffusion bioassay against *Pseudomonas aeruginosa*, *Escherichia coli*, *Staphylococcus aureus*, *Streptococcus pneumoniae* and *Klebsiella pneumoniae*[88]. They found that the guava leaf ethanol extract exhibited antibacterial activity against all isolates except *Staphylococcus aureus* while the aqueous extract of the leaves displayed a notable level of activity against all tested bacterial isolates at a concentration of 100 mg/L. In the methanol extract, the highest inhibitory activity was observed against Klebsiella pneumonia.

According to Dewage *et al.,* (2023) guava peel and pulp methanolic extracts displayed enhanced antibacterial activity against *Staphylococcus aureus* and *Escherichia coli*[84]. Notably, *Pseudomonas aeruginosa* exhibited heightened susceptibility to the antibacterial effects of guava pulp extract. Guava peel extract showcased the highest antifungal activity with an inhibition zone of 16.00 ± 2.62 mm, whereas guava pulp showed no antifungal activity. Guava leaves exhibited a moderate level of antimicrobial activity. In this study, they used the agar well diffusion method for methanolic extract of guava peel, pulp and leaves against *Escherichia coli* (ATCC 25922), *Staphylococcus aureus* (ATCC 25923), *Pseudomonas aeruginosa* (ATCC 9027) and *Candida albicans* (ATCC 10231).

Photoprotective property (UV protection) of Guava

Ultra violet spectrum which ranges from 100–400 nm has been divided into 3 different regions. Ultraviolet A region is between 320-400 nanometers while ultraviolet B and ultraviolet C are between 280-320 and 100-280 nanometers, respectively[89]. UV A and UV B radiations are considered as one of the main reasons behind skin damage leading to sunburn. UV C is the major biologically damaging radiation to the skin but the ozone layer filters out UV C radiation. Sunscreen ingredients can act as either a physical or a chemical barrier to solar radiation and scatter, absorb, or reflect harmful rays to protect the human skin[90].

Melanin, serving as a natural absorber of UV radiation, serves as the body's initial barrier against the deleterious impacts of UV-induced photodamage. However, there are instances where the melanin levels may fall short of providing adequate protection for the skin[91]. Various strategies are employed to shield the skin from the adverse consequences of UV exposure, including minimizing sun exposure during peak UV radiation periods, wearing protective clothing, wide-brimmed hats, and sunglasses, as well as the application of sunscreens[92]. Within sunscreen formulations, the constituents possess the capability to either deflect or absorb ultraviolet rays at the skin's surface, effectively safeguarding the skin from the detrimental effects of the sun's UV rays[74].

The effectiveness of sunscreen is conventionally measured using the sun protection factor (SPF). The SPF scale categorizes protection levels as follows: Low (SPF 2-15), Medium (SPF 15-30), High (SPF 30-50), and Highest (SPF>50)[57]. With substantial antimicrobial and antioxidant properties observed in guava (*Psidium guajava*) fruit and leaves, extensive attention has been directed toward exploring their potential as photoprotective agents for sunscreen in recent years[93]. In a study conducted by Milani *et al.,* (2018), it was found that extracts from byproducts of guava fruit processing can enhance the effectiveness of chemical UV solar filters[46]. The research group further illustrated that the phytocosmetic formulation not only absorbed solar radiation within the UV B wavelength range but also significantly enhanced photoprotection efficacy by 17.99% in cosmetic formulations, resulting in an SPF value of 22.3 ± 1.1, surpassing the reference formulation with an SPF value of 18.4 ± 0.7.

Based on research conducted by Ilomuanya *et al.,* (2018) a polyherbal face cream formulation that incorporated extracts of both *Psidium guajava* leaves and *Ocimum gratissimum* leaves demonstrated

significant antioxidant potential[94]. This formulation holds the potential to offer preventive benefits against skin carcinogenesis, sunburn, and aging caused by harmful UV rays. The cream's observed high antioxidant activity is anticipated to yield positive effects on various aspects of skin health, including prevention of aging, sun protection, and potentially even skin cancer prevention. Research conducted by Samejima and Park (2019) demonstrated a substantial level of anti-collagenase activity within the guava leaf's butanol (BuOH) fraction, surpassing the activity found in other fractions, including the crude extract[95]. These findings suggest that the leaf extract holds the potential to counteract the processes of skin wrinkling and aging by offering protection against the effects of exposure to ultraviolet radiation.

In a study by Puspaningtyas (2012) it was found that red guava fruit extract possesses tyrosinase enzyme inhibition activity, leading to a reduction in melanin production[96]. Tyrosinase is a pivotal enzyme in melanin biosynthesis. The inhibition of this enzyme can consequently contribute to the reduction of hyperpigmentation and enhance the skin's brightness by mitigating melanogenesis. Mota *et al.,* (2019) reported that the SPF value of a sunscreen formulation containing 7.5% 2-ethyl-hexyl methoxycinnamate was significantly improved by approximately 134% when it was incorporated with guava fruit extract[97]. Dewage *et al.,* (2023) investigated the photoprotective capacity of guava peel, pulp, and leaf methanol extracts[84]. The study revealed that guava leaf methanolic extract exhibited a notably higher level of photoprotection (SPF = 30.38 ± 0.22) against UV-B radiation in comparison to guava peel (SPF = 20.59 ± 0.49) and pulp (SPF = 16.24 ± 0.67) methanol extracts. Imam *et al.,* (2015) found that a cream developed by using a combination of *Psidium gujava*, *Pyrus communis*, and *Musa accuminata* fruit extracts can block the ultraviolet rays at around 73%[61].

Challenges and potentials of Guava extract as an additive in sunscreen formulations

Based on the findings of the studies mentioned, it is evident that guava extracts exhibit significant promise as a natural source in the development of sunscreen products, as leaves and fruits of the plants mainly exhibit antioxidant, antimicrobial as well as photoprotective properties. Scientists discovered and identified many bioactive phenolic and flavonoid compounds in Guava leaves that are responsible for antioxidant and antimicrobial activities including hyperin, epicatechin, quercetin, gallic acid, kaempferol, catechin, avicularin, apigenin, guaijaverin, chlorogenic acid, myricetin and rutin etc[98-100]. Most of the studies showed that flavonoids and phenolic constituents could have the potential to act as ultraviolet protectors[60]. Flavonoids also help in maintaining the regular activity of enzymes in the skin and it will affect the division of epithelial cells in the skin[61].

Identifying the precise compounds responsible for the photoprotective potential in guava extracts is a critical research gap. Once these specific compounds are identified, they can be isolated and utilized to produce sunscreen formulations with high SPF values. To establish the safe utilization of guava extracts on an industrial scale, it is imperative to conduct both toxicological and clinical studies. Expanding research on the use of guava extracts as additives has the potential to lead to the development of a variety of value-added cosmetic products, targeting the increased demand for herbal products for skin health[101].

CONCLUSION

Guava (*Psidium guajava* L.), a tropical fruit rich in bioactive phytochemicals, stands out as a promising candidate for cosmeceutical production. Even though it has significant bioactivities, a few studies have been conducted to reveal its potential applications to the world. This comprehensive review delves into the cosmetological potential of various parts of the *Psidium guajava* plant, including leaves, peel, pulp, and seeds. Our focus centers on recent studies, conducted over the past two decades by researchers across the globe, shedding light on the extraction of chemical constituents in guava plant parts and the antioxidant, antimicrobial, and photoprotective attributes inherent to it. While these findings paint a promising picture, they may not be conclusive enough to integrate guava into commercial sunscreen formulations directly. However, by highlighting the need for toxicological evaluations, stability evaluation, and rigorous clinical trials, the reported findings underscore that

guava holds the promise of serving as a secure, cost-effective, natural source of ingredients for the cosmeceutical industry.

Conflict of Interest

The authors report there are no competing interests to declare.

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