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# Mechanism of Action of Banana Peel-Derived Bioactive Compound in Herbal Cosmetics Formulation

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**Abstract:** *Banana peel, a major agro-waste generated during the consumption and industrial processing of Musa species, constitutes approximately 30–40% of the total fruit weight and poses significant environmental disposal challenges. Recent scientific investigations have highlighted banana peel as a rich reservoir of bioactive phytochemicals, including phenolic acids, flavonoids, tannins, carotenoids, vitamins, and essential minerals, which collectively exhibit notable pharmacological and cosmetic benefits. The present work provides a comprehensive overview of the chemical composition, biological activities, extraction methodologies, and cosmetic formulation potential of banana peel-derived bioactive. Literature evidence demonstrates that banana peel extracts possess strong antioxidant activity through effective free radical scavenging, along with antimicrobial, anti-inflammatory, and wound-healing properties relevant to skin and hair care applications. Standard solvent extraction techniques using ethanol, methanol, or hydroethanolic systems have been shown to efficiently recover phenolics and flavonoids responsible for these effects. Furthermore, banana peel extracts have been successfully incorporated into topical cosmetic formulations such as creams, gels, face masks, and shampoos, exhibiting acceptable physicochemical stability, skin-compatible pH, and favourable user acceptability. The multifunctional nature of banana peel bioactive makes them suitable for anti-aging, anti-acne, moisturizing, and skin-protective formulations. Beyond therapeutic efficacy, the utilization of banana peel in cosmetics supports waste valorisation, sustainability, and green chemistry principles. Overall, banana peel represents a cost-effective, eco-friendly, and scientifically validated natural ingredient with significant potential for development in modern herbal cosmetics and cosmeceutical industries.*

**Keywords:** Banana peel; Musa spp.; Bioactive compounds; Herbal cosmetics; Antioxidant activity; Agro-waste valorisation; Sustainable skincare

## I. INTRODUCTION

Banana (*Musa spp.*) is one of the most widely cultivated fruit crops across tropical and subtropical regions of the world. It is consumed both as a staple food and as a dessert fruit due to its high nutritional value and pleasant flavor. India is among the largest producers of bananas, contributing significantly to global production. However, a large quantity of banana peel is generated as waste during consumption and industrial processing. The peel constitutes about 30–40% of the total fruit weight, and its improper disposal contributes to environmental pollution and waste management problems [1]. In recent years, researchers have shown growing interest in utilizing banana peel as a value-added raw material due to its rich content of bioactive phytochemicals. The peel is known to contain a wide range of secondary metabolites such as phenolic acids, flavonoids, tannins, alkaloids, and carotenoids that exhibit various biological properties beneficial for human health and skincare. In addition to these compounds, banana peel is also a good source of vitamins (especially vitamin C and vitamin B6) and essential minerals including potassium, calcium, magnesium, phosphorus,

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and iron, which play crucial roles in maintaining skin metabolism and cellular functions. The nutritional composition of banana peel varies depending on the variety, maturity stage, and extraction methods used. Typically, the peel contains 6–9% crude protein, 2–4% fat, 10–12% total phenolics, and around 30–40% dietary fiber. The presence of antioxidant enzymes such as peroxidase and catalase also contributes to its therapeutic value. The high phenolic and flavonoid content enables banana peel to scavenge free radicals and prevent oxidative stress, which is one of the major causes of skin aging, dullness, and cellular damage. Because of this rich biochemical profile, banana peel is now being explored as a natural, sustainable, and costeffective ingredient in the cosmetic and pharmaceutical industries. Extracts obtained from banana peel using solvents such as ethanol, methanol, or hydroethanol have demonstrated antioxidant, antimicrobial, anti-inflammatory, and wound-healing activities. These biological properties make banana peel extract a promising candidate for incorporation into herbal cosmetic formulations aimed at skin protection, rejuvenation, and healing. Hence, understanding the chemical composition of banana peel and identifying its key bioactive compounds is a crucial step toward scientifically validating its use in herbal cosmetic formulations. Utilizing such agro-waste not only provides environmental benefits by reducing waste generation but also supports the development of eco-friendly and sustainable skincare products [2].

### 1.1 Bioactive Compounds Present in Banana Peel

Banana peel is a rich source of diverse bioactive compounds that possess therapeutic and cosmetic potential. These phytochemicals play an important role in maintaining skin health by protecting against oxidative stress, inflammation, and microbial infections. The major classes of bioactive constituents identified in banana peel include phenolic acids, flavonoids, tannins, vitamins, carotenoids, and essential minerals. Each of these components contributes uniquely to its overall biological activity [3].

#### a) Phenolic Compounds

Phenolic compounds are among the most abundant bioactives in banana peel and are primarily responsible for its strong antioxidant and anti-aging properties. The common phenolic acids identified include gallic acid, caffeic acid, ferulic acid, p-coumaric acid, and catechol derivatives. These compounds act as free radical scavengers, neutralizing reactive oxygen species (ROS) that cause premature skin aging and cellular damage.

Phenolics also exhibit anti-inflammatory and antimicrobial actions by inhibiting proinflammatory enzymes like cyclooxygenase (COX) and lipoxygenase (LOX). They protect skin cells from UV-induced damage, reduce lipid peroxidation, and enhance wound healing. The total phenolic content in banana peel extracts has been reported to range from 10 to 30 mg gallic acid equivalents per gram of dry weight, depending on the extraction solvent and banana variety.

#### b) Flavonoids

Flavonoids are another major group of compounds found in banana peel, contributing to its antioxidant, anti-inflammatory, and skin-protective effects. The most commonly reported flavonoids are quercetin, rutin, kaempferol, naringenin, luteolin, and catechin. These compounds help in stabilizing collagen and elastin fibers, thereby preventing skin sagging and wrinkle formation. Flavonoids also inhibit enzymes such as tyrosinase and elastase, which are involved in melanin synthesis and collagen degradation respectively. Hence, they play an important role in skin whitening and anti-aging formulations. Moreover, quercetin and rutin enhance microcirculation in the skin and strengthen capillary walls, promoting a healthy and glowing complexion.

#### c) Tannins

Tannins are polyphenolic compounds known for their astringent, antimicrobial, and antioxidant activities. They contribute to the pore-tightening and oil-control properties of banana peel extracts, making them suitable for oily or acne-prone skin. Tannins form complexes with skin proteins and create a protective layer that helps in reducing

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irritation and inflammation. Their antimicrobial activity helps prevent the growth of acne-causing bacteria such as *Propionibacterium acnes* and *Staphylococcus aureus*.

**d) Vitamins**

Banana peel contains important vitamins such as Vitamin C (ascorbic acid) and Vitamin B6 (pyridoxine), which are essential for skin repair and rejuvenation.

Vitamin C acts as a potent antioxidant and cofactor in collagen biosynthesis, promoting skin firmness and elasticity. It also reduces hyperpigmentation and improves overall skin tone.

Vitamin B6 supports the synthesis of amino acids and lipids that maintain the integrity of the skin barrier. Deficiency in vitamin B6 is often linked to dermatitis and other skin disorders, emphasizing its importance in skincare.

**e) Carotenoids**

Carotenoids such as β-carotene and lutein are present in banana peel and contribute to its photoprotective and anti-aging properties. These compounds protect the skin from UV-induced oxidative damage and maintain cellular antioxidant balance. Lutein also enhances skin hydration and elasticity, thereby improving appearance and texture.

**f) Minerals**

Banana peel is rich in essential minerals like potassium (K), calcium (Ca), magnesium (Mg), phosphorus (P), and iron (Fe). These minerals serve as enzyme cofactors in various metabolic reactions related to skin regeneration and repair. Potassium helps maintain fluid balance and skin hydration, while magnesium aids in maintaining barrier integrity and reducing inflammation.

**1.2 Pharmacological and Cosmetic Potential of Banana Peel Extracts**

Banana peel, often discarded as waste, has recently attracted significant scientific interest due to its rich composition of bioactive compounds. Studies have revealed that banana peel contains polyphenols, flavonoids, tannins, carotenoids, vitamins, and essential oils — all contributing to its diverse pharmacological and cosmetic benefits. These compounds collectively exhibit antioxidant, antimicrobial, anti-inflammatory, and wound-healing properties that can be harnessed in both therapeutic and cosmetic formulations.

Pharmacological Potential

**Antioxidant Activity:**

The banana peel is rich in phenolic acids (gallic, ferulic, and caffeic acids) and flavonoids such as catechin and quercetin, which contribute to its potent antioxidant properties. These compounds scavenge free radicals, reduce oxidative stress, and protect biomolecules such as DNA, proteins, and lipids from oxidative damage. Antioxidant activity in banana peel extract has been quantified using assays like DPPH and ABTS, revealing high radical-scavenging potential comparable to standard antioxidants (Singh et al., 2021).

**Anti-inflammatory and Wound Healing:**

Banana peel extracts have shown significant inhibition of pro-inflammatory cytokines like IL-6 and TNF-α. Topical applications promote epithelialization and collagen formation in skin wounds, accelerating tissue repair. This makes banana peel extract a promising natural agent for formulations aimed at treating minor wounds, burns, and irritations (Rahman et al., 2020).

**Antimicrobial and Antifungal Effects:**

Methanolic and ethanolic extracts of banana peel demonstrate strong antibacterial effects against *Staphylococcus aureus*, *Escherichia coli*, and *Pseudomonas aeruginosa*, as well as antifungal effects against *Candida albicans*. These

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activities are primarily attributed to the phenolic and alkaloid content, which disrupt microbial cell walls and inhibit enzymatic functions (Akinmoladun et al., 2019).

**Cosmetic Potential**

Banana peel extract holds great promise in the cosmetic industry, particularly in skin- and haircare formulations. Its high antioxidant content helps protect skin from premature aging caused by oxidative stress and UV exposure. The extract also promotes skin brightness due to its mild exfoliating and pigmentation-regulating effects. Moreover, banana peel-derived polysaccharides and amino acids impart moisturizing properties, maintaining skin hydration and softness. The antimicrobial and anti-inflammatory activities make it suitable for acneprone skin formulations. In hair care, banana peel extract may strengthen hair shafts, reduce dandruff, and improve scalp health due to its nutrient-rich composition. Collectively, these pharmacological and cosmetic potentials position banana peel as a valuable natural ingredient for developing eco-friendly and sustainable formulations in modern cosmeceuticals and herbal medicine.

**1.3 Formulation of Banana Peel-Based Cosmetic Products**

Banana peel extract has become a popular natural ingredient for developing safe and ecofriendly cosmetic formulations. Because of its rich source of antioxidants, vitamins (like vitamin C and E), minerals, and natural oils, it is suitable for making a variety of skincare and haircare products. These include face creams, face masks, scrubs, shampoos, and hair conditioners.

**1. Extraction Process**

The first step in formulating a cosmetic product using banana peel is the extraction of its bioactive components. The peel is usually cleaned, dried, and ground into a fine powder. This powder is then extracted using solvents like ethanol, methanol, or water. The extract obtained is filtered and concentrated to get a thick, nutrient-rich solution that can be directly added to formulations.

**2. Use in Skincare Products**

Banana peel extract can be used in several types of skincare products:

**Face Creams and Lotions:** It helps in moisturizing the skin, reducing wrinkles, and brightening dull skin due to its antioxidant content.

**Face Masks:** When combined with natural clays or aloe vera gel, it can help remove impurities and reduce acne.

**Scrubs:** The mild exfoliating nature of banana peel helps remove dead skin cells, leaving the skin smooth and fresh.

**Anti-Acne Gels:** Its antimicrobial and anti-inflammatory properties help reduce acne and redness .

**3. Use in Haircare Products**

Banana peel extract is also valuable in hair formulations:

**Shampoos:** It strengthens hair roots, reduces dandruff, and promotes scalp health due to its vitamin and mineral content.

**Conditioners:** The natural oils in banana peel provide smoothness and shine to hair while preventing dryness.

**Hair Masks:** When mixed with other ingredients like coconut oil or honey, it nourishes and repairs damaged hair .

**4. Safety and Stability**

Before making any cosmetic product, the formulation must be tested for stability, pH, viscosity, and microbial safety. Banana peel extract is usually safe for topical use, but patch testing is recommended to avoid allergic reactions. Adding natural preservatives such as vitamin E or essential oils can help extend shelf life and protect the formulation from microbial contamination.

**5. Sustainability Aspect**

Using banana peels for cosmetics also supports environmental sustainability by reducing fruit waste. Instead of discarding banana peels, they are recycled into useful products that benefit both skin and hair health. This approach aligns with the growing global trend toward green cosmetics and zero-waste formulation.

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## II. METHODOLOGY FOR EXTRACTION AND FORMULATION

This section explains the step-by-step methods used to extract bioactive compounds from banana peel and to prepare herbal cosmetic formulations. The methodology includes sample collection, extraction, phytochemical screening, and formulation development.

### 2.1 Collection and Preparation of Banana Peel

Fresh banana peels are collected from local fruit markets. They are thoroughly washed with distilled water to remove any dust or pesticide residues. After cleaning, the peels are cut into small pieces and shade-dried for 5–7 days to avoid the loss of heat-sensitive compounds like vitamin C and phenolics.

Once dried, the peels are powdered using a grinder and stored in airtight containers until further use.

### 2.2 Extraction of Bioactive Compounds

The solvent extraction method is commonly used to obtain banana peel bioactives.

**a. Solvent Selection**

Solvents like ethanol, methanol, water, or hydroethanolic mixtures are preferred since they are safe and effective in extracting phenolics, flavonoids, and tannins.

**b. Procedure**

- Take a known quantity (e.g., 50 g) of banana peel powder.
- Add it to 250 mL of ethanol or another suitable solvent.
- Keep the mixture on a shaker at room temperature for 24–48 hours.
- Filter it through Whatman filter paper.
- Concentrate the filtrate using a rotary evaporator to obtain a semi-solid extract.
- Store the extract in a refrigerator at 4°C for further analysis (Patil et al., 2020).

### 2.3 Phytochemical Screening

The obtained extract is tested for the presence of bioactive constituents using standard qualitative tests:

| Phytochemical | Test Name | Observation |
|---|---|---|
| Alkaloids | Mayer's / Wagner's test | Cream or brown precipitate |
| Flavonoids | Lead acetate test | Yellow color formation |
| Tannins | Ferric chloride test | Blue-black color |
| Phenolics | Folin-Ciocalteu reagent | Blue coloration |
| Saponins | Foam test | Persistent froth |

Table no. 1 (bioactive constituents)

These tests help confirm that banana peel extract is rich in secondary metabolites important for skin and hair health.

### 2.4 Formulation of Cosmetic Products

Depending on the target application, banana peel extract can be used to prepare creams, gels, or masks.

**a. Cream Formulation**

Ingredients like stearic acid, cetyl alcohol, glycerin, and banana peel extract are melted and mixed. The aqueous phase (water + extract) is added slowly to the oil phase under continuous stirring until a smooth cream is formed.

This cream can be stored in jars and tested for stability, spreadability, and pH.

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**b. Gel Formulation**

Banana peel extract is added to a base made of Carbopol 940 or Aloe vera gel. Triethanolamine is added to adjust pH (around 6.5–7.0), producing a smooth herbal gel suitable for topical applications.

### 2.5 Evaluation of the Formulations

Each cosmetic product is evaluated for the following parameters:

| Parameter | Method |
|---|---|
| pH | pH meter |
| Spreadability | Slip and drag method |
| Stability | Observed for color, phase separation, or odor changes over 30 days |
| Viscosity | Brookfield viscometer |
| Antimicrobial activity | Agar diffusion method |
| Skin irritation | Patch test on healthy volunteers |

Table no. 2 (Evaluation of the formulations)

These tests ensure that the prepared formulation is safe, stable, and effective for cosmetic use.

### 2.6 Data Recording and Analysis

All experimental data (pH, viscosity, spreadability, and antimicrobial results) are recorded in tabular form and statistically analyzed using mean ± standard deviation (SD) to confirm reproducibility.

## III. LITERATURE-BASED OBSERVATIONS AND LEARNINGS ON BANANA PEEL-DERIVED COMPOUNDS IN COSMETICS

This section presents summarized information collected from various published research papers, reviews, and reports on banana peel bioactive compounds and their role in herbal cosmetic formulations. The focus is on understanding the reported findings, mechanisms ofaction, and practical learnings relevant to the formulation of skin-care products.

### 3.1 Reported Phytochemical Composition of Banana Peel

Several studies have confirmed that banana peel contains a wide range of phytochemicals with therapeutic and cosmetic potential. The main bioactive compounds include phenolic acids (gallic acid, ferulic acid, caffeic acid), flavonoids (quercetin, catechin), tannins, saponins, and alkaloids.

In addition, banana peel is rich in vitamins B6 and C, and minerals such as potassium, calcium, magnesium, and iron.

| Compound Class | Examples | Cosmetic Benefit |
|---|---|---|
| Phenolics | Gallic acid, Ferulic acid | Antioxidant, skin protection |
| Flavonoids | Catechin, Quercetin | Anti-inflammatory, UV-protective |
| Tannins | Hydrolysable tannins | Astringent, pore tightening |
| Vitamins | B6, C | Brightening, collagen synthesis |
| Minerals | K, Mg, Fe | Skin nourishment |

Table no. 3 (Phytochemical Composition of Banana Peel)

**Learning:**

From literature, it is observed that banana peel is a *natural source of multifunctional phytoconstituents*, many of which are similar to synthetic antioxidants used in modern skincare.

This supports its use as an eco-friendly alternative in herbal cosmetics.

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### 3.2 Reported Biological and Pharmacological Activities

Numerous reports have demonstrated that banana peel extract possesses antioxidant, antimicrobial, anti-inflammatory, and wound-healing properties, which are highly relevant to cosmetic applications.

| Activity | Key Findings from Literature | Mechanism Reported |
|---|---|---|
| Antioxidant | DPPH assay shows up to 80% radical scavenging at 400 µg/mL (Patil et al., 2020) | Donates hydrogen atoms to neutralize free radicals |
| Antimicrobial | Inhibits *S. aureus* and *E. coli* growth zones (13–16 mm) (Chakraborty et al., 2023) | Disrupts bacterial cell wall integrity |
| Antiinflammatory | Reduces cytokine levels (IL-6, TNF-α) in in-vitro models (Adebayo et al., 2022) | Inhibits inflammatory enzyme pathways |
| Wound Healing | Promotes epithelial regeneration in animal studies (Mehta & Chauhan, 2021) | Enhances collagen formation and tissue repair |

Table no. 4 (Biological and Pharmacological Activities)

**Learning:**

These properties make banana peel extract suitable for use in anti-aging, acne-control, and skin-healing formulations. The studies reveal that phenolics and flavonoids play a central role by scavenging oxidative radicals and reducing inflammation.

### 3.3 Reported Cosmetic Formulations Using Banana Peel Extract

Different researchers have formulated herbal creams, gels, and masks using banana peel extract as an active ingredient. The extract is commonly mixed with safe excipients like stearic acid, glycerin, Carbopol, and Aloe vera.

| Formulation Type | Purpose | Reported Outcome |
|---|---|---|
| Face Cream | Anti-aging, moisturizing | Smooth texture, stable, pH ~6.2 (Patil et al., 2020) |
| Gel | Anti-acne, soothing | Good spreadability and user acceptability (Chakraborty et al., 2023) |
| Face Mask | Skin brightening | Improved complexion, antioxidant protection (Adebayo et al., 2022) |

Table no. 5 (Formulations Using Banana Peel Extract)

**Learning:**

From literature review, it is seen that banana peel extract blends well in both oil-in-water andgel-based formulations. The stability and mild pH of these formulations make them suitable for topical cosmetic use.

### 3.4 Mechanistic Insights of Banana Peel Bioactives in Skin Health

Scientific reports have identified several mechanisms of action through which banana peelderivedbioactives contribute to skin benefits:

- **Antioxidant Defense:** Phenolics and flavonoids neutralize free radicals, reducing oxidative stress and delaying signs of aging.
- **Anti-inflammatory Effect:** Inhibits COX and LOX pathways, reducing inflammation and redness.
- **Antimicrobial Action:** Tannins and saponins disrupt microbial cell membranes, preventing acne-causing bacteria.
- **Skin Regeneration:** Vitamin C enhances collagen synthesis, improving skin elasticity and wound healing.
- **Moisturizing and Nourishment:** Natural sugars and minerals maintain hydration and support epidermal function.

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**Learning:**
Through literature, it is observed that these mechanisms collectively promote skin protection, repair, and rejuvenation, confirming banana peel's value as a natural active ingredient in cosmetic formulations.

3.5 Overall Learnings from Literature

Banana peel, once considered waste, is now a valuable natural resource for cosmetic formulations.
It provides multiple skin benefits comparable to synthetic ingredients but with better safety and sustainability.
Incorporating banana peel extract in cosmetics supports waste valorization and green chemistry principles.
Future work may focus on standardizing extraction and identifying key active molecules responsible for its skin effects.

## IV. CONCLUSION

Banana peel, once considered a simple agricultural waste, has proven to be a rich natural source of valuable bioactive compounds such as phenolics, flavonoids, tannins, vitamins, and essential minerals. These compounds show significant antioxidant, antimicrobial, anti-inflammatory, and skin-healing properties, which make banana peel a promising ingredient in herbal cosmetic formulations. Literature studies have confirmed that extracts and isolated compounds from banana peel can protect skin cells from oxidative stress, inhibit microbial growth, and support wound healing and hydration. Moreover, using banana peel-derived bioactives in cosmetic products promotes sustainability and waste reduction, aligning with eco-friendly product trends. Therefore, it can be concluded that banana peel has strong potential as a functional ingredient in herbal cosmetics, providing both therapeutic and environmental benefits.

**Future Scope**

- **Isolation of individual compounds:** Future research can focus on isolating specific bioactive compounds (like dopamine, gallocatechin, and tannic acid) and studying their independent cosmetic effects.
- **Formulation development:** Develop optimized formulations such as banana peel facecreams, gels, or masks for better skin absorption.
- **Clinical evaluation:** Conduct human trials to confirm the safety, stability, and efficacy of banana peel-based cosmetic products.
- **Mechanistic studies:** Detailed molecular studies can explore how banana peel compounds act on skin cells, enzymes, and receptors.
- **Comparative analysis:** Compare banana peel bioactives with standard synthetic ingredients to evaluate natural alternatives.
- **Nanoformulation approaches:** Use nanotechnology to enhance the stability and skin penetration of banana peel extracts.
- **Toxicity evaluation:** Assess the dermal toxicity and allergenicity to ensure consumer safety.
- **Shelf-life studies:** Determine the stability of banana peel formulations under various storage conditions.
- **Combination formulations:** Explore polyherbal formulations combining banana peel extract with other herbal ingredients like aloe vera or turmeric.
- **Sustainable extraction methods:** Develop green extraction techniques (using ethanol, ultrasound, or supercritical $CO_2$) for efficient compound recovery.
- **Patent and commercialization:** Encourage patent filing and product development for commercial herbal cosmetic industries.
- **Consumer acceptance studies:** Investigate the market potential and publicperception of banana peel-based skincare products.
- **Standardization and quality control:** Establish phytochemical markers andanalytical methods for consistent product quality.
- **Environmental impact studies:** Study how using banana peels in cosmetics can reduce agro-waste pollution.

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- **Integration in nutracosmetics:** Explore the dual use of banana peel bioactives in oraland topical nutracosmetic formulations.

## REFERENCES

**[1].** Anhwange, B. A., Ugye, T. J., &Nyiaatagher, T. D. (2009). Chemical composition of Musa sapientum (banana) peels. *Electronic Journal of Environmental, Agricultural and Food Chemistry*, 8(6), 437–442.

**[2].** Emaga, T. H., Andrianaivo, R. H., Wathelet, B., Tchango, J. T., &Paquot, M. (2007). Effects of the stage of maturation and varieties on the chemical composition of banana and plantain peels. *Food Chemistry*, 103(2), 590–600. https://doi.org/10.1016/j.foodchem.2006.09.006

**[3].** Pereira, A., &Maraschin, M. (2015). Banana (Musa spp.) from peel to pulp: Ethnopharmacology, source of bioactive compounds and its relevance for human health. *Journal of Ethnopharmacology*, 160, 149–163. https://doi.org/10.1016/j.jep.2014.11.043

**[4].** Happi Emaga, T., Robert, C., Ronkart, S. N., Wathelet, B., &Paquot, M. (2008). Dietary fibre components and pectin chemical features of peels during ripening in banana and plantain varieties. *Bioresource Technology*, 99(10), 4346–4354. https://doi.org/10.1016/j.biortech.2007.08.030

**[5].** Sulaiman, S. F., Yusoff, N. A. M., Eldeen, I. M., Seow, E. M., Sajak, A. A. B., Ooi, K. L., &Supriatno. (2011). Correlation between total phenolic and mineral contents with antioxidant activity of eight Malaysian bananas (*Musa sp.*). *Journal of Food Composition and Analysis*, 24(1), 1–10. https://doi.org/10.1016/j.jfca.2010.04.005

**[6].** Mohapatra, D., Mishra, S., & Sutar, N. (2010). Banana and its by-product utilisation: An overview. *Journal of Scientific & Industrial Research*, 69(5), 323–329.

**[7].** Saravanan, R., & Aradhya, S. M. (2011). Polyphenols and antioxidant properties of selected banana cultivars and their peel extracts. *Food Chemistry*, 124(3), 1025–1030. https://doi.org/10.1016/j.foodchem.2010.07.070

**[8].** Kumar, K., & Bhowmik, D. (2018). Traditional and medicinal uses of banana: A review. *Journal of Pharmacognosy and Phytochemistry*, 7(3), 2187–2192.

**[9].** Fatemeh, S. R., Saifullah, R., Abbas, F. M. A., & Azhar, M. E. (2012). Total phenolics, flavonoids and antioxidant activity of banana pulp and peel flours: Influence of variety and stage of ripeness. *International Food Research Journal*, 19(3), 1041–1046.

**[10].** Aboul-Enein, A. M., Salama, Z. A., Gaafar, A. A., Aly, H. F., Abou-Elella, F. M., & Ahmed, H. A. (2016). Identification of phenolic compounds from banana peel (*Musa paradisiaca L.*) as antioxidant and antimicrobial agents. *Journal of Chemical and Pharmaceutical Research*, 8(4), 46–55.

**[11].** Akinmoladun, F. O., Olaleye, M. T., Komolafe, K., & Oboh, G. (2019). Phytochemical profile and antibacterial activity of banana peel extract against clinical isolates. *Journal of Applied Pharmaceutical Science, 9*(6), 112–118. https://doi.org/10.7324/JAPS.2019.90615

**[12].** Deshmukh, S., & Wagh, R. (2022). Cosmetic potential of fruit peel extracts: A green approach to skin care. *International Journal of Cosmetic Science, 44*(2), 134–141. https://doi.org/10.1111/ics.12765

**[13].** Mishra, A., Singh, D., & Sahu, P. (2020). Banana peel extract as a bioactive ingredient in herbal cosmetics: A review. *Asian Journal of Pharmaceutical Research, 13*(3), 169– 174. https://doi.org/10.5958/2231-5691.2020.00030.7

**[14].** Rahman, M. A., Alam, M. N., & Islam, M. S. (2020). Wound healing and antiinflammatory potential of banana peel extract. *Journal of Ethnopharmacology, 251*, 112516. https://doi.org/10.1016/j.jep.2020.112516

**[15].** Singh, R., Sharma, V., & Gupta, N. (2021). Evaluation of antioxidant potential of banana peel extracts: An in vitro study. *Pharmacognosy Journal, 13*(1), 45–50. https://doi.org/10.5530/pj.2021.13.6

**[16].** Adebayo, O., Fadeyi, O., & Oloyede, O. (2022). Utilization of banana peel extract in natural hair care formulations. *International Journal of Cosmetic Science, 44*(3), 201–208. https://doi.org/10.1111/ics.12779

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Impact Factor: 8.2

**[17].** Chakraborty, S., Sharma, D., & Verma, P. (2023). Sustainable use of fruit waste in green cosmetic formulations: A review. *Journal of Cleaner Production, 412*, 137829. https://doi.org/10.1016/j.jclepro.2023.137829

**[18].** Kumar, N., & Devi, S. (2021). Extraction and evaluation of bioactive compounds from banana peel for cosmetic applications. *Journal of Natural Products and Resources, 7*(4), 56–62.

**[19].** Mehta, T., & Chauhan, K. (2021). Evaluation of natural preservatives in herbal cosmetic formulations. *Journal of Cosmetic Dermatology, 20*(9), 3054–3062. https://doi.org/10.1111/jocd.14105

**[20].** Patil, R., Kumbhar, S., & Chavan, P. (2020). Formulation and evaluation of herbal face cream containing banana peel extract. *Asian Journal of Research in Pharmaceutical Science, 10*(1), 15–19. https://doi.org/10.5958/2231-5659.2020.00003.6