Review Article

Utilization of Pomegranate Peel in Cosmetics: A Comprehensive Review of Its Bioactive Compounds

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Received: 04-03-2026; **Revised:** 26-05-2026; **Accepted:** 02-06-2026; **Published online:** 20-06-2026.

ABSTRACT

Pomegranate (*Punica granatum* L.) peel, an agro-industrial byproduct, has gained significant attention in recent years due to its rich phytochemical composition and diverse biological activities. The present review highlights the potential of pomegranate peel as a multifunctional ingredient in cosmetic and cosmeceutical applications. The peel is a valuable source of bioactive compounds, including polyphenols, flavonoids, tannins, and phenolic acids, which contribute to its strong antioxidant, antimicrobial, anti-inflammatory, anti-aging, depigmenting, and wound healing properties. Various extraction techniques such as solvent extraction, Soxhlet extraction, ultrasound-assisted extraction, and microwave-assisted extraction play a crucial role in the efficient recovery of these bioactive constituents. Among these, modern green extraction methods offer enhanced yield, reduced processing time, and better preservation of thermolabile compounds. The extracted phytochemicals have shown significant efficacy in combating oxidative stress, inhibiting microbial growth, reducing inflammation, and promoting skin regeneration. Furthermore, pomegranate peel has been successfully incorporated into different cosmetic formulations, including facial scrubs, creams, gels, and face masks, where it functions as an exfoliating agent, antioxidant booster, and natural preservative. Its ability to improve skin texture, elasticity, and overall appearance makes it a promising alternative to synthetic ingredients. Despite its numerous benefits, considerations regarding safety, standardization, and formulation optimization remain essential for its effective application. Overall, pomegranate peel represents a sustainable and cost-effective natural resource with immense potential in the development of advanced skincare products. Future research focusing on clinical validation and formulation innovations may further enhance its applicability in the cosmetic industry.

Keywords: Pomegranate peel, phytochemicals, Antioxidant, Cosmetic formulations, Extraction methods, Anti-aging, Skin depigmentation, Wound healing, Natural cosmetics, Cosmeceuticals.

INTRODUCTION

Natural cosmetics, often known as herbal cosmetics, are said to be safe and efficient for shielding the skin from environmental factors. They boost the appearance of the skin without altering the structures or functions of the body. The Greek word "Kosmos," which refers to "decorating skill," is where the word "cosmetic" comes from[1]. Natural herb ingredients in personal and health care products have gained popularity due to their increased benefits. Herbs are mild, calming, and more effective, according to recent studies. Products made with a variety of natural herbal elements serve as a basis for the development of successful herbal cosmetics, also known as "herbal cosmetics." The lack of adverse effects and skin compatibility of conventional herbal remedies are driving up demand for them. They deliver nutrition and other minerals that are beneficial to the body[2].The pomegranate (*Punica granatum* L.) belongs to the Punicaceae family of plants. It is an important fruit because of its nutritional and health benefits. In traditional medicine, pomegranate fruit peel is also used to treat palpitations, ischemic conditions, and pneumonia. Pomegranate peel is a byproduct of the production of fruit juice and accounts for about 30–40% of the fruit component[3]. Pomegranate peels, which are often seen as an agro-industrial waste, may contain important secondary plant metabolites and nutrients. Its unique composition of compounds, particularly the secondary metabolites like flavonoids and plant phenolics, is connected to its potent biological action. It also has the potential to create novel goods that may satisfy the demands of the expanding health market by optimizing food waste recovery techniques that might be applied in the food and bioprocess sectors[4]. Therefore, this review aims to comprehensively evaluate the bioactive compounds present in pomegranate peel and their potential applications in cosmetic formulations, along with associated benefits, challenges, and future perspectives.

Botanical Profile[5]

Table 1: Taxonomical classification of *Punica granatum*

RANK	CATEGORY
Kingdom	Plantae
Division	Magnoliophyta
Class	Magnoliopsida
Order	Myrtales
Family	Lythraceae
Genus	*Punica*
Species	*P. granatum*

Prior to its recent inclusion in the Lythraceae family, Punica granatum was categorized under the distinct Punicaceae family. Punica granatum, sometimes referred to as

pomegranate, is the major species in the genus Punica, whereas Punica protopunica is the less frequent species that is usually found on the island of Socotra. The plant is referred to as “a pharmacy unto itself" in the Ayurvedic medical system, where it is utilized as a blood purifier, anthelmintic agent, and remedy for ulcers and diarrhoea. Pomegranates are utilized in the Middle East and India as part of the Unani medical system to cure diabetes[5].

Phytochemical Profile[5,6]

Table 2: Phytochemical profile of different parts of *Punica granatum*

Plant Part	Major Phytochemicals
Bark	Hydrolyzable tannins (ellagitannins, gallotannins): punicalagin, castalagin, brevifolin, galloylpunicalin; Alkaloids: pseudopelletierine, hygrine, serine; Terpenoids and sterols: friedooleanan-3-one
Peel	Flavonoids: quercetin, delphinidin, pelargonidin; Hydrolyzable tannins: punicalagin, pedunculagin, and granatin B; Catechins: gallocatechin; Phenolic acids: chlorogenic acid, ellagic acid
Fruit	Ellagic acid derivatives: ellagic acid; Flavanols: rutin, kaempferol, quercetin; Hydrolyzable tannins: corilagin
Seed	Fatty acids and triglycerides: conjugated linolenic acid, palmitic acid, tri-O-punicylglycerol; Steroidal compounds: estrone, testosterone; Ellagic acid derivatives: ellagic acid
Juice	Anthocyanidins: cyanidin, delphinidin; Procyanidins and catechins: procyanidin B1, procyanidin B2, catechin; Organic acids: citric acid, gallic acid, chlorogenic acid; Flavonoids: rutin, quercetin
Root	Alkaloids: pelletierine, isopelletierine, norhygrine, hygrine
Leaves	Hydrolyzable tannins: punicalin, tellimagrandin, punicafolin, tercatain; Flavonoid glycosides: luteolin-3-O-β-D-glucoside, apigenin-4-O-β-D-glucoside; simple phenolics: brevifolin

PHYTOCHEMICAL COMPOSITON

Pomegranate (Punica granatum) peel is a rich source of several bioactive substances, primarily polyphenols, which provide it a variety of biological and cosmetic properties. The peel is a useful source for cosmeceutical applications since it has the highest concentration of phenolic compounds among the fruit's many sections[7,8].

Tannins and Polyphenols

Pomegranate peel contains a large class of phytochemicals called polyphenols, the most prevalent of which are hydrolyzable tannins. These include gallotannins and their derivatives, as well as ellagitannins such as punicalagin and punicalin. Pomegranate peel's strong antioxidant potential is thought to be mostly attributed to punicalagin[9,10].

Flavonoids

Another significant class of phytochemicals included in pomegranate peel are flavonoids, which include luteolin, kaempferol, and quercetin. Additionally, anthocyanidins that support pigmentation and antioxidant action include delphinidin, cyanidin, and pelargonidin[11].

Phenolic Acids

Phenolic Acids Phenolic acids such as gallic acid, chlorogenic acid, and caffeic acid are present in notable amounts in pomegranate peel. These compounds exhibit strong antioxidant and anti-inflammatory properties, which are beneficial in maintaining skin health and preventing oxidative damage[12].

Additional Phytoconstituents

Pomegranate peel is rich in polyphenols, vitamins, minerals, organic acids, and trace levels of terpenoids, sterols, and alkaloids. Together, these components enhance the plant's potential for both medicinal and cosmetic purposes[13]. Pomegranate peel's phytochemical content can change based on a number of variables, including cultivar, climate, location, and extraction techniques. Nonetheless, its importance as a natural cosmeceutical ingredient is highlighted by the constantly high content of phenolic chemicals[14].

METHOD OF EXTRACTION

Solvent Extraction

Solvent extraction (leaching) is widely used to isolate bioactive compounds from solid matrices using suitable solvents. It includes solid–liquid, liquid–liquid, and supercritical methods, with efficiency depending on the solvent used. However, environmental concerns and solvent emissions remain key limitations[15].

Negi and Jayaprakasha evaluated different solvents for extracting compounds from pomegranate peel, including water, ethyl acetate, acetone, and methanol. Among these, methanol yielded the highest extraction efficiency (9.4%), whereas ethyl acetate showed the lowest yield (1.04%). The total phenolic content was reported to be highest in methanol extract (460 mg/g catechin equivalent), followed by acetone (400 mg/g), ethyl acetate (170 mg/g), and water (140 mg/g)[16].

According to Wang et al., methanol demonstrated the highest extraction yield of phenolic compounds from pomegranate peel (8.26%) at 40 °C, followed by water (5.90%), ethanol (1.55%), acetone (0.37%), and ethyl acetate (0.18%). Interestingly, although ethyl acetate produced the lowest overall yield, it resulted in the highest concentration of total phenolics (20.24%), suggesting greater selectivity toward phenolic constituents[17].

Soxhlet Extraction

A common method for separating bioactive chemicals from plant materials like pomegranate peel is soxhlet extraction. This process involves putting powdered and dried peel in a

thimble and continually extracting it under reflux settings using an appropriate solvent. Repeated solvent cycling improves solvent penetration into the plant matrix, allowing for the effective recovery of phytochemical constituents such as tannins, flavonoids, and polyphenols[18].

Temperature, extraction period, and solvent type all have a significant impact on Soxhlet extraction efficiency. Because they are more soluble, polar solvents like methanol and ethanol are frequently used to extract phenolic chemicals from pomegranate peel. Although the extraction yield may vary based on the solvent solution and operation circumstances, studies have shown that Soxhlet extraction produces notable levels of total phenolics and has great antioxidant potential[19].

Soxhlet extraction has significant drawbacks despite its efficacy, such as high solvent consumption, a lengthy extraction period, and the potential for heat-sensitive compounds to degrade as a result of continual heating. Consequently, it is sometimes contrasted with contemporary extraction methods like ultrasonic and microwave-assisted extraction, which provide shorter extraction times and higher efficiency, even if it is still a common and trustworthy approach[20].

Ultrasound-Assisted Extraction (UAE)

Ultrasound-assisted extraction (UAE) is a new green extraction process that is commonly utilized to isolate bioactive chemicals from plant materials, such as pomegranate peel. The approach is based on acoustic cavitation, in which ultrasonic vibrations cause microbubbles in the solvent to burst rapidly, resulting in localized pressure and temperature. This event breaks plant cell walls, which increases the release of intracellular phytoconstituents into the solvent media[21].

The efficiency of UAE is determined by numerous operating factors, including ultrasonic frequency, extraction duration, temperature, and solvent type. Lower frequencies often cause larger cavitation effects, resulting in enhanced cell disruption and mass transfer. Furthermore, moderate temperatures and appropriate extraction duration contribute to greater recovery of phenolic chemicals without considerable degradation[22].

UAE has been shown to considerably improve the extraction of phenolic compounds from pomegranate peel, notably ellagitannins and flavonoids, which are responsible for the fruit's antioxidant effect. Studies have demonstrated that UAE delivers higher total phenolic content in less time compared to traditional extraction procedures, proving its advantages in terms of efficiency and efficacy[23].

Compared to previous procedures, UAE has various advantages, including lower solvent usage, shorter extraction times, and higher extraction yields. Furthermore, it is considered an ecologically beneficial and energy-efficient technology, making it extremely ideal for recovering bioactive chemicals from agro-industrial waste, such as pomegranate peel[24].

Microwave-Assisted Extraction (MAE)

A sophisticated extraction method called microwave-assisted extraction (MAE) is frequently used to effectively recover bioactive chemicals from plant materials like pomegranate peel. This technique uses microwave radiation to quickly and evenly heat the solvent and plant matrix through dipole rotation and ionic conduction. Increased internal pressure in plant cells causes the cell wall to break, which makes it easier for intracellular phytoconstituents to be released into the solvent[25].

A number of factors, such as temperature, solvent type, extraction time, and microwave power, affect MAE efficiency. Because they can efficiently absorb microwave radiation, polar solvents including methanol, ethanol, and water are frequently chosen. To maximize extraction yield while avoiding the thermal destruction of heat-sensitive chemicals, these parameters must be optimized[26]. According to reports, MAE improves the extraction process of phenolic elements from pomegranate peel, especially flavonoids and ellagitannins, which have potent antioxidant properties.

Research has shown that when compared to traditional methods like Soxhlet extraction, MAE offers greater extraction efficiency and much shorter extraction times[27].

Comparison of Extraction Methods for Pomegranate Peel[15-27]

Table 3: Comparison of extraction methods used for pomegranate peel

Method	Principle	Advantages	Limitations	Suitable Compounds
Solvent Extraction	Dissolution of compounds in suitable solvent	Simple, low cost, easy to perform	Time-consuming, high solvent use, less efficient	Phenolics, flavonoids
Soxhlet Extraction	Continuous hot solvent reflux extraction	Efficient, exhaustive extraction	High temperature, long time, solvent intensive	Polyphenols, tannins
Ultrasound-Assisted Extraction (UAE)	Acoustic cavitation disrupts cells	Faster, better yield, low solvent use	Equipment cost, optimization needed	Phenolics, antioxidants
Microwave-Assisted Extraction (MAE)	Microwave heating causes cell rupture	Very fast, energy-efficient, high yield	Risk of thermal degradation, expensive setup	Polyphenols, flavonoids

MAE has a number of benefits over conventional extraction techniques, such as lower solvent usage, quicker extraction times, and higher extraction yields. It is also thought to be an eco-friendly and energy-efficient method, which makes it ideal for the value-adding of agro-industrial waste like pomegranate peel[24].

BIOLOGICAL ACTIVITIES

Anti-oxidant Activity

Pomegranate peel's high concentration of polyphenolic chemicals, such as flavonoids, phenolic acids, and ellagitannins, makes it a powerful natural source of antioxidants. These substances are essential for eliminating free radicals and avoiding oxidative stress, which is a significant cause of cellular damage and skin aging. Pomegranate peel extracts have been shown in studies to have potent free radical scavenging action, which is mainly due to the presence of substances like gallic acid, catechin, and quercetin[28].

Pomegranate peel's antioxidant capacity has been thoroughly assessed utilizing a variety of in vitro tests, including DPPH and FRAP techniques. According to research, pomegranate peel extracts significantly suppress oxidative processes, and increased antioxidant potential is closely correlated with high phenolic content. These characteristics make it a viable component of cosmetic formulas meant to shield the skin from oxidative damage brought on by environmental stresses like pollution and UV rays[28].

Pomegranate peel-derived antioxidants can help preserve skin integrity by lowering lipid peroxidation and shielding cellular components from oxidative deterioration, according to recent research. Furthermore, these bioactive substances aid in the stability of collagen and elastin fibers, which is crucial for anti-aging cosmetic applications[29].

Pomegranate peel extracts can be used in cosmeceutical products including creams, gels, and serums since they have been demonstrated to improve antioxidant defense systems. The significance of pomegranate peel as a sustainable and efficient source of bioactive chemicals for skin protection and renewal has been further highlighted by the rising interest in natural antioxidants[29].

Antimicrobial Activity

Pomegranate peel exhibits significant antimicrobial activity against a wide range of pathogenic microorganisms, primarily due to its rich content of polyphenolic compounds such as punicalagin, ellagic acid, and flavonoids. These bioactive constituents are known to disrupt microbial cell membranes, inhibit enzyme activity, and interfere with microbial metabolism, ultimately leading to cell death. Studies have demonstrated that pomegranate peel extracts are effective against both Gram-positive and Gram-negative bacteria, including *Staphylococcus aureus*, *Escherichia coli*, and *Pseudomonas aeruginosa*, which are commonly associated with skin infections and cosmetic contamination[30].

The antimicrobial efficacy of pomegranate peel has also been attributed to its high tannin content, which can precipitate microbial proteins and inhibit the growth of microorganisms. In addition, phenolic compounds present in the peel can alter membrane permeability and cause leakage of cellular components. Research findings indicate that ethanolic and methanolic extracts of pomegranate peel exhibit strong inhibitory activity against various bacterial and fungal strains, suggesting their potential use as natural antimicrobial agents in cosmetic formulations[31].

Recent investigations have further highlighted the antifungal properties of pomegranate peel, particularly against species such as *Candida albicans*, which is commonly involved in skin and mucosal infections. The presence of bioactive compounds such as punicalagin and gallic acid contributes to the inhibition of fungal growth by affecting cell wall integrity and metabolic processes. These findings support the application of pomegranate peel extracts in formulations aimed at preventing microbial contamination and enhancing product shelf life[32].

Moreover, the incorporation of pomegranate peel extracts into topical formulations has shown promising results in controlling microbial growth while maintaining skin compatibility. Due to its broad-spectrum antimicrobial activity and natural origin, pomegranate peel is considered a valuable ingredient in the development of preservative systems and cosmeceutical products, offering a safer alternative to synthetic antimicrobial agents[33].

Anti-inflammatory Activity

Pomegranate peel possesses significant anti-inflammatory properties, primarily attributed to its rich composition of polyphenols such as ellagic acid, punicalagin, and flavonoids. These bioactive compounds are known to modulate inflammatory pathways by inhibiting the production of pro-inflammatory mediators, including cytokines, prostaglandins, and nitric oxide. Studies have shown that extracts of pomegranate peel can suppress the activation of nuclear factor-kappa B (NF-κB), a key regulator involved in inflammatory responses, thereby reducing inflammation at the cellular level[34].

The anti-inflammatory activity of pomegranate peel is also associated with its ability to inhibit enzymes such as cyclooxygenase (COX) and lipoxygenase (LOX), which play crucial roles in the synthesis of inflammatory mediators. By reducing the activity of these enzymes, pomegranate peel extracts help in alleviating skin irritation, redness, and swelling. Experimental studies have demonstrated that topical application of pomegranate peel extracts can significantly reduce inflammation in various in vitro and in vivo models[35].

Furthermore, the presence of tannins and flavonoids contributes to the stabilization of cell membranes and prevents the release of inflammatory agents from damaged tissues. These compounds also exhibit antioxidant properties, which indirectly support anti-inflammatory effects by reducing oxidative stress, a major contributor to

chronic inflammation. This dual activity enhances the therapeutic potential of pomegranate peel in dermatological applications[36].

In cosmetic formulations, the anti-inflammatory properties of pomegranate peel are particularly beneficial for sensitive and acne-prone skin. Its incorporation into creams, gels, and lotions can help soothe irritated skin, reduce redness, and improve overall skin health. As a natural ingredient with minimal side effects, pomegranate peel serves as an effective alternative to synthetic anti-inflammatory agents in cosmeceutical products[37].

Anti-aging Activity

Pomegranate peel has gained considerable attention for its anti-aging potential due to the abundance of polyphenolic constituents, particularly ellagitannins, flavonoids, and phenolic acids. These compounds contribute to the protection of skin cells by scavenging reactive oxygen species and minimizing oxidative stress, which is a primary factor responsible for the deterioration of skin structure over time. Experimental studies have demonstrated that extracts derived from pomegranate peel can attenuate oxidative damage at the cellular level, thereby helping to delay the onset of visible signs of aging such as wrinkles and loss of elasticity[38].

A major mechanism underlying its anti-aging effect involves the regulation of matrix metalloproteinases (MMPs), enzymes that degrade structural proteins like collagen and elastin in the dermal layer. Suppression of MMP activity helps preserve the integrity of the extracellular matrix, while certain phenolic compounds, including ellagic acid, have been reported to stimulate collagen production. This dual action contributes to improved skin firmness and maintenance of structural stability[39].

In addition, pomegranate peel exhibits notable photoprotective properties by mitigating the harmful effects of ultraviolet (UV) radiation. UV exposure induces the formation of reactive oxygen species, which accelerate photoaging processes such as pigmentation, inflammation, and collagen breakdown. Bioactive constituents from pomegranate peel have been shown to protect skin cells against UV-induced oxidative stress, thereby reducing photodamage and supporting skin health[40].

Furthermore, the incorporation of pomegranate peel extracts into topical formulations has been associated with improvements in skin hydration, elasticity, and overall texture. Owing to its combined antioxidant, anti-inflammatory, and collagen-protective properties, pomegranate peel represents a promising natural ingredient for anti-aging cosmetic products, offering a safer alternative to synthetic agents[41].

Skin Depigmentation and Whitening Activity

Pomegranate peel has been widely investigated for its potential role in skin depigmentation and whitening due to the presence of bioactive compounds such as ellagic acid, flavonoids, and tannins. These compounds are known to regulate melanogenesis, the biological process responsible for melanin production in the skin. Excessive melanin synthesis leads to hyperpigmentation disorders, including melasma, freckles, and age spots, which are major cosmetic concerns. Studies have demonstrated that pomegranate peel extracts can inhibit tyrosinase activity, a key enzyme involved in melanin biosynthesis, thereby reducing melanin formation and promoting a more uniform skin tone[42].

Ellagic acid, one of the main phenolic constituents of pomegranate peel, has been reported to interfere with the activity of tyrosinase and related proteins involved in melanin production. It also modulates signalling pathways associated with melanocyte activity, leading to decreased pigmentation. In addition, flavonoids present in the peel contribute to the suppression of oxidative stress, which indirectly influences melanogenesis, as oxidative stress is known to stimulate melanin synthesis[43].

Recent studies have further highlighted that pomegranate peel extracts can reduce UV-induced pigmentation by protecting skin cells from oxidative damage and inflammation. Ultraviolet radiation stimulates melanocyte activity and increases melanin production; however, the antioxidant and anti-inflammatory properties of pomegranate peel help mitigate this effect. This dual action makes it particularly useful in formulations designed for skin brightening and photoprotection[44].

In cosmetic applications, pomegranate peel extract is increasingly incorporated into creams, serums, and lotions aimed at improving skin complexion and reducing pigmentation. Its natural origin, combined with its ability to modulate melanogenesis without causing significant side effects, makes it a promising alternative to synthetic depigmenting agents such as hydroquinone. Therefore, pomegranate peel represents a valuable ingredient in the development of safe and effective skin whitening and brightening products[45].

Wound Healing and Skin Repair Activity

Pomegranate peel has demonstrated significant potential in promoting wound healing and skin repair, primarily due to its rich content of polyphenols, tannins, and flavonoids. These bioactive compounds contribute to various stages of the wound healing process, including inflammation control, tissue regeneration, and collagen formation. Studies have reported that pomegranate peel extracts can accelerate wound contraction and enhance epithelialization, thereby improving the overall healing rate of damaged skin[46].

One of the key mechanisms involved in wound healing is the stimulation of fibroblast proliferation and collagen synthesis. Polyphenolic compounds such as ellagic acid and punicalagin have been shown to enhance the deposition of collagen fibers, which are essential for maintaining skin strength and integrity. Additionally, these compounds promote angiogenesis, facilitating improved blood supply to the wounded area and supporting tissue regeneration[47].

The antimicrobial and anti-inflammatory properties of pomegranate peel further contribute to its wound healing efficacy. By inhibiting the growth of pathogenic microorganisms and reducing inflammation at the wound site, pomegranate peel extracts help prevent infection and create a favorable environment for healing. This combined action accelerates tissue repair and minimizes complications associated with delayed healing[48].

Furthermore, pomegranate peel extracts have been reported to improve skin barrier function and hydration, which are critical factors in the recovery of damaged skin. Their incorporation into topical formulations such as gels, ointments, and creams has shown promising results in enhancing skin repair and reducing scar formation. Owing to its multifunctional properties and natural origin, pomegranate peel is considered a valuable ingredient in dermatological and cosmetic formulations aimed at wound management and skin regeneration[49].

COSMETIC APPLICATION AND FORMULATION ASPECTS

Pomegranate peel has emerged as a valuable natural ingredient in cosmetic formulations due to its rich phytochemical composition and multifunctional biological activities. The presence of polyphenols, flavonoids, and tannins provides antioxidant, antimicrobial, anti-inflammatory, and anti-aging benefits, making it highly suitable for incorporation into various skincare products. Its utilization in cosmetic formulations not only enhances product efficacy but also aligns with the growing demand for natural and sustainable ingredients in the cosmetic industry[50].

Facial Scrub

Pomegranate peel powder is widely used as a natural exfoliating agent in facial scrubs. Its coarse texture helps in the mechanical removal of dead skin cells, dirt, and excess sebum from the skin surface. Additionally, the presence of phenolic compounds provides antioxidant protection during exfoliation, preventing oxidative damage. Such formulations contribute to improved skin texture, unclogged pores, and enhanced skin radiance[51].

Creams and Lotions

Pomegranate peel extracts are incorporated into creams and lotions for their moisturizing and anti-aging properties. The bioactive compounds help in maintaining skin hydration, improving elasticity, and reducing the appearance of wrinkles. These formulations also benefit from the anti-inflammatory properties of the peel, making them suitable for sensitive and irritated skin conditions[52].

Gels and Serum

Due to their lightweight and non-greasy nature, gels and serums containing pomegranate peel extracts are preferred for delivering active compounds directly into the skin. These formulations are particularly useful for acne-prone and oily skin, as they provide antimicrobial and antioxidant benefits without clogging pores. The fast absorption of gels enhances the bioavailability of active constituents[53].

Face Masks and Packs

Pomegranate peel is also used in face masks and packs for deep cleansing and skin rejuvenation. These formulations help in removing impurities, tightening pores, and improving skin tone. The depigmenting and antioxidant properties of the peel contribute to a brighter and more even complexion[54].

Natural Preservative Potential

In addition to its functional benefits, pomegranate peel extract exhibits antimicrobial activity that can be utilized as a natural preservative in cosmetic formulations. This helps in extending product shelf life while reducing reliance on synthetic preservatives, which are often associated with adverse effects[55].

SAFETY AND TOXICITY CONSIDERATION

Pomegranate peel is generally considered safe for topical application due to its natural origin and long history of use in traditional medicine. However, its safety in cosmetic formulations depends on factors such as concentration, extraction method, and formulation type. Although the peel is rich in beneficial polyphenols, excessive concentrations may lead to mild skin irritation or sensitivity in certain individuals, particularly those with sensitive skin[56].

Toxicological studies have indicated that pomegranate peel extracts exhibit low toxicity when used within appropriate limits. The presence of tannins and other bioactive compounds, while beneficial, may cause astringent effects or dryness if used in high concentrations. Therefore, optimization of formulation parameters is essential to ensure both efficacy and safety[57].

Furthermore, it is important to evaluate the potential for allergic reactions and conduct standard dermatological tests such as patch testing before incorporating pomegranate peel extracts into commercial products. Ensuring compliance with regulatory guidelines and safety standards is crucial for the successful application of these extracts in cosmetic formulations[58].

Overall, pomegranate peel demonstrates a favorable safety profile when used appropriately, supporting its potential as a safe and effective natural ingredient in cosmetic and cosmeceutical products.

CONCLUSION

Pomegranate peel has emerged as a promising natural resource for cosmetic applications owing to its rich composition of bioactive compounds, particularly polyphenols, flavonoids, and tannins. These constituents are responsible for a wide range of biological activities, including antioxidant, antimicrobial, anti-inflammatory, anti-aging, depigmenting, and wound healing effects, all of which are highly relevant to skincare and cosmeceutical formulations.

The effectiveness of these bioactive compounds is closely linked to the extraction techniques employed. While conventional methods such as solvent and Soxhlet extraction remain widely used, advanced approaches like ultrasound- and microwave-assisted extraction offer improved efficiency, reduced processing time, and better preservation of active constituents.

Furthermore, the incorporation of pomegranate peel into various cosmetic formulations, including scrubs, creams, gels, and face masks, demonstrates its versatility and practical applicability in the cosmetic industry. Its natural origin, combined with a generally favorable safety profile, makes it an attractive alternative to synthetic ingredients commonly used in skincare products.

However, despite its significant potential, further research is required to standardize extraction processes, optimize formulation strategies, and validate long-term safety and efficacy through clinical studies. Future advancements in green extraction technologies and sustainable formulation approaches are expected to enhance the utilization of pomegranate peel, supporting its role as an effective and eco-friendly ingredient in modern cosmetic science.

Source of Support: The author(s) received no financial support for the research, authorship, and/or publication of this article

Conflict of Interest: The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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