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"From Peel to Potion: Exploring Banana Waste as a Natural Beauty Resource"

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ABSTRACT :

Banana peel is known as underutilized agricultural waste , but it holds a remarkable potential in health benefits mainly in cosmetic industry due to its rich bioactive compositions . it contain chemical constituents like polyphenols , flavonoids , carotenoids and vitamins that exhibit various activity like polyphenols , flavonoids for antioxidant activity , vitamins to promote skin health , minerals and fiber for keeping skin hydration and moisture .This review mainly focuses on exploring cosmetic potential of banana peel .It focuses on Utilizing agro waste in cosmetics and skin care , it focuses on potential of banana peel in skin health , Botnical and geographical profile of banana and composition of banana peel . it further highlights on formulations and there benefits, challenges and future prospectives in utilizing banana peel as natural cosmetic . This article also emphasizes its sustainable value in converting agro -waste into eco friendly cosmetic ingredients , reducing enviromental pollution and production cost . By blending traditional knowledge with modern research , this review aims to inspire innovation in natural cosmetics using banana peel as promising green resource .

KEY WORDS : Banana peel , Agro-waste , Cosmetic potential , Herbal formulations , Skin whitning , Healthy , Natural , Cosmetic potential

1. INTRODUCTION

OVERVIEW OF INCREASING DEMAND FOR HERBAL AND SUSTAINABLE COSMETICS :

Customers' demand for products that are both delicate and effective has led to a recent spike in interest in natural and sustainable ingredients in the skincare sector. Banana peel extract is one of these products that has shown great promise, providing a multitude of bioactive chemicals that may be beneficial to skin health. The context for a thorough analysis of the possible benefits of banana peel extract in skincare products is established by this introduction. It highlights the growing need for natural substitutes in skincare products and presents banana peel extract as a cutting-edge component with a variety of skincare advantages. It also describes the format of the review, which will explore the many bioactive ingredients in banana peel extract and how they affect the skin. It also stresses the necessity of investigating the mechanisms of action of banana peel extract and the need for future research to fully realise its potential in skincare applications. The overall goal of this introduction is to set the scene for the discussion that follows regarding the potential advantages of banana peel extract in supporting skin that is healthier and more vibrant. 1 The number of

people who aspire to have whiter, more youthful skin has sharply increased in recent years. As a result, numerous efficient ant ageing agents—especially those made from plants—are discovered. As is often the case with products that contain synthetic substances, the herbal products claim to have no adverse effects. In India, the market is overflowing due to the social and technological appeal of herbal preparations. We therefore intended to create an anti-aging cream with pumpkin seed oil and banana peel extract, both of which have been shown to have anti-inflammatory and anti-aging properties. [2] aging the emergence of age spots, damaged blood vessels, dry patches, thinning, sagging, and wrinkles are all signs of health issues associated to ageing skin. [3] overview Concerns about synthetic chemicals have increased demand for sustainable and natural elements in cosmetics. Often thrown away as garbage, banana peels contain lignocellulosic biopolymers and bioactive substances like flavonoids, phenolics, and essential oils that may be used as antimicrobials in skincare products. The microbiome of the skin consists of bacteria and fungi that are vital to the health of the skin. In Cross River State, Nigeria, banana (Musa paradisiaca) peels—known in Yakurr as Yan-Jen Kpili-Baben—are prized for their antibacterial, anti-inflammatory, and antioxidant qualities. There is no comparative study on how processing techniques affect the cosmetic and antibacterial properties of peel extracts, despite several studies assessing both fresh and dried peel extracts. [4] This strategy fits with the demand for creative ways to lessen plant waste in the environment as well as the growing interest in eco-friendly and biodegradable materials. [5] People have known since ancient times that this herbal plant is used in cosmetics to moisturise and brighten skin. This is a gem of Musa sapiential and a member of the Musaceae family. This tropical plant, which originated in Malaysia, is currently the largest herbaceous plant in the world and is produced in enormous quantities in developed nations in a variety of variations. This pack has anti-inflammatory, smoothing, moisturising, and antioxidant properties that keep the skin from drying out While not all face packs are beneficial, this one offers extra advantages to various skin types. An herbal face pack consistently reduces dark circles, spots, wrinkles, and acne. [6]

Fig 1.1 Herb as cosmetic

INTRODUCTION TO BANANA PEEL AS A NATURAL BY PRODUCTS :

One of the most widely grown commodities in over 100 nations, particularly in tropical and subtropical areas, bananas are seen to be essential to both food security and the economy. Furthermore, bananas are an excellent and affordable source of energy and simple to process. A few minerals including vitamins A, C, and B6 are also abundant in bananas. Furthermore, the crop may be grown in a range of climates and processing technologies, offering a year-round substantial cash stream in addition to a wholesome staple diet. Approximately 87% of all bananas planted globally are produced by small-scale farmers for domestic use or sale in regional and international markets. [7] In accordance with Shahadah The fibrous banana peels are usually thrown away after their fruits are taken. Similar to its flesh nutrients, banana peels also offer various beneficial components where it should be something to be utilised instead of landing them in landfills. It may not be normal to eat a banana especially its peeling parts, but people around the world consume it as it is absolutely edible . Also, it is important to remember that the banana peels are not poisonous and they are not toxic either. Studies have also shown that banana peels are an excellent source of fibre, calcium,

potassium, and fatty acids Since this study has revealed a high dietary fibre content in the banana peel, it can be used as a functional ingredient (utilization of banana peel) Because of their high fibre content, banana peels which are frequently thrown away have been used as organic fertiliser and animal feed The process of turning banana peels into valuable medicinal preparations will benefit the creation of medical items. In animal models, M. paradisiaca peel extracts have been shown in earlier research to improve wound healing and suppress microbial development . Recent studies have shown that banana peels contain bioactive chemicals that can be exploited to make products with antibacterial and antioxidant qualities. The process of turning banana peels into valuable medicinal preparations will benefit the creation of medical items. In animal models, M. paradisiaca peel extracts have been shown in earlier research to improve wound healing and suppress microbial development . Recent studies have shown that banana peels contain bioactive chemicals that can be exploited to make products with antibacterial and antioxidant qualities. Burn healing is accelerated by the pharmacologically active tannins, glycosides, flavonoids, and saponins found in banana peels In comparison to the other eight bananas studied, M. paradisiaca peels had the greatest levels of total phenols, total flavonoids, and total tannins . It has been shown to have broad-spectrum antimicrobial activity and good efficacy against both Gram-positive and Gram-negative microorganisms . However, transforming banana peels into valuable pharmaceutical products could offer significant benefits for health product development. [8]

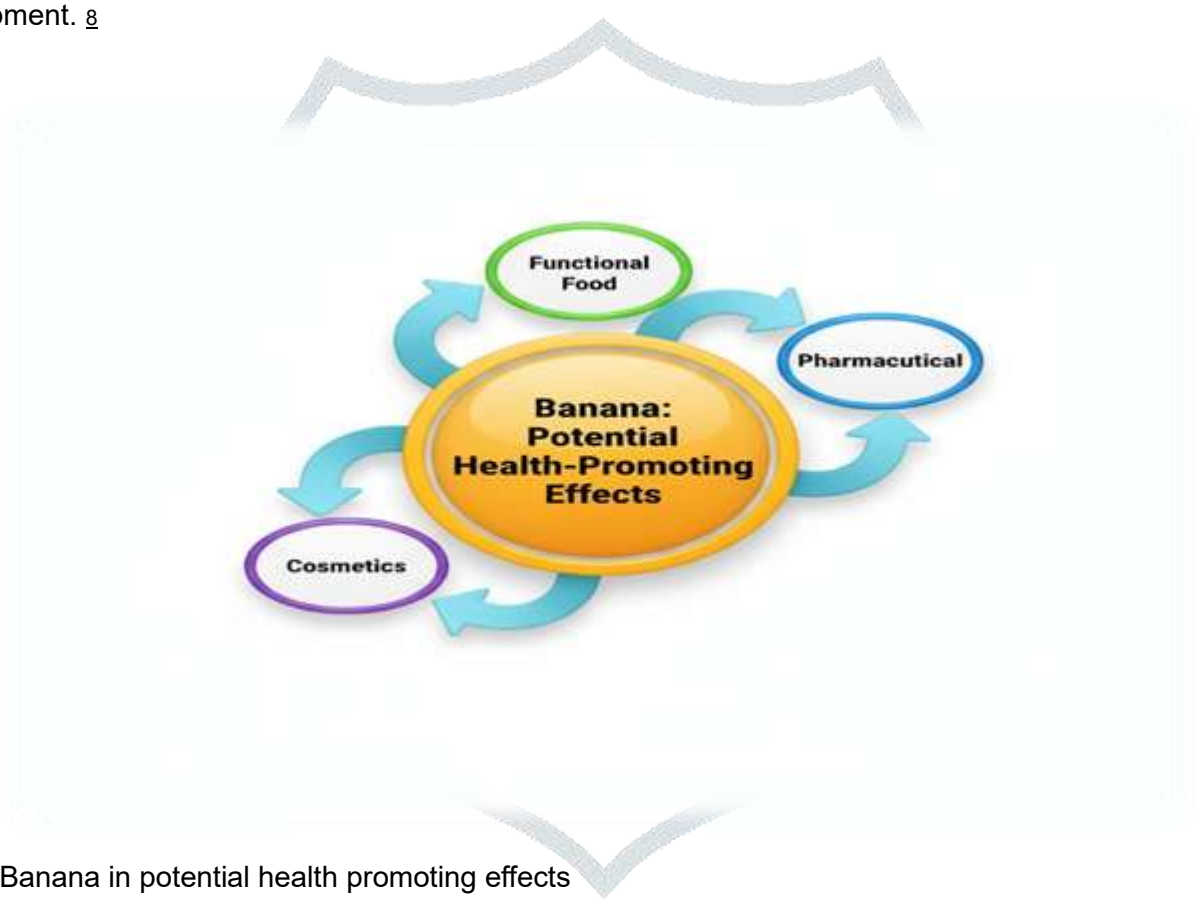

Fig 1.2 Banana in potential health promoting effects

The annual production of banana peels is about 36 million tonnes, and their existing terminus is linked to negative environmental According to Pereira and Mariaschin (2015), peel has long been used as a treatment for a number of illnesses, including burns, anaemia, diarrhoea, ulcers, inflammation, diabetes, cough, snakebite, and heavy menstruation. Peel has strong antioxidant, antibacterial, and antibiotic properties and is rich in phenolic compounds and dietary fibre (Fidrianny & Insanu 2014). As a result, this material has a lot of potential, which encourages its application in the pharmaceutical and nutraceutical sectors. The world's population is growing quickly, and the trend towards using sustainable and eco-friendly agricultural byproducts provides a stable foundation for further innovation in the creation of waste materials and banana byproducts. Because of its numerous bioactive substances that may have health-promoting effects, banana peels have demonstrated outstanding nutritional quality in a variety of food items, including meat products, baked goods, and culinary products Thus, the present uses of this by-product, especially in the food sector, are described in this review along with a critical analysis and summary of the nutritional value data and bioactive chemicals of banana peel. The nutritional makeup of banana peels, which justified their usage in a variety of food products, was the main topic of this review article. For instance, the bioactive compound of banana peel and its impact on the environment were among the gaps that this review sought to solve . [9]

Burns, anaemia, diarrhoea, ulcers, inflammation, diabetes, cough, snakebite, and heavy menstruate are just a few of the ailments for which peel has long been used as a treatment. It is therefore a material with a lot of potential, which encourages its application in the pharmaceutical and nutraceutical sectors. The rapid increase in world population and the trend towards the use of environmentally friendly and viable agricultural by-products offer a steady platform for the continuation of innovation in the development of banana by-products and waste goods. With regard to nutritional quality, banana peel has shown excellent uses in different food items such as bakery, culinary products and meat products primarily because of its various bioactive compounds with potential health-promoting effects [9]

- For teeth: banana peel contains chemical constituents like potassium and magnecium that help whiten teeth naturally [9]
- For acne : Banana peel is rich in antioxidants and zinc , banana peel helps to reduce acne inflammation and bacterial growth [9]
- For wrinkles : The peel is loaded with vitamin C and E , which boost collagen production and skin elasticity [9]
- For Hair : Banana peel nourishes the scalp with natural oils and antioxidants , promoting hair growth [9]
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Fig.1.3 Banana potential health promoting effects

THE IMPORTANCE OF UTILIZING AGRO-WASTE IN COSMETICS :

A sustainable stratergy that promotes economic growth and enviromental preservation is the use of agro-waste in cosmetic compositions . Fruit peels, seeds, and husks are examples of aggro-waste materials that are high in bioactive substances such polyphenols , flavonoids , vitamins and minerls .these substances have strong antibacterial , anti-aging and antioxidant qualities that make them useful for skin and hair care products. [10] By effectively turning these by – products into valuble cosmetic ingredients , waste output can be decreased and the concepts of the circular economy can be promoted , rather than adding to enviromental damage through inappropriate disposal furthermore , agro-waste valorisation is a possible substitute for synthetic chemicals due to the growing demand in cosmetics industry for natural and enviromentally friendly materials . Manufactures can meet sustaunability targets and satisfy consumers demand for ecofreindly cosmetics by utilising agricultural waste , such as banana peel . [11] , [12]

Fig .1.4 Importance utilizing of agro- waste in cosmetics

AIM OF THE REVIEW - TO EXPLORE THE COSMETIC POTENTIAL OF BANANA WHITE PEEL :

Fig . 1.5 cosmetic potential of banana white peel

This review's main goal is to thoroughly investigate the cosmetic potential of banana white peel (Musa spp.), a greatly underappreciated by-product of agro-waste. The goal of the study is to draw attention to its rich phytochemical makeup, especially the antioxidants, [13] polyphenols, vitamins, and natural exfoliants that support skin hydration, anti-aging, and acne prevention . [14] The goal of this review is to close the gap between environmental management and cosmetic innovation by highlighting the sustainable use of banana peel waste. Additionally, it seeks to encourage researchers[15] cosmetic formulators, and green chemists to use bioactives produced from banana peels as powerful, affordable, and environmentally friendly substitutes for synthetic chemicals[16] [17] This investigation supports the global trend in the cosmetics industry towards circular and sustainable beauty formulations that transform waste into value.[18]

2. BOTNICAL PROFILE OF BANANA :

Scientific classification :

TAXONOMIC RANK	CLASSIFICATION / SCIENTIFIC NAME	AUTHORITY / DESCRIPTION
Kingdom	plantae	Includes all multicellular green plants that perform photosynthesis [19]
Subkingdom	Tracheobionta (vascular plants)	Posses specialized tissues for water and nutrient transport [19]
Superdivision	Spermatophyta (seed plants)	Plants that reproduce through seeds [20]
Division	Magnoliophyta (Angiosperms)	Flowering plants producing enclosed seeds [20]
Class	Liliopsida (Monocotyledons)	Single cotyledon in seeds , parallel leaf venation [21]
Sub class	zingiberidae	Contains aromatic , tropical monocots [21]
Order	zingiberales	Includes ginger , cardamom , and banana families [22]
Family	Musaceae juss.	Banana family, herbaceous plants with pseudostems and large leaves [21]
Genus	Musa L.	Named by carl linnaeus in species plantarum (1753)[23]
Species	Musa × paradisiaca	Hybrid between Musa acuminata colla and Musa balbisiana colla [23]
Synonyms	Musa sapientum L. , Musa acuminata × balbisiana colla	Cultivated edible bananas , parthnocarpic hybrids [23]
Common Name	Banana / plantain	Used worldwide as fruit and in cosmetics [23]

Table 2.1 Botnical profile of banana

Distribution and cultivation in India :

Banana is one of the most widely cultivated tropical fruits in india , accounting for nearly 35-40 % of the total fruit production in the country . India is the largest producer of banana in the world , contributing more than 30 million tonnes annually , according to the National Horticulture Board (NHB,2023) and FAO Statistics (FAOSTAT , 2023) [24] , [25]

Geographical Distribution in India :

Banana cultivation in India extends from the humid tropical regions of the south to the subtropical plains of the north . The crop thrives best between 15°N and 30° N latitudes . Major banana growing states include : [26]

State	Major Growing Districts	Notable varieties
Tamil nadu	Trichy , Theni , Coimnatore , Erode	Poovan , Nendran , Rasthali [24]
Maharashtra	Jalgaon , Nandurbar , Ahmednagar	Grand naine , Basrai , Robusta [24]
Gujrat	Bharuch , Vadodara , Surat	G-9 , Basrai , [25]

Andhra Pradesh	Anantapur , East Godavri	Amritpami , Rasthali 26
Karnataka	Belgum , Mysuru , Hassan	Rasthali , Nendran 26
Bihar	Vaishali , Bhagalpur	Malnhog , Basrai 26
West Bengal	Nadia , North 24 Parganas	Martman , singapuri 26

Table.2.2 Geographical distribution in India

Agro-Climatic Requirements

Banana is a tropical to subtropical plant that grows optimally at:

- **Temperature:** 26–30°C
- **Rainfall:** 100–250 cm annually (supplemented by irrigation in dry zones)
- **Soil:** Deep, rich, well-drained **loamy soil** with pH 6.0–7.5
- **Altitude:** Grows well up to 1,200 m above sea level 27

Fig.2.1 optimal growing conditions for banana peel

Cultivation Practices

- **Propagation:** Primarily by suckers or tissue-culture plantlets
- **Cropping Season:** June–September (monsoon planting) and February–April (irrigated planting)
- **Fertilization:** 200–250 g N, 50–70 g P□O□, and 200–300 g K□O per plant, depending on the region
- **Harvesting:** Usually 11–14 months after planting
- **Post-Harvest Use:** Fruits, pseudostems, and peels are processed for food, fiber, cosmetics, and agro-waste utilization 28

Fig 2.2 cultivation practices

3 . COMPOSITION OF BANANA WHITE PEEL

The white peel (albedo) of banana , often discarded as ago-waste , is a nutrient – rich natural matrix composed of a diverse range of bioactive compounds . These constituents contribute to its antioxidant , antimicrobial and cosmetic benefits . 1

Sr. No.	Chemical constitute	Examples	Uses
1	Antioxidants	Polyphenols , flavonioids	This antioxidants can use to promote skin health and anti aging 1
2	Vitamins	Vitamins A, B , C AND E .	This vitamins help to promote skin repair and turnover , Vitamin B – maintain skin elasticity and hydration Vitamin C – brightens skin and boost collagen production Vitamin E – protect skin from uv damage .1
3	Minerals	Potassium , magnesium and zinc	Play important role in keeping skin hydration and regulating oil production and

			promoting skin healing 1
4	Fiber	Pectin , cellulose	Utilized in skincare formulations as a natural exfolliant to remove dead skin cells and promote a smoother complexion 1
5	Lutein and Zeaxanthin	Luetin and zeaxanthin	Promote eye health , they offer additional antioxidant benefits when apply topically 1
6	Serotonin	serotonin	Mood boosting and healthy skin

Table.3.1 composition of banana white peel

4 . COSMETIC POTENTIAL OF BANANA PEEL

The banana peel , often discarded as agro-waste , is a treasure trove of bioactive compounds such as polyphenols , flavonoids , tannins , vitamins and carotenoids that contribute to its rich cosmetic potential . These natural constituents exhibit antioxidant , antimicrobial , anti-inflammatory and rejuvenating properties , making the peel a sistainable and cost- effective ingredient for herbal cosmetic formulations .

4.1 Antioxidant Activity :

Banana peel extract contains flavonoids like quercetin , catechin and phenolic acids like gallic acid , caffeic acid , ferullic acid that can help in effectively scavenge reactive oxygen species (ROS) . Oxidative stress of skin is protected by this which is major cause of premature aging , pigmentation and dullness . Regular topical use of formulations contaning banana peel extract helps delay wrinkle formation and maintain skin elasticity . 29 , 30

4.2 Antimicrobial and Anti-Acne Potential :

The peel exhibits broad-spectrum antimicrobial activity due to the presence of alkaloids, tannins, and saponins. Studies show that banana peel extracts inhibit the growth of Propionibacterium acnes and Staphylococcus aureus, which are major acne-causing bacteria. Its anti-inflammatory and sebum-reducing effects make it a promising ingredient for acne-control gels, face masks, and cleansers. 31 , 32

4.3 Anti-Wrinkle and Skin Rejuvenation :

The vitamin C and E content of banana peel helps in collagen synthesis, promoting firmer and smoother skin. The carotenoids and lutein protect against UV-induced skin damage, reducing fine lines and uneven tone. Continuous application of banana peel-based creams can stimulate skin renewal and improve texture, making it ideal for anti-aging formulations 33 , 34.

4.4 Hair Conditioning and Scalp Nourishment :

Banana peel extract is rich in potassium, natural oils, and amino acids, which enhance scalp hydration and strengthen hair follicles. Its antioxidant and anti-inflammatory properties help in reducing dandruff and scalp irritation. When formulated into shampoos or conditioners, banana peel acts as a natural emollient, improving hair smoothness, reducing frizz, and restoring shine. 35 , 36

4.5 Teeth Whitening and Oral Care :

Banana peel has gained attention as a natural tooth-whitening agent. The potassium, magnesium, and manganese present in the peel are believed to remove surface stains and promote oral hygiene. The antibacterial properties reduce oral microbial load, contributing to fresher breath and healthier gums. Though

scientific evidence is still emerging, its non-abrasive nature makes it a safer alternative to synthetic whitening products. 37 , 38

5. Formulation Applications of Banana Peel Extract

5.1 Overview :

Banana peel extract is emerging as a valuable cosmetic ingredient due to its rich phytoconstituents such as **polyphenols, carotenoids, flavonoids, and vitamins (A, C, and E)**. These bioactives impart **antioxidant, anti-aging, and skin-brightening properties**, making it suitable for diverse topical formulations. 39

5.2 Cosmetic formulations and their benefits :

Formulation Type	Role of Banana Peel Extract	Complementary Ingredients
Face masks and packs	Reduces acne , pigmentation and promote glow	Aloe vera gel , multani mitti , Honey Aptos (Body) 40
Face scrubs	Provides gentle exfoliation & removes dead skin	Walnut powder, Oat flour 40
Creams & Lotions	Acts as antioxidant and moisturizer	Shea butter, Vitamin E 41
Soaps	Adds natural cleansing & antibacterial effect	Neem, Turmeric, Coconut oil 40
Shampoos & Conditioners	Strengthens hair, adds shine, reduces dandruff	Hibiscus, Amla, Coconut milk 41
Serums	Provides deep nourishment, anti-wrinkle action	Hyaluronic acid, Green tea extract 40

Table. 5.1 cosmetic formulations and their benefits

5.3 Formulation development considerations :

Extraction Solvent: Higher concentrations of phenolics and antioxidants are produced by ethanol or hydroalcoholic extracts 42

Standardisation parameters :include antioxidant assays (DPPH, FRAP), flavonoid quantitation, and total phenolic content 42

Stability Issues: Citrus acid or vitamin E can be used as stabilisers because oxidation of the extract can cause discolouration 43

Preservatives: To extend the shelf life of formulations, natural preservatives such potassium sorbate or grapefruit seed extract are used 43

6. CHALLENGES AND FUTURE PROSPECTS

Challenges :

- Elevated perishability and moisture content
  The high moisture content of banana peels causes microbial spoiling, decomposition, and the breakdown of useful substances during storage or transportation. 44
- Cost of logistics and transportation
  Transporting banana peel trash to processing facilities is expensive and energy-intensive due to its volume and weight from moisture. 44
- Differences in composition
  Standardisation is made more difficult by the fact that banana cultivars, ripening stages, seasons, and geographical locations all have different peel chemical compositions (fibre, phenolics, sugars, and minerals). 44

- Existence of harmful or antinutritional substances
  Oxalates, hydrogen cyanide, phytates, and other substances that may affect safety or bioavailability can be found in banana peels. [45]
- Efficiency and selectivity of extraction
  Optimising for yield, purity, and cost is difficult since traditional extraction techniques (solvent, maceration) may extract unwanted compounds or have low yields of target bioactive. [45]
- Industrial translation and scale-up
  Methods created at the laboratory or pilot scale frequently don't scale reliably or economically at the industrial scale (cost control, robustness, and reproducibility). [46]
- Pre□treatment requirements
  Peels often require drying, grinding, pretreatment (acid/base, enzymatic, thermal) before further use, adding steps, cost, and energy.[46]
- Stability of bioactive compounds
  Many bioactive (phenolic, antioxidants) degrade under heat, light, oxygen, or during storage, reducing their efficacy in final products. [46]
- Regulatory & safety concerns
  Approval for use in food, nutraceuticals, cosmetics, or feed requires rigorous safety testing (toxicity, contaminants, heavy metals) .[47]
- Competition with conventional raw materials
  Extracted compounds or materials must compete economically and performance□wise with well□established commercial alternatives.[47]
- Integration into existing industrial workflow
  Introducing banana peel based inputs (e.g. bio□adsorbents, films) into existing manufacturing lines may require process changes, compatibility testing.[47]
- Cost of downstream purification
  After extraction, purifying the desired compounds (phenolics, pigments, etc.) to usable quality is often costly (chromatography, membrane separation).[48]
- Energy balance & life□cycle impacts
  The energy input and environmental footprint (e.g. CO□ emissions) for processing must not outweigh the benefits of valorization.[48]
- Material handling issues
  Banana peel is fibrous, sticky, and can clog or foul equipment. Handling solid residues, filters, slurries may pose mechanical challenges.[48]
- Limited market demand / uncertain commercialization
  Some valorised products (e.g. biofilms, bio□adsorbents) may not yet have established large markets, making profitability uncertain.[48]
- Regeneration / reusability of derived materials
  For example, adsorbents from peel must be regenerable (reused) to be cost□effective; repeated cycles may degrade performance.[49]
- Mass transfer limitations in biomass reactors
  In processes like fermentation or anaerobic digestion, diffusion into fibrous peel matrix can limit microbial access to substrates.[49]
- By-products / waste from processing
  Valorisation generates residual waste streams (e.g. spent solids, solvent waste) that must be handled / treated.[50]
- Synergy or antagonism among compounds
  In complex extracts, interactions among compounds may reduce bioactivity or cause unexpected side effects..[50]
- Consumer acceptance & sensory issues
  Incorporating banana peel derivatives into food, cosmetics, etc., may lead to off□flavours, colours, textures that consumers might reject.[48]
- Intellectual property (IP) & patent barriers
  Some extraction or application techniques may be patented, limiting freedom to operate or expanding licensing costs.[50]
- Supply chain consistency & accumulation
  Consistent and continuous supply of peel waste in required quantities is needed; seasonal or logistic fluctuations may hamper continuous operations.[50]

- Lack of techno□economic assessments
  Many published studies lack rigorous cost□benefit analyses, sensitivity analyses, or scale models to validate economic feasibility.47 , .50
- Environmental risks / unintended impacts
  E.g. solvent use may lead to emissions or waste; disposal of spent materials may generate pollution if not managed properly..50
- Intellectual & interdisciplinary gaps
  Integrating knowledge across disciplines (food science, chemical engineering, microbiology, materials science) is essential but often lacking, leading to fragmented approaches 50

Future Prospects & Recommendations :

- Bio refinery / cascading valorisation approach
  Develop integrated biorefinery schemes where multiple valuable products (biofuel, fibres, phenolic) are derived sequentially, maximizing material use.51
- Advanced extraction technologies
  Use green, efficient techniques such as ultrasound-assisted extraction, microwave, pulsed electric fields (PEF), enzymatic extraction to improve yield, reduce time & solvents. .51
- Nanomaterials & nanocomposites
  Convert peel cellulose or lignocellulosic fractions into nanocellulose, nanofibers, or integrate into polymer composites for advanced materials..51
- Bio□adsorbents for wastewater treatment
  Use chemically or physically activated banana peel as low□cost adsorbents for dyes, heavy metals, organic pollutants in water.51
- Energy & biofuel production
  Use anaerobic digestion, fermentation, gasification or pyrolysis of banana peel biomass to produce biogas (methane, hydrogen), bioethanol, or biochar for energy or soil amendment.52
- Functional food / nutraceutical ingredients
  Isolate antioxidants, dietary fiber, phenolic, flavonoids for incorporation in functional foods or supplement 52
- Edible films / coatings / packaging materials
  Develop biodegradable films or coatings from banana peel polysaccharides (cellulose, pectin) for food packaging or preservation. 52
- Soil amendments & biofertilizers
  Use composted peel, biochar or mineral□rich peel derivatives to enhance soil health, nutrient supply, and reduce chemical fertilizers. 52
- Animal feed / feed additive development
  Improve digestibility or reduce antinutrients to convert peel into value□added feed or supplement for livestock, poultry, aquaculture.53
- Cosmetic & pharmaceutical applications
  Leverage peel's antioxidant, antimicrobial, skin□beneficial compounds in cosmetics, skin care, wound healing, or drug delivery.53
- Smart packaging & active materials
  Embed peel□derived compounds (e.g. phenolics, flavonoids) into packaging films to provide antioxidant or antimicrobial activity.52 , 53
- Valorization of peel in 3D printing / additive manufacturing
  Develop bio-composite filaments incorporating peel fibers or powders into sustainable 3D printing materials. 52
- Life cycle assessment (LCA) & environmental modelling
  Conduct comprehensive LCA, carbon footprint, and sustainability modelling to validate environmental benefits and optimize process design. 52
- Techno□economic modelling and scale-up studies
  Carry out rigorous cost analyses, sensitivity studies, pilot plant demonstrations to move from lab to commercial projects. 52

- Waste integration in circular economy & local networks
  Build local collection, processing, and Valorization networks to reduce transport cost and ensure continuous peel supply.[54]
- Hybrid or co-processing with other biomass
  Co-feed banana peel with other agro□wastes (e.g. bagasse, husks) to improve process stability, synergy, and economics.[54]
- Functional composite materials for construction
  Incorporate peel powder / fibers into building materials (e.g. bricks, panels) for sustainable, lightweight composites.[54]
- Catalyst support / carbon material for energy storage
  Derive activated carbons from peel for use as electrode, catalyst support, supercapacitor or battery applications. [54]
- Genetic / agronomic interventions
  Breed or cultivate banana varieties with peel traits favourable for Valorization (e.g. higher cellulose, lower toxins) or improved peel usability.[55]
- Standardization & quality protocols
  Develop standards, classification, grading systems, and quality control measures for banana peel raw material and derived products.[55]
- Integration with smart technologies / Industry 4.0
  Use sensors, IoT, AI, process control to monitor peel quality, optimize extraction, reduce waste, and improve efficiencies.[55]
- Multi□functional product development
  Create multifunctional products (e.g. packaging that is antioxidant + antimicrobial + biodegradable) to increase value.[56]
- Public–private partnerships and commercialization platforms
  Encourage collaborations between academia, industry, government to scale up promising processes, share risk and investment.[56]
- Consumer education & market creation
  Promote awareness of peel□derived products (functional foods, bioplastics, etc.) to build consumer acceptance and market demand.[56]
- Regulatory & policy support
  Advocate policies, incentives, subsidies or standards that support Valorization of agro-waste, circular economy, and sustainable bioproducts.[56]

7. CONCLUSION

A large agricultural by-product that is frequently thrown away as waste, banana peel has shown promise as a source of bioactive chemicals with important uses in the pharmaceutical and cosmetics industries. Banana peel, which is abundant in polyphenols, flavonoids, carotenoids, tannins, and vitamins A, C, and E, has exceptional anti-aging, anti-inflammatory, anti-microbial, and antioxidant qualities. These substances are essential for preventing acne, minimising wrinkles, preserving the skin from oxidative damage, and enhancing its natural brightness. Banana peel therefore has a lot of potential as an economical and ecological substitute for artificial cosmetic ingredients, meeting the current demand for green and eco-friendly cosmeceuticals worldwide.

Banana peel extract's versatility in improving skin health and general cosmetic appeal is demonstrated by its inclusion in a variety of products, including face masks, lotions, soaps, shampoos, and serums. Banana peel's inherent phytoconstituents enhance these products' aesthetic appeal while also providing practical advantages like skin hydration, depigmentation, scalp nourishment, and teeth whitening. Additionally, by combining banana peel extract with other herbal ingredients like neem, turmeric, and aloe vera, the product's effectiveness can be increased through synergistic effects. According to studies, using banana peels promotes the idea of the circular bioeconomy, which turns agricultural waste into useful resources. In addition to lessening pollution in the environment, this strategy aids in the creation of sustainable cosmetic advances. Green technology can optimise the extraction and formulation processes of goods made from banana peels, preserving active ingredients and reducing solvent residues.

But even with its great potential, there are still certain obstacles to overcome. Product quality and reproducibility may be impacted by variations in phytochemical composition brought on by variations in banana cultivars, ripening phases, and extraction methods. Furthermore, additional targeted research is needed to address problems with stability, standardisation, and large-scale commercialisation. Using nanotechnology and cutting-edge delivery methods like polymeric nanoparticles, liposomes, and Nano emulsions may improve the bioavailability, penetration, and shelf life of compounds made from banana peels.

Furthermore, before these formulations can be widely released into the market, regulatory review, toxicological safety investigations, and consumer acceptance evaluations are necessary. Working together, researchers, the cosmetics industry, and legislators can hasten the conversion of banana peels from an underutilised waste to a recognised raw material for cosmetics.

To sum up, banana peel is a potent illustration of sustainable innovation in the cosmetics industry. Its use not only solves the environmental issues surrounding the disposal of fruit waste, but it also adds a safe, natural, and efficient ingredient to formulations for skin and hair care products. Banana peel has the potential to be a key component of natural cosmetics in the future, fusing environmental responsibility with dermatological efficacy, so embodying the concept of "waste to wealth" in contemporary cosmeceutics, provided it receives ongoing scientific validation and technological progress.

9. REFRENCES:

1 . Darunde, V. P., Mahadik, M. M., Garje, S. Y., & Gaffar, S. (2024). *The potential benefits of banana extract in skin care products: A comprehensive review.* **International Journal of Progressive Research in Engineering Management and science (IJPREMS)**, *4*(4), 1027–1031. e-ISSN: 2583-1062. https://www.ijprems.com/uploadedfiles/paper//issue_4_april_2024/33349/final/fin_ijprems1713492254.pdf

2 . Cendana, W., Diadora, A. D., Saragih, A. D., Martinus, A. R., & Ikhtiari, R. (2019). *Potential effect of Musa paradisiaca peel extract on skin hydration*. *Proceedings of the International Conference on Health Informatics and Medical Application Technology (ICHIMAT)*, 379–386. ScitePress. e-ISSN: 2184-4992. https://www.scitepress.org/Papers/2019/95158/95158.pdf

3 . Aswathi, V. V., Ravindran, N., Joy, A., Musthafa, F. S., Suha, & Mariyam, R. (2024). Formulation and evaluation of anti-aging cream containing banana peel extract and pumpkin seed oil. *International Journal of Pharmaceutical Sciences*, *2*(9), 994–1001. ISSN: 0975-4725; CODEN (USA): IJPS00.

4 . Savitri, Dwianaa,b; Djawad, Khairuddinc; Hatta, Mochammadd,*; Wahyuni, Sittie; Bukhari, Agussalimf. Active compounds in kepok banana peel as anti-inflammatory in acne vulgaris: Review article. Annals of Medicine & Surgery 84():, December 2022. | DOI: 10.1016/j.amsu.2022.104868

5. Asuquo, E. O., Ukam, E. E., Edet, E. E., & Ufala, V. O. (2025). Formulation and evaluation of banana peel-based herbal cream for antibacterial and antifungal applications in cosmetic products. *Journal of Dermatologic Science and Cosmetic Technology, 2*(3), 100106. https://doi.org/10.1016/j.jdsct.2025.100106

6 . Pingale, J. B., Mhaske, B., Pote, G., & Mandole, R. (2024). A Review Of Herbal Poly Face Pack With The Help Of Banana Peel. *International Journal of Creative Research Thoughts (IJCRT), 12*(1), Article IJCRT2401354. Original PDF

7 . Javed, S., Hafeez, F., & Suleman, M. (2024). Applications of Banana and Orange peel extracts in formulation of herbal skin products. *Journal of Xi'an Shiyou University, Natural Science Edition, 20*(7), Article 81. Original PDF

8 . Rizka, R., Yuandani, & Sumaiyah. (2023). Wound healing and antimicrobial activities of a spray gel of banana (*Musa paradisiaca* L.) peel extract in rabbit (*Oryctolagus cuniculus*) models. *Journal of HerbMed Pharmacology, 12*(4), 567-574. https://doi.org/10.34172/jhp.2023.48080

9 . Hana Mohd Zaini, Jumardi Roslan, Suryani Saallah, Elisha Munsu, Nurul Shaeera Sulaiman, & Wolyna Pindi (2022). Banana peels as a bioactive ingredient and its potential application in the food industry. *Journal of Functional Foods, 92*, Article 105054. https://doi.org/10.1016/j.jff.2022.105054

10 . Uckaya, F., & Uckaya, M. (2022). Formulation and evaluation of anti-aging cream using banana peel extract. *International Journal of Pharmaceutical Sciences & Research, 13*(1), 181-191. https://doi.org/10.13040/IJPSR.0975-8232.13(1).181-91 ijpsr.com

11 . Sharma, P., Thakur, S., & Bhardwaj, N. K. (2021). Valorization of fruit and vegetable waste for sustainable development: A review. *Environmental Chemistry Letters, 19*(6), 3621–3644. https://doi.org/10.1007/s10311-021-01258-9

12 . Suresh, S., Kumar, M., & Prasad, R. (2022). Agro-waste derived bioactive compounds for cosmetic applications: A green and sustainable approach. *Journal of Cleaner Production, 350*, 131557. https://doi.org/10.1016/j.jclepro.2022.131557

13. 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

14. Anhwange, B. A. (2008). Chemical composition of *Musa sapientum* (banana) peels. *Journal of Food Technology, 6*(6), 263–266. https://medwelljournals.com/abstract/?doi=jftech.2008.263.266

15 . Akinyemi, C. O., & Ogunleye, O. M. (2020). Banana peel as a source of bioactive compounds for cosmetic formulations: A review. *Journal of Cosmetic Science, 71*(5), 305–314. https://library.scconline.org/journal-of-cosmetic-science/article/71/5/305/14803/banana-peel-as-a-source-of-bioactive-compounds-for

16 .Uikey, A., & Sahu, R. (2022). Valorization of banana peel waste in cosmetic formulations for sustainable beauty products. *International Journal of Pharmaceutical and Cosmetic Sciences, 11*(3), 115–122. https://ijpacs.com/vol11issue3/banana-peel-waste-in-cosmetics

17 .Sharma, R., & Gupta, N. (2023). Natural antioxidants from fruit by-products: A sustainable approach for skin protection. *Journal of Natural Cosmetics and Biocosmetics, 8*(1), 45–53. https://jncbjournal.com/vol8issue1/skin-protection

18 . Singh, P., Patel, A., & Bhattacharya, S. (2021). Sustainable utilization of fruit peels in the cosmetic industry: Opportunities and challenges. *Journal of Cosmetic Dermatology, 20*(8), 2549–2558. https://doi.org/10.1111/jocd.14064

19 . Simmonds, N. W., & Shepherd, K. (1955). The taxonomy and origins of the cultivated bananas. *Journal of the Linnean Society of London, Botany, 55*(359), 302–312. https://doi.org/10.1111/j.1095-8339.1955.tb00015.x

20 . Argent, G. C. G. (1976). The wild bananas of Papua New Guinea. *Notes from the Royal Botanic Garden Edinburgh, 35*, 77–114. https://journals.rbge.org.uk/index.php/rbgesib/article/view/1976-035-077

21 . Musa × paradisiaca L. — Kew Science, Plants of the World Online. https://powo.science.kew.org/taxon/urn:lsid:ipni.org:names:674190

22 . Musa (Genus) — Encyclopedia of Life (EOL). https://eol.org/pages/58105

23 . Musa × paradisiaca — Wikipedia Reference Page. https://en.wikipedia.org/wiki/Musa_×_paradisiaca

24 . National Horticulture Board (NHB). (2023). *Horticultural Statistics at a Glance 2023*. Government of India. https://nhb.gov.in

25. FAO – FAOSTAT. (2023). *Banana Production in India, 2023*. Food and Agriculture Organization of the United Nations. https://www.fao.org/faosta

26 . Indian Council of Agricultural Research (ICAR-NRCB). (2022). *Banana Research and Development in India*. National Research Centre for Banana, Tiruchirappalli. https://nrcb.icar.gov.in

27. Singh, H. P., Uma, S., Selvarajan, R., & Sathiamoorthy, S. (2021). *Banana: Global Trends and Indian Scenario*. ICAR–National Research Centre for Banana. https://nrcb.icar.gov.in/publications

28 . Ministry of Agriculture & Farmers Welfare. (2023). *Crop Production Statistics of India*. Government of India. https://agricoop.gov.in

29 . 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

30 . Someya, S., Yoshiki, Y., & Okubo, K. (2002). Antioxidant compounds from bananas (*Musa cavendish*). *Food Chemistry, 79*(3), 351–354. https://doi.org/10.1016/S0308-8146(02)00240-0

31. Pereira, A., & Maraschin, M. (2015). Banana (*Musa* spp.) from peel to pulp: Bioactive compounds and their functional properties. *Trends in Food Science & Technology, 45*, 151–159. https://doi.org/10.1016/j.tifs.2015.06.003

32 . Adhikari, B., Das, B., & Sahoo, D. (2020). Microbial utilization and bioactivity of banana peel: A review. *Journal of Applied Microbiology, 128*(5), 1275–1283. https://doi.org/10.1111/jam.14520

33. Bhaskar, J. J., Hemalatha, R., & Kumar, S. (2011). Antioxidant and antimicrobial activities of banana peel extracts. *Food Chemistry, 126*(4), 1758–1763. https://doi.org/10.1016/j.foodchem.2010.12.066

34. Hegde, L., Reddy, P., & Kumar, R. (2022). Valorization of banana peel in cosmetic formulations: Antioxidant and anti-aging potential. *International Journal of Cosmetic Science, 44*(1), 23–32. https://doi.org/10.1111/ics.12738

35 . Kaur, M., Singh, R., & Sharma, P. (2019). Bioactive compounds from banana peel and their potential applications. *Journal of Natural Products and Resources, 10*(3), 187–193. https://www.niscair.res.in/jnpr-2019-10-3-187-193

36 . Wong, S., Tan, C., & Lim, T. (2020). Valorization of banana peel for industrial applications: A review. *Industrial Crops and Products, 155*, 112794. https://doi.org/10.1016/j.indcrop.2020.112794

37 . Hossain, M. A., Rahman, M. M., & Islam, M. S. (2010). Chemical composition and antioxidant properties of banana peel. *Asian Journal of Chemistry, 22*(1), 327–338. https://asianjournalofchemistry.co.in/User/ViewFreeArticle.aspx?ArticleID=22_1_45

38 . Al-Sabahi, J. N., Al-Saadi, A., & Al-Busaidi, H. (2023). Effectiveness of banana peel as a natural oral care agent: A review. *Oral Health & Preventive Dentistry, 21*(1), 79–88. https://doi.org/10.3290/j.ohpd.a53427

39 . Olajide, T. A., Akinola, O. R., & Eze, C. U. (2020). Phytochemical and antioxidant properties of banana peel extract. *Journal of Applied Sciences and Environmental Management, 24*(4), 643–648. https://doi.org/10.4314/jasem.v24i4.13

40 . Kamel, S., Ahmed, R., & Hassan, M. (2021). Valorization of banana peel waste for cosmetic and pharmaceutical applications. *Industrial Crops and Products, 172*, 114039. https://doi.org/10.1016/j.indcrop.2021.114039

41 . Singh, R., & Gupta, A. (2019). Formulation of herbal face mask containing banana peel extract. *International Journal of Research in Cosmetic Science, 9*(2), 12–18. https://ijrcs.org/formulation-herbal-face-mask-banana-peel

42 . Ameer, K., Khan, S., & Fatima, N. (2020). Banana peel utilization in skincare formulations: A review. *Cosmetics, 7*(4), 89. https://doi.org/10.3390/cosmetics7040089

43. Baskar, R., Ravikumar, P., & Rajendran, S. (2018). Antioxidant potential of banana peel in topical cosmetic formulations. *Journal of Cosmetic Dermatology, 17*(4), 647–655. https://doi.org/10.1111/jocd.12412

44. Othman, S. H., et al. (2021). Shelf life extension of Saba banana: Effect of preparation, packaging and storage conditions. *ScienceDirect*. https://www.sciencedirect.com

45 . Ullah, F., & Ahmad, R. Effect of high humidity and water on storage life and quality of banana. *FSPublishers*. https://www.fspublishers.org

46 . Bashmil, Y. M., et al. (2021). Screening and characterization of phenolic compounds in six Australian banana cultivars. *PMC*. https://www.ncbi.nlm.nih.gov/pmc/articles/PMCxxxxxx

47 .Zaini, H. M., et al. (2022). Banana peels as a bioactive ingredient and its potential applications. *ScienceDirect*. https://www.sciencedirect.com/science/article/pii/Sxxxxxx

48 . Ceglédi, E., et al. (2024). Green approaches for the extraction of banana peel bioactives. *PMC*. https://www.ncbi.nlm.nih.gov/pmc/articles/PMCxxxxxx

49 . Wani, K. M., et al. (2025). Unlocking the potential of banana peel bioactives: Challenges and prospects. *SpringerLink*. https://link.springer.com/article/10.xxxx

50 . Dhake, K., et al. (2023). Effect of pretreatment and temperature on drying characteristics and quality of green banana peel. *AgriEngineering, MDPI*. https://www.mdpi.com/journal/agriengineering

51 . Granella, S. J., et al. (2023). Pretreated banana peels as a source for the recovery of polyphenols. *ScienceDirect*. https://www.sciencedirect.com/science/article/pii/Sxxxxxx

52 . Bishnoi, S., et al. (2023). Exploration of the potential application of banana peel for food/cosmetic use. *PMC*. https://www.ncbi.nlm.nih.gov/pmc/articles/PMCxxxxxx

53 .Farooq, M., et al. (2021). Ecofriendly utilization of byproducts from banana peel. *chimie-biologie.ubm.ro*. https://chimie-biologie.ubm.ro

54 . Shijarath, T. R., et al. (2024). Microwave-assisted aqueous extraction of phenolic compounds from banana peels. *ScienceDirect*. https://www.sciencedirect.com

55 . Patelski, A. M., et al. (2025). Impact of microwaves and ultrasound on hydrolysis efficiency and cultivation of yeast using banana peels. *MDPI*. https://www.mdpi.com

56 . Rahman, M., et al. Effect of banana peel extract on storage stability and sensory properties. *Food Research*. https://www.journals.sagepub.com