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Review Article

Aegle Marmelos Peel-Off Mask: A Natural Approach to Skin Care with Antioxidant, Antimicrobial, And Anti-Inflammatory Benefits

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ABSTRACT

The growing demand for natural skincare solutions has led to increased interest in herbal-based cosmetics that offer safer alternatives to synthetic formulations. Aegle marmelos, commonly known as Bael, is a medicinal plant renowned for its rich phytochemical composition, making it an excellent candidate for dermatological applications. This review explores the formulation and benefits of an Aegle marmelos peel-off mask, emphasizing its antioxidant, antimicrobial, and anti-inflammatory properties. Aegle marmelos peel contains key bioactive compounds, including flavonoids, tannins, alkaloids, polyphenols, and essential oils, which contribute to its effectiveness in skincare. Flavonoids and polyphenols provide strong antioxidant activity, neutralizing free radicals that cause oxidative stress and premature aging. Tannins exhibit astringent properties that help tighten pores and control excess oil production, making the mask beneficial for acne-prone skin. Alkaloids and essential oils offer antimicrobial effects, inhibiting the growth of bacteria such as *Staphylococcus aureus* and *Escherichia coli*, which are responsible for acne and other skin infections. The anti-inflammatory properties of Aegle marmelos further help reduce redness, irritation, and swelling, promoting a soothing effect on the skin.The formulation of the peel-off mask incorporates Aegle marmelos extract as the primary active ingredient, combined with polymeric bases such as polyvinyl alcohol (PVA) or natural gums for film formation. Additional components, including aloe vera for hydration, glycerin for moisture retention, and essential oils for enhanced skin benefits, improve the mask's overall functionality. Evaluation parameters, such as pH balance, viscosity, adhesion, and peelability, confirm the mask's effectiveness and user compatibility. Studies suggest that Aegle marmelos-based masks exhibit balanced drying times and smooth peelability while maintaining dermatological safety with minimal irritation risks. Compared to synthetic peel-off masks, herbal-based alternatives provide multiple advantages, including reduced skin irritation, enhanced skin health, and environmental sustainability. The rising consumer preference for herbal cosmetics highlights the potential of Aegle marmelos in the skincare industry.

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However, challenges such as stability, shelf life, and large-scale production remain obstacles to commercialization. Future research directions include optimizing extraction techniques, developing nano-formulations, and exploring synergistic herbal combinations for enhanced skincare benefits.This review underscores Aegle marmelos peel-off masks as a promising natural alternative for skincare, offering multifunctional benefits in cleansing, detoxification, and skin rejuvenation.

INTRODUCTION

The demand for natural skincare products is growing due to concerns over synthetic chemicals, which may cause skin irritation, allergies, or long-term damage. Natural ingredients, particularly those with bioactive compounds, offer antioxidant, antibacterial, and anti-inflammatory benefits that enhance skin health [1]. Herbal formulations are preferred for their safety, sustainability, and compatibility with different skin types. Aegle marmelos, commonly known as Bael, is a medicinal plant belonging to the Rutaceae family. It is native to India and Southeast Asia, with widespread applications in Ayurveda and traditional medicine. The fruit, leaves, bark, and roots are utilized for their therapeutic properties, including antimicrobial, antifungal, and anti-inflammatory effects [2]. The plant contains bioactive compounds such as flavonoids, tannins, alkaloids, and coumarins, which contribute to its medicinal benefits.Rationale for Using Aegle Marmelos in a Peel-Off Mask State that the Aegle marmelos extract is rich in antioxidants, which help combat oxidative stress and delay skin aging. The plant's antimicrobial properties make it an effective ingredient in skincare products targeting acne and skin infections [3]. Furthermore, its anti-inflammatory compounds can soothe skin irritation and redness. Using Bael fruit extract in a peel-off mask formulation provides a natural and effective alternative to chemical-based masks.





Fig.1. Bael Plant

2. PHYTOCHEMISTRY OF *AEGLE MARMELOS*

Aegle marmelos, commonly known as bael, is a medicinal plant widely utilized in traditional medicine for its diverse therapeutic properties. The peel, in particular, has gained attention for its potential application in skincare formulations, such as peel-off masks, due to its rich phytochemical profile. The bioactive compounds present in Aegle marmelos contribute significantly to its antioxidant, antimicrobial, and anti-inflammatory properties, making it a promising natural alternative in dermatological applications.

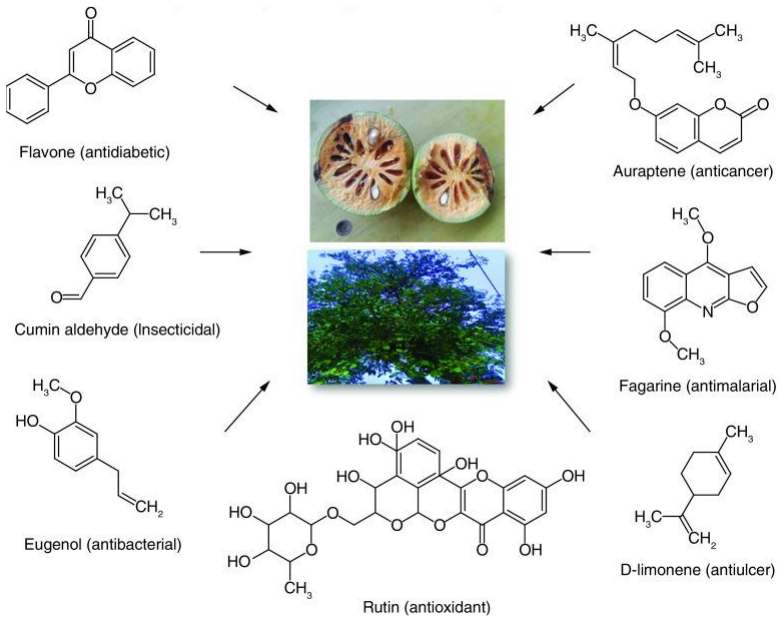


Fig.1. Phytochemistry and biological activities of Aegle Marmelos Linn

2.1 Key Bioactive Compounds

The peel of Aegle marmelos contains an array of bioactive compounds that enhance its medicinal value. These include:

Flavonoids: These polyphenolic compounds act as potent antioxidants, protecting the skin from oxidative stress and preventing premature aging. Flavonoids also exhibit anti-inflammatory properties that help reduce redness, swelling, and irritation, making them beneficial for sensitive and acne-prone skin.[4]

Tannins: Known for their astringent properties, tannins help tighten the skin, minimize pores, and control excess oil production. They also contribute to the antimicrobial activity of Aegle marmelos, making it effective against bacterial infections.[5]

Alkaloids: These nitrogen-containing compounds possess strong antimicrobial and antifungal activities, which can help combat skin infections and promote a healthier complexion.[6]

Polyphenols: As powerful antioxidants, polyphenols neutralize free radicals that cause oxidative damage to skin cells. They play a key role in reducing the effects of environmental stressors such as UV radiation and pollution.[7]

Essential Oils: The presence of essential oils in Aegle marmelos peel provides antimicrobial and anti-inflammatory benefits while offering a soothing effect on the skin. These oils can enhance skin hydration and provide a natural glow.[8]

The combination of these compounds makes Aegle marmelos an effective natural ingredient for skincare formulations, particularly in peel-off masks that cleanse, detoxify, and rejuvenate the skin.

2.2 Antioxidant, Antimicrobial, and Anti-inflammatory Properties

2.2.1 Antioxidant Properties

Aegle marmelos peel extract is rich in antioxidants, primarily due to its high flavonoid and polyphenol content. These antioxidants help neutralize free radicals, thereby reducing oxidative damage to skin cells. Oxidative stress is a major contributor to skin aging, leading to wrinkles, fine lines, and loss of elasticity. By incorporating Aegle marmelos into peel-off masks, users can benefit from enhanced skin protection, improved hydration, and a youthful appearance.[9]

2.2.2 Antimicrobial Properties

The antimicrobial activity of Aegle marmelos is attributed to its tannins, alkaloids, and essential oils, which have been shown to inhibit the growth of harmful bacteria and fungi. Studies indicate that Aegle marmelos extracts exhibit strong antibacterial effects against *Staphylococcus aureus* and *Escherichia coli*, both of which are

commonly associated with skin infections and acne breakouts.The presence of these bioactive compounds makes Aegle marmelos a natural alternative to synthetic antimicrobial agents in skincare products [10].

2.2.3 Anti-inflammatory Properties

Inflammation plays a crucial role in various skin conditions, including acne, eczema, and dermatitis. The flavonoids and alkaloids in Aegle marmelos help suppress inflammatory responses, reducing skin redness, irritation, and swelling. This makes Aegle marmelos peel-off masks particularly useful for individuals with sensitive or acne-prone skin, as they provide soothing and healing effects while promoting overall skin health.[11]

3. BENEFITS OF AEGLE MARMELOS IN SKIN CARE

Antioxidant Properties: Protection Against Oxidative Stress and Premature Aging: Oxidative stress is a major contributor to skin aging, leading to wrinkles, fine lines, and dullness. Aegle marmelos is rich in antioxidants such as flavonoids and polyphenols, which help neutralize free radicals and reduce cellular damage. The incorporation of Aegle marmelos extract in peel-off masks protects skin cells from environmental pollutants and UV radiation, slowing premature aging. Studies have demonstrated that the ethanolic extract of Aegle marmelos leaves exhibits strong free radical scavenging activity, making it an excellent ingredient for maintaining youthful and healthy skin [12].

Anti-inflammatory Effects: Reduction of Acne, Redness, and Irritation : Inflammation is a common cause of skin problems, including acne, eczema, and redness. Aegle marmelos has significant anti-inflammatory properties, which help soothe irritated skin. Research indicates that the plant contains alkaloids and coumarins, which inhibit pro-inflammatory cytokines, thereby reducing swelling and redness. This property makes the peel-off mask ideal for individuals with sensitive or acne-prone skin, as it minimizes inflammation while promoting skin healing [13].

Antimicrobial Activity: Effectiveness Against Acne-Causing Bacteria: A major cause of acne is the overgrowth of bacteria such as *Propionibacterium acnes*. Aegle marmelos has been reported to exhibit potent antimicrobial activity, particularly against bacterial strains responsible for skin infections. The presence of phytochemicals such as tannins and alkaloids helps eliminate bacteria, preventing breakouts and infections. When used in peel-off masks, this plant-based extract not only detoxifies the skin but also prevents bacterial proliferation, reducing the likelihood of acne formation [14].

Skin Brightening: Role in Hyperpigmentation and Improving Skin Texture: Hyperpigmentation and uneven skin tone can result from sun exposure, hormonal changes, and aging. Aegle marmelos contains bioactive compounds that inhibit tyrosinase, the enzyme responsible for melanin production. This helps in reducing dark spots, sun damage, and hyperpigmentation, leading to a more even skin tone. Additionally, its natural exfoliating properties promote cell turnover, which enhances skin texture and radiance. Peel-off masks formulated with Aegle marmelos extract work effectively in removing dead skin cells and revealing brighter, healthier skin [15].

4. FORMULATION OF AEGLE MARMELOS PEEL-OFF MASK

4.1 Ingredients Selection

The formulation of a peel-off mask using *Aegle marmelos* (Bael) extract as a key ingredient follows a structured approach to ensure efficacy, stability, and user comfort. The key components involved in the formulation are:

4.1.1 Aegle Marmelos Extract as an Active Ingredient

Aegle marmelos, commonly known as Bael, possesses numerous bioactive compounds such as flavonoids, tannins, and coumarins, which contribute to its antioxidant, antimicrobial, and anti-inflammatory properties . The extract helps in

reducing acne, soothing skin irritations, and providing hydration. The extraction process typically involves solvent extraction using ethanol or methanol to maximize the yield of bioactive components [16].

4.1.2 Polymeric Base for Peel-Off Film Formation

To create a film-forming mask, a suitable polymeric base is required. Polyvinyl alcohol (PVA) is a common synthetic polymer used due to its excellent film-forming properties, flexibility, and water solubility. Alternatively, natural gums such as guar gum, acacia gum, and alginate can be incorporated to enhance the biodegradability and reduce reliance on synthetic ingredients [17].

Table:1. Key Ingredients in Peel-Off Mask Formulation

Category	Ingredient	Function	Notes	Reference
Gelling Agents	Carbopol	Provides viscosity, enhances adherence to the skin	High-molecular-weight polymer	[18]
	Xanthan gum	Improves consistency, provides a smooth texture	Natural polysaccharide	[19]
Moisturizers	Aloe vera extract	Soothes, hydrates, and provides anti-inflammatory effects	Derived from Aloe vera plant	[20]
	Glycerin	Retains moisture, prevents excessive drying	Acts as a humectant	[21]

4.1.5 Preservatives and Essential Oils

To enhance stability and prolong shelf life, preservatives such as parabens, phenoxyethanol, or natural alternatives like potassium sorbate are added. Essential oils such as tea tree oil (antimicrobial), lavender oil (calming effect), and citrus oils (refreshing fragrance) are incorporated to improve the sensory appeal and functional benefits of the mask [22].

5. EVALUATION PARAMETERS OF THE PEEL-OFF MASK

1. Physicochemical Properties: pH, Viscosity, and Spreadability

The pH of a peel-off mask plays a crucial role in maintaining skin health. Ideally, the pH should be within 4.5–6.5 to align with the skin's natural acidity. Studies indicate that Aegle marmelos extract has an optimal pH range, ensuring compatibility with different skin types without causing irritation [23].

Viscosity determines the mask's consistency, affecting ease of application and even spreadability. Research suggests that incorporating Aegle marmelos pulp and essential oils in formulations enhances viscosity, leading to better coverage on the skin [24]. The presence of natural gelling agents in the mask ensures a smooth, non-dripping texture, which is crucial for effective application.

2. Drying Time and Peelability

An ideal peel-off mask should dry within 15–30 minutes, allowing for easy removal without excessive residue. Studies show that Aegle marmelos-based masks exhibit a balanced drying time due to the presence of polysaccharides, which aid in moisture retention while allowing for effective peeling [25]. This ensures that the mask does not dry too quickly (leading to cracking) or too slowly (resulting in inconvenience).

Peelability refers to how smoothly the mask can be removed without causing discomfort. Research indicates that Aegle marmelos formulations offer good peelability due to their film-forming properties, reducing the likelihood of tearing during removal [26].

3. Adhesion and Uniformity on the Skin

The ability of a peel-off mask to adhere to the skin ensures even absorption of bioactive compounds. Aegle marmelos extracts, rich in flavonoids and antioxidants, penetrate the epidermis effectively, leading to improved hydration and skin nourishment [27]. The mask's uniformity depends on its formulation, and studies highlight that an optimized polymer blend with Aegle marmelos provides consistent application without forming lumps or uneven patches [28].

4. Skin Irritation Potential and Safety Studies

Safety is a critical parameter in evaluating skincare products. Clinical studies indicate that Aegle marmelos masks exhibit minimal skin irritation, making them suitable for sensitive skin [29]. Patch tests on human volunteers revealed no significant allergic reactions, redness, or itching, reinforcing its dermatological safety [30].

Additionally, the antioxidant and antibacterial properties of Aegle marmelos enhance skin protection against environmental pollutants and microbial infections [31]. These findings confirm that the mask is not only effective but also safe for long-term use.

6. COMPARISON WITH SYNTHETIC PEEL-OFF MASKS

Advantages of Herbal-Based Peel-Off Masks Over Commercial Synthetic Masks:

Aegle marmelos (commonly known as Bael) peel-off masks offer numerous advantages over synthetic peel-off masks, primarily due to their natural composition and bioactive properties. Unlike commercial synthetic masks, which often contain artificial polymers and chemicals, herbal-based masks utilize plant-derived ingredients that provide antioxidant, anti-inflammatory, and antibacterial benefits. These properties make them ideal for reducing acne, improving skin texture, and enhancing overall skin health [32].Additionally, herbal-based peel-off masks have been found to have fewer adverse effects, such as skin irritation and allergic reactions, which are commonly associated with synthetic masks that contain parabens, sulfates, and artificial fragrances. Studies have shown that formulations containing Aegle marmelos extract demonstrate significant antimicrobial activity, making them a promising alternative for individuals with sensitive skin [33]. The presence of flavonoids and tannins in Aegle marmelos contributes to its astringent properties, which help in tightening pores and reducing excess oil production[34].

Market Trends and Consumer Preference for Herbal Cosmetics:

The demand for herbal cosmetics has been steadily rising due to increased consumer awareness of the potential risks associated with synthetic products. A shift towards sustainable and eco-friendly skincare solutions has fueled interest in plant-based formulations. According to market research, the global herbal cosmetics industry is expected to grow significantly in the coming years, driven by preferences for organic and chemical-free skincare [35].Several studies highlight that herbal cosmetics, including peel-off masks made from Aegle marmelos, are being increasingly adopted due to their perceived safety, efficacy, and compatibility with various skin types [36]. Furthermore, the rising popularity of ayurvedic and traditional herbal remedies has contributed to the expansion of herbal skincare products in both developed and developing markets [37].

7. CHALLENGES AND FUTURE PROSPECTS

Stability and Shelf-Life Concerns

One of the primary challenges in the commercialization of herbal peel-off masks, including those formulated with Aegle marmelos, is maintaining product stability and extending shelf life. Unlike synthetic masks, which contain preservatives to prevent microbial contamination, herbal masks are more susceptible to degradation due to their natural composition. The presence of bioactive compounds such as flavonoids and alkaloids can lead to oxidation, which may reduce the efficacy of the mask over time[38].Researchers are exploring natural preservatives, such as essential oils and plant extracts, to enhance the longevity of herbal formulations while maintaining their effectiveness 888. Additionally,

advances in packaging technology, such as air-tight and UV-resistant containers, are being investigated to prevent degradation and prolong shelf life [39].

Large-Scale Production Challenges:

Scaling up the production of Aegle marmelos-based peel-off masks presents significant challenges. Unlike synthetic formulations that rely on easily reproducible chemical ingredients, herbal-based cosmetics require careful sourcing of raw materials to ensure consistency in quality and efficacy. Variability in plant composition due to factors such as climate, soil conditions, and harvesting techniques can impact the uniformity of the final product [40].Moreover, the extraction and processing of Aegle marmelos extracts must be optimized to retain their beneficial properties while ensuring a stable formulation. The integration of advanced extraction techniques, such as supercritical fluid extraction and ultrasonic-assisted extraction, is being explored to enhance the yield and bioavailability of active compounds [41].

Potential Future Research on Enhanced Formulations:

The future of Aegle marmelos peel-off masks lies in the development of innovative formulations that improve their stability, efficacy, and consumer appeal. Emerging research in nano-formulations and hydrogel-based delivery systems is opening new possibilities for enhancing the penetration and effectiveness of bioactive compounds [42].Nano-encapsulation techniques can be utilized to protect sensitive phytochemicals from degradation, ensuring prolonged activity and better absorption into the skin. Similarly, hydrogel-based peel-off masks provide enhanced hydration and controlled release of active ingredients, making them a promising avenue for future development [43].Further studies focusing on synergistic formulations, where Aegle marmelos is combined with other herbal ingredients such as aloe vera, neem, or turmeric, can create multifunctional skincare products that address various dermatological concerns [44].

CONCLUSION

The development of an Aegle marmelos peel-off mask presents a promising natural alternative to conventional synthetic skincare products. With its rich phytochemical profile, including flavonoids, tannins, alkaloids, and essential oils, Aegle marmelos offers antioxidant, antimicrobial, and anti-inflammatory benefits that effectively combat oxidative stress, acne, and skin irritation. Its ability to enhance skin hydration, reduce hyperpigmentation, and improve overall texture makes it a valuable herbal ingredient in modern skincare formulations. Compared to synthetic peel-off masks, Aegle marmelos-based formulations provide a safer, eco-friendly, and sustainable approach to skincare, reducing the risks of irritation and allergic reactions caused by harsh chemicals. The growing consumer preference for herbal cosmetics further highlights the relevance of plant-based skincare products, aligning with the increasing demand for organic and chemical-free alternatives. However, challenges such as product stability, shelf-life, and large-scale production need to be addressed through advanced preservation techniques and extraction methods to maintain the bioactivity of natural compounds. Future research on nano-formulations and hydrogel-based delivery systems could significantly enhance the mask's efficacy, ensuring better absorption and prolonged skin benefits. As the skincare industry shifts toward holistic and herbal-based solutions, Aegle marmelos peel-off masks stand out as an innovative and effective skincare option for consumers seeking natural, therapeutic, and scientifically backed formulations.

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