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Review Article

Microbiome-Friendly Cosmetics: A New Approach to Skincare

Umesh Lokhande, Vaishnavi Jadhav*, Prajyoti Mandhare, Kimaya Kevate, Sakshi Saswade, Vishal Kadu, Chaitali Ingawale, Vishakha Rane

Department of Pharmaceutics, Kasturi Shikshan Sanstha College of Pharmacy, Shikrapur, Pune.

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ABSTRACT

The human skin microbiome, which consists of a diverse array of bacteria, fungi, viruses, and other microorganisms, is essential for maintaining healthy skin. Recent scientific findings have shed light on the complex relationship between these microbial communities and the overall health of the skin, prompting a significant shift in the cosmetics industry. Products that focus on the microbiome aim to support, protect, and restore the skin's natural microbial balance, offering a fresh perspective on skincare that goes beyond traditional products that might disrupt this sensitive ecosystem. Dysbiosis, or an imbalance in microbial populations, has been associated with various skin issues, such as acne, eczema, and rosacea. Factors like environmental pollution, harsh skincare ingredients, and lifestyle choices can upset the microbiome, compromising the skin's natural defenses. In response, the industry is creating microbiome-friendly products that include prebiotics, probiotics, and postbiotics. Prebiotics serve to nourish beneficial bacteria, probiotics introduce live microorganisms to help restore balance, and postbiotics byproducts of probiotics provide anti-inflammatory and protective benefits. There is a growing consumer interest in microbiome-friendly cosmetics, fueled by an increasing awareness of the skin's microbiome and a preference for clean, sustainable, and scientifically supported products. Younger consumers, especially millennials and Gen Z, are more inclined to select products that emphasize long-term skin health rather than quick aesthetic fixes. This trend aligns with the broader movements toward personalized skincare and clean beauty. As research on the microbiome progresses, the potential for innovation in cosmetics expands, promising more tailored and effective solutions for different skin types and conditions. This review delves into the science behind microbiome-focused skincare, the advantages of biotics in cosmetics, and the challenges and future prospects of this rapidly evolving field.

INTRODUCTION

***Corresponding Author:** Vaishnavi Jadhav

Address: Department of Pharmaceutics, Kasturi Shikshan Sanstha College of Pharmacy, Shikrapur, Pune.

Email ✉: vaishnavijadhav917@gmail.com

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The history of microbiome in skincare started with early practices that emphasized cleanliness and sterility, often relying on harsh products to eliminate bacteria. Key milestones in this journey include the following: In the 19th century, germ theory was established by Louis Pasteur and Robert Koch, which shifted the focus towards microbial cleanliness in skincare, frequently using strong antiseptics. From the 1960s to the 1970s, antibiotic and antiseptic agents were introduced in skincare products with the aim of eradicating bacteria, inadvertently disrupting the skin's natural microbial balance. In 2007, the Human Microbiome Project was launched, mapping the diverse microbial communities on the human body, including the skin, and emphasizing their role in health. In the early 2010s, emerging research on the skin microbiome highlighted its significance in maintaining skin health, leading to the creation of microbiome-friendly skincare products. By the mid-2010s, skincare products containing prebiotics, probiotics, and postbiotics were introduced to support the skin's natural microbial balance. In the late 2010s and continuing into the present, research on the microbiome has become mainstream, resulting in the widespread adoption of microbiome-friendly products and the development of personalized skincare solutions tailored to individual microbial profiles.[1 The human skin, similar to the gut, is home to a rich and varied community of microorganisms, collectively referred to as the skin microbiome. This community includes bacteria, fungi, viruses, and mites, all of which play a crucial role in maintaining skin health and overall well-being. Recent studies on the skin microbiome have significantly altered our understanding of skincare, showing that these microbial communities are not just passive residents but active contributors to essential skin functions like immune defense, barrier integrity, and inflammation regulation. This newfound knowledge has prompted a major

shift in the cosmetics industry, moving the focus from traditional skincare methods to products that are friendly to the microbiome and work in harmony with the skin's natural microbial population. This trend reflects a growing movement in the cosmetic industry towards science-based, personalized, and health-oriented products. Rather than concentrating solely on superficial benefits like cleansing, moisturizing, or anti-aging, microbiome-friendly cosmetics aim to restore and maintain the skin's natural microbial balance. This approach is based on the understanding that a healthy skin microbiome is vital for optimal skin function, and that any disruption of this balance known as dysbiosis can lead to various skin issues, including acne, eczema, rosacea, and even premature aging. The increasing recognition of the microbiome's significance in skin health has spurred innovations in skincare, leading to the creation of products that include prebiotics, probiotics, and postbiotics, specifically targeting the microbiome. This introduction delves into the role of the skin microbiome, its connection to skin health, the effects of dysbiosis, and how microbiome-friendly cosmetics are reshaping the future of skincare.[2,3] The skin microbiome is made up of a diverse range of microorganisms that live on the surface and in the deeper layers of the skin. It plays a crucial role in the skin's ecosystem, working in tandem with the skin's physical barrier to defend against environmental threats and harmful pathogens. The human skin hosts billions of microbes, including more than 1,000 species of bacteria, as well as fungi, viruses, and mites. These microorganisms maintain a mutually beneficial relationship with their host, supporting skin health while thriving in the unique conditions of the skin. The makeup of the skin microbiome can vary greatly based on factors like body location, skin type, age, genetics, and environmental influences. For example, the microbial communities found on



the forehead, which is oilier, differ from those on the forearm, which is relatively dry. Likewise, moist areas such as the armpits and groin harbor different microorganisms compared to drier regions of the body. This diversity arises from the unique environments shaped by sebum production, moisture levels, and temperature across different skin areas. Among the most prevalent members of the skin microbiome are bacteria like *Staphylococcus*, *Corynebacterium*, and *Propionibacterium* species, which play vital roles in maintaining skin health. They safeguard the skin by competing with harmful pathogens for space and resources, producing antimicrobial peptides, and enhancing the skin's immune response. Beneficial microbes also play a key role in maintaining the skin's acidic pH, which is vital for the skin barrier's proper function. The skin microbiome supports skin health in various ways, acting as an extension of the skin's natural defense mechanisms. It helps preserve the skin's barrier function, modulates immune responses, and alleviates inflammation.

Barrier Function-The outermost layer of the skin, known as the stratum corneum, serves as a physical barrier that blocks harmful substances and prevents moisture loss. The skin microbiome bolsters this barrier by generating substances that inhibit the growth of pathogenic microorganisms. For instance, certain skin bacteria produce antimicrobial peptides that can eliminate harmful bacteria, viruses, and fungi, thus shielding the skin from infections.

Immune Modulation-The skin microbiome is crucial in regulating the skin's immune system. It aids in training the immune system to differentiate between harmful and harmless microorganisms, which helps avoid unnecessary immune responses that could trigger inflammation or allergic reactions. This is particularly significant in preventing skin conditions like eczema, where the immune system may overreact to benign triggers.

Inflammation Control- Beneficial microorganisms

contribute to reducing inflammation by producing anti-inflammatory compounds that calm irritated skin. This is especially important for those with sensitive or reactive skin types, where inflammation can result in redness, irritation, and discomfort.

Maintenance of Skin pH- The skin's natural pH is slightly acidic, usually between 4.5 and 5.5. This acidity is crucial for the skin barrier's proper function and the survival of beneficial microbes. The skin microbiome helps maintain this acidic environment, which is essential for protection against harm.[4,5,6] Dysbiosis refers to an imbalance in the skin's microbiome, where the diversity and composition of microbial communities are altered, often leading to an overgrowth of harmful microorganisms. Dysbiosis can be triggered by several factors, including the use of harsh skincare products, environmental stressors, poor diet, and medical conditions. When the skin microbiome is disrupted, its ability to protect and regulate the skin's health is compromised, leading to various skin issues. Some of the most common skin conditions linked to dysbiosis include:

Acne -Cutibacterium acnes (formerly known as *Propionibacterium acnes*) is a bacterium that naturally resides in the sebaceous (oil-producing) glands of the skin. In a balanced microbiome, it plays a relatively harmless role. However, when the skin's oil production increases, as it does during puberty, *C. acnes* can multiply rapidly, leading to clogged pores, inflammation, and the formation of acne.

Eczema (Atopic Dermatitis)- Individuals with eczema often have a reduced microbial diversity and an overgrowth of *Staphylococcus aureus*. This bacterium exacerbates inflammation, weakens the skin barrier, and leads to the characteristic symptoms of eczema, such as itching, redness, and dryness.

Rosacea- Research suggests that individuals with rosacea may have a disrupted microbiome, particularly in terms of an imbalance in skin mites (such as *Demodex*) and certain



bacterial species. This dysbiosis can trigger inflammation and the flushing, redness, and bumps associated with rosacea. Premature Aging- An imbalanced microbiome can weaken the skin's barrier, making it more susceptible to environmental damage from UV radiation, pollution, and oxidative stress. Over time, this can accelerate the aging process, leading to wrinkles, fine lines, and a loss of elasticity.[7,8]As understanding of the microbiome's impact on skin health has increased, the cosmetics industry has started to create products that nurture the skin's natural microbial balance. These microbiome-friendly cosmetics focus on protecting and restoring the skin's microbiome instead of disrupting it, presenting a fresh perspective on skincare that moves beyond conventional methods. Skincare products that target the microbiome often feature ingredients designed to maintain the skin's microbial balance or replenish beneficial bacteria. Key strategies include the incorporation of prebiotics, probiotics, and postbiotics. Prebiotics- These are non-living ingredients that act as nourishment for the beneficial bacteria on the skin. By feeding the good bacteria, prebiotics help foster a healthy and diverse microbiome, which in turn supports overall skin health. Common prebiotic ingredients include plant-based fibers, certain sugars, and seaweed extracts. Probiotics- These are live bacteria or yeast applied directly to the skin to help restore microbial balance. Probiotic skincare aims to introduce beneficial microbes onto the skin,

supporting the skin's natural defenses, enhancing hydration, and reducing inflammation. Strains like *Lactobacillus* and *Bifidobacterium* are frequently used in these formulations. Postbiotics- These are the metabolic byproducts of probiotics. These bioactive compounds, including peptides, enzymes, and short-chain fatty acids, have been shown to provide beneficial effects on the skin. Postbiotics can help calm inflammation, strengthen the skin barrier, and protect against harmful microorganisms. As scientific understanding of the skin microbiome continues to evolve, so too will the development of microbiome-friendly skincare products. The trend toward personalized skincare, where products are tailored to an individual's unique microbiome, is gaining momentum. Advances in microbiome analysis and diagnostic tools may soon allow consumers to choose products based on their specific microbial profile, offering more targeted and effective solutions for maintaining skin health. The increasing consumer interest in clean and natural beauty products is driving the popularity of microbiome-friendly cosmetics. Many individuals are looking for skincare items that avoid harsh chemicals, preservatives, and synthetic fragrances, as these can disrupt the skin's microbiome. Consequently, we can expect to see a growing number of products that focus on microbiome health while also being environmentally friendly and sustainably sourced.[9,10]

The Skin Microbiome

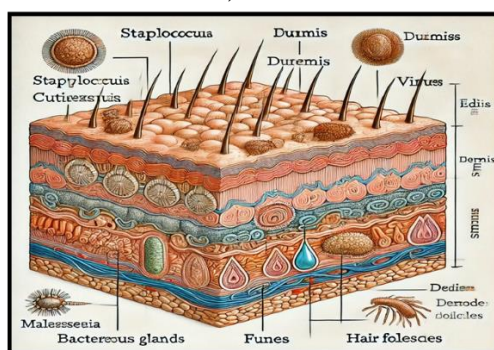


Fig 1.1 : The Skin Microbiome[11]

This diagram offers a clear, labeled view of the skin microbiome in a cross-section. It illustrates the various microorganisms that inhabit the skin, including bacteria, fungi, viruses, and mites. For example, bacteria like *Staphylococcus* are found on the skin's surface, while *Cutibacterium acnes* lives in the oily sebaceous glands. *Malassezia* fungi are prevalent near hair follicles, and *Demodex mites* can be found deeper within the hair follicles and sebaceous glands. Additionally, bacteriophages, which are viruses that target bacteria, are shown interacting with bacterial populations. Each component is accurately placed in its environment, providing a detailed visual of the skin's microbial ecosystem. The skin microbiome is a complex and dynamic community of microorganisms, including bacteria, fungi, viruses, and mites, that reside on the skin's surface. These microorganisms play a crucial role in maintaining skin health, regulating immune responses, and serving as a natural barrier against harmful pathogens. The makeup of the microbiome differs across various skin areas, influenced by factors such as moisture, oil levels, and the skin's pH. The predominant microorganisms in the skin microbiome are bacteria, with key species including *Staphylococcus*, *Cutibacterium*, and *Corynebacterium*. For instance, *Staphylococcus epidermidis* is a common commensal bacterium that produces antimicrobial peptides (AMPs) to safeguard the skin from harmful pathogens. *Staphylococcus aureus*, another species within the same genus, can lead to infections when it proliferates, especially in people with weakened skin barriers. *Cutibacterium acnes* is another important bacterium that flourishes in oily areas like the face and back. It helps break down sebum, the oily substance produced by sebaceous glands, but when it overgrows, it can cause inflammation and result in acne. *Corynebacterium* species are commonly found in moist regions such as the armpits and groin, where they contribute to body odor by breaking down components of sweat. Fungi also play a vital role in the skin microbiome. The most prominent fungal species is *Malassezia*, which relies on lipids and thrives in oily areas like the scalp and face. While it is usually harmless, an overgrowth of *Malassezia* can lead to issues like dandruff and seborrheic dermatitis. Other fungi, such as *Candida*, are

typically located in moist skin areas, like skin folds, and can cause infections like candidiasis, particularly in individuals with weakened immune systems. Viruses, including bacteriophages (which target bacteria) and human papillomaviruses (HPVs), are also part of the skin microbiome. Bacteriophages help manage bacterial populations, such as *Cutibacterium acnes*, and are being studied for their potential in acne treatments. Additionally, mites like *Demodex* inhabit hair follicles and sebaceous glands. These mites are generally harmless but can be linked to conditions like rosacea when their populations increase significantly.[12,13] The skin itself offers a variety of environments, each supporting different types of microbial populations. Moist areas, such as the armpits and between the toes, tend to favor bacteria like *Corynebacterium* and *Staphylococcus aureus*. Oily regions, like the forehead and scalp, are home to oil-loving microbes such as *Cutibacterium acnes* and *Malassezia*. In contrast, dry areas, like the forearms and legs, have fewer microbes but still support species like *Staphylococcus epidermidis*. The skin microbiome serves several crucial functions. It acts as a protective barrier by competing with harmful pathogens for nutrients and space, producing antimicrobial compounds, and modulating the immune response. Additionally, the microbiome plays a metabolic role by breaking down components of sebum and sweat, producing byproducts like fatty acids that help maintain the skin's acidic pH. This acidic environment is essential for preventing the growth of harmful microorganisms. Disruptions in the skin microbiome, referred to as dysbiosis, are linked to various skin conditions. For instance, in acne, an overgrowth of *Cutibacterium acnes* in sebaceous glands can lead to inflammation. In atopic dermatitis (eczema), individuals often exhibit reduced microbial diversity and an excess of *Staphylococcus aureus*, which worsens skin inflammation. Psoriasis, another inflammatory skin condition, is associated with changes in microbial populations within psoriatic plaques, although the exact mechanisms are still being investigated. Rosacea has been linked to increased populations of *Demodex mites*, which may trigger an immune response that results in inflammation and redness.[14,15] Several factors influence the makeup



of the skin microbiome. Host factors such as age and genetics play a significant role. The microbiome evolves throughout life, showing distinct differences between infants, adults, and the elderly. Environmental factors like climate, humidity, and UV exposure also impact microbial diversity, with warmer, more humid environments promoting greater microbial growth. Hygiene practices also play a crucial role. Therapeutic approaches focusing on the skin microbiome are becoming increasingly popular in both dermatology and the cosmetics industry. Skincare products that contain probiotics and prebiotics aim to restore the balance of microbes by either adding beneficial bacteria (probiotics) or supplying nutrients that encourage the growth of existing microbes (prebiotics). Research is also exploring bacteriophage therapy, which utilizes viruses that specifically target harmful bacteria such as *Cutibacterium acnes*, as a potential acne treatment. Furthermore, many cosmetic brands are creating products designed to maintain the natural microbiome, steering clear of ingredients that might disrupt microbial communities.[16] The skin microbiome is essential for overall skin health, playing a vital role in defending against pathogens, aiding immune responses, and influencing skin conditions when its balance is thrown off. As research delves deeper into the intricacies of the skin microbiome, innovative treatments and skincare products are being developed to support and enhance its functionality.

Microbiome Friendly Cosmetics

Gentle and Non-Irritating Ingredients in Microbiome-Friendly Cosmetics

In the world of skincare, selecting the right ingredients is essential, particularly when the goal is to create cosmetics that are friendly to the microbiome. These products are designed to support and maintain the skin's natural microbial ecosystem. To accomplish this, the ingredients need to be gentle and non-irritating. Here's a closer look at these vital components.

Surfactants: Surfactants play a crucial role in cleansers and shampoos, as they help remove impurities from the skin. Conventional surfactants can be harsh, often stripping the skin of its natural oils and upsetting the delicate balance of the skin microbiome. In microbiome-friendly cosmetics, the emphasis is on gentler alternatives. Decyl glucoside, which comes

from corn glucose and coconut oil, and coco-glucoside, a blend of coconut oil and glucose, are examples of mild, non-ionic surfactants that cleanse effectively without causing irritation. Another gentle surfactant, sodium cocoyl glutamate, is derived from coconut oil and glutamic acid, recognized for its mild cleansing abilities. These surfactants ensure that while the skin is cleaned, its natural oils and microbial balance are preserved.

Emollients and Moisturizers: Emollients and moisturizers are essential for keeping the skin hydrated and repairing the skin barrier. Ingredients like squalane, often derived from olives or sugarcane, provide moisture without clogging pores. Hyaluronic acid, a substance naturally found in the skin, aids in moisture retention and supports the skin's barrier. Jojoba oil closely resembles the skin's natural sebum, making it an excellent option for balancing and soothing the skin. These moisturizers not only hydrate but also help maintain a healthy skin microbiome by ensuring the skin barrier remains intact and functional.

Soothing Agents: Soothing agents are vital for calming inflammation and irritation, which can disrupt the skin microbiome. Aloe vera, known for its anti-inflammatory and hydrating properties, helps soothe and nourish the skin. Chamomile extract is known for its antioxidant and calming properties, which help to alleviate redness and irritation. Calendula extract, sourced from marigold flowers, adds further anti-inflammatory and healing advantages. These soothing ingredients are crucial for promoting skin health and preserving the balance of the skin's microbial community.

Preservatives: Preservatives play a vital role in preventing microbial contamination and prolonging the shelf life of products. However, conventional preservatives can sometimes be harsh and may disrupt the skin microbiome. Phenoxyethanol is a widely used preservative that works effectively at low concentrations and is generally less irritating than stronger alternatives. Ethylhexylglycerin is often paired with phenoxyethanol to boost its effectiveness and also offers skin-conditioning benefits. Rosemary extract serves as a natural alternative, providing preservative qualities along with antioxidant



properties, which help safeguard products without relying on harsh chemicals.

p^H Adjusters: Keeping the skin's natural p^H balance is essential for the health of the microbiome. The skin typically has a slightly acidic p^H, usually between 4.5 and 5.5. Citric acid acts as a gentle p^H adjuster, helping to align product p^H levels without causing irritation. Sodium hydroxide is used in very small amounts to fine-tune p^H and is carefully monitored to prevent any discomfort. By ensuring that products maintain the skin's ideal p^H, we can support a balanced microbiome and avoid disruption.

Additional Considerations: In addition to the main types of ingredients, microbiome-friendly cosmetics steer clear of other potential irritants. Many products often contain artificial fragrances and colorants, which are typically avoided due to their risk of causing irritation or allergic reactions. The focus is on hypoallergenic formulations that have been dermatologically tested to minimize the likelihood of sensitivities.

The creation of microbiome-friendly cosmetics involves a thoughtful selection of gentle and non-irritating ingredients. By using mild surfactants, effective emollients and moisturizers, soothing agents, and suitable preservatives and p^H adjusters, these products aim to maintain and support the skin's natural microbial balance. This strategy not only helps prevent irritation but also promotes overall skin health and resilience.[17,18]

Probiotics In Microbiome Friendly Cosmetics

Probiotics are live microorganisms that provide health benefits when applied to the skin. In skincare, these microorganisms mainly consist of different strains of bacteria that work in harmony with the skin's natural microbiota. Their use aims to support and restore a balanced microbial ecosystem, which is vital for maintaining healthy skin. Incorporating probiotics into microbiome-friendly cosmetics is a modern approach in skincare, reflecting a deeper understanding of the skin's microbiome and its importance for overall skin health. While probiotics are well-known for their positive effects on gut health, they also offer benefits for the skin when used topically. The skin microbiome is made up of a diverse range of microorganisms that collaborate to protect and maintain skin health. By

introducing beneficial bacterial strains, probiotics help to balance this sensitive ecosystem, fostering a healthier skin environment. The main way probiotics benefit the skin is through competitive exclusion. They occupy space on the skin's surface, outcompeting harmful microorganisms for resources and binding sites. This advantage helps prevent the overgrowth of harmful bacteria, lowering the risk of infections and keeping the microbial community balanced. Additionally, probiotics influence the skin's immune responses. They boost the production of antimicrobial peptides and regulate inflammatory pathways, which can help manage various inflammatory skin conditions like acne, eczema, and rosacea. This modulation results in a more balanced immune response, which helps to reduce inflammation and irritation. Another important advantage of probiotics is their capacity to improve the skin's barrier function. Probiotics can strengthen the skin's protective barrier, crucial for preventing moisture loss and protecting the skin from environmental stressors and pathogens.[19] A strong barrier promotes overall skin health and resilience, making the skin less vulnerable to damage and irritation. Additionally, probiotics support skin health by producing beneficial metabolites. For instance, certain probiotic strains generate short-chain fatty acids (SCFAs) and antimicrobial peptides. SCFAs, like lactic acid, help to lower the skin's p^H, fostering an environment that encourages beneficial microbes while inhibiting harmful bacteria. These metabolites are essential for maintaining a balanced skin microbiome and promoting healthy skin. However, there are several challenges in incorporating probiotics into cosmetics. One major concern is ensuring the stability and viability of live microorganisms throughout the product's shelf life. Probiotics are sensitive to factors such as temperature, light, and oxygen, which can impact their effectiveness. Advanced formulation techniques, such as encapsulation and microencapsulation, are used to protect probiotics and maintain their activity. Another challenge is ensuring compatibility with other ingredients in cosmetic formulations. Probiotics need to be combined with preservatives and active compounds in a manner that does not diminish their efficacy. This necessitates careful formulation to guarantee that probiotics remain



effective and beneficial. Probiotics present a promising opportunity for enhancing the skin microbiome and improving skin health. Their ability to support a balanced microbial environment, strengthen the skin barrier, reduce inflammation, and promote hydration highlights their significance in microbiome-friendly

cosmetics. The incorporation of probiotics in skincare marks a notable progress, showcasing an enhanced comprehension of the skin's microbial ecosystem and its importance in preserving overall skin health, despite the challenges in formulation.[20]

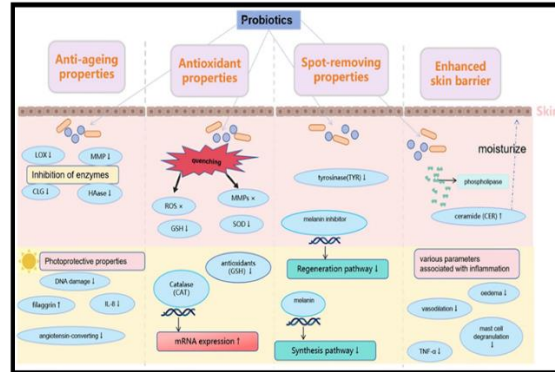


Fig 1.2: Applications of Probiotics in Cosmetics [21]

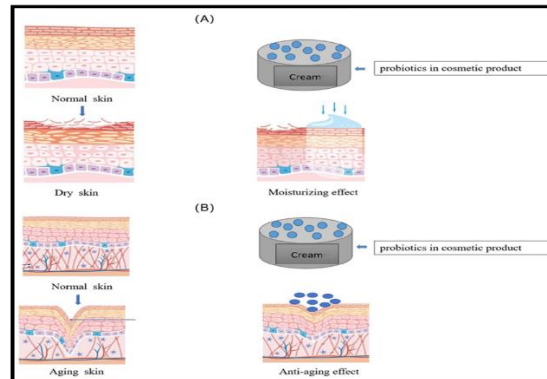


Fig 1.3: The Beauty Properties of Probiotics to the Skin [22]

Prebiotics In Microbiome-Friendly Cosmetics

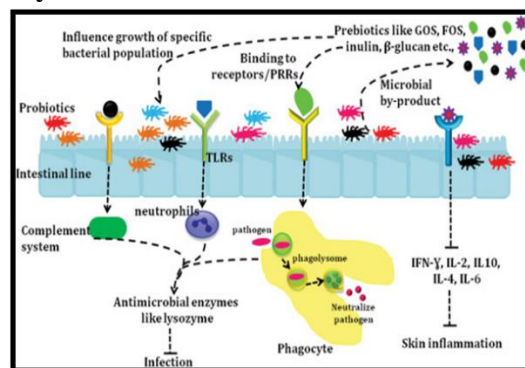


Fig 1.4 : Mechanism of Action of Prebiotics [23]

Prebiotics play a crucial role in the formulation of microbiome-friendly cosmetics by supporting the health and balance of the skin’s microbial ecosystem. Unlike probiotics, which introduce beneficial microorganisms to the skin, prebiotics serve as nourishment for the existing beneficial bacteria on the

skin. This detailed exploration sheds light on the role of prebiotics in skincare, their mechanisms of action, benefits, and considerations in their use. Prebiotics are naturally occurring compounds that selectively stimulate the growth and activity of beneficial microorganisms, thereby supporting a healthy skin

microbiome. In the context of skincare, prebiotics help to create an environment that favors the proliferation of beneficial microbes while inhibiting the growth of potentially harmful bacteria. This balance is essential for maintaining skin health and resilience. One of the primary mechanisms through which prebiotics benefit the skin is by serving as a food source for beneficial microorganisms. Compounds such as oligosaccharides, inulin, and lactulose provide essential nutrients that support the growth and activity of good bacteria. These prebiotic substances help to enhance the overall microbial diversity on the skin, which is crucial for a robust and balanced microbiome[9]. Prebiotics also play a role in reinforcing the skin's natural defenses. By promoting the growth of beneficial bacteria, prebiotics help to strengthen the skin's barrier function. A healthy barrier is critical for preventing moisture loss and protecting the skin from environmental stressors, pathogens, and irritants. This enhanced barrier function supports overall skin health and reduces the likelihood of skin issues such as dryness, sensitivity, and inflammation. Moreover, prebiotics contribute to the maintenance of a balanced p^H on the skin's surface. A stable p^H environment is vital for supporting the growth of beneficial microorganisms and preventing the dominance of pathogenic species. By helping to regulate the skin's p^H , prebiotics play a role in sustaining a favorable microbial environment. The use of prebiotics in skincare also offers specific benefits for managing various skin conditions. For instance, by supporting a balanced microbiome, prebiotics can help reduce the prevalence of inflammatory skin conditions such as acne and eczema. They achieve this by fostering a microbial environment that inhibits the growth of pathogenic bacteria and supports the

proliferation of beneficial microbes that can mitigate inflammation and improve skin health. Despite their benefits, incorporating prebiotics into cosmetics requires careful consideration. Formulating with prebiotics involves selecting appropriate compounds that can remain stable and effective throughout the product's shelf life. Additionally, prebiotics must be compatible with other formulation ingredients, including preservatives and active components, to ensure that they do not lose their efficacy or adversely interact with other ingredients.[24]

Postbiotics In Microbiome-Friendly Cosmetics

Postbiotics represent a relatively recent advancement in the field of microbiome-friendly cosmetics. Unlike probiotics, which involve live microorganisms, and prebiotics, which serve as nourishment for beneficial bacteria, postbiotics consist of metabolic by-products and components produced by probiotics during their growth and fermentation processes. These substances offer a unique approach to supporting and enhancing the skin's microbial ecosystem. This passage explores the role of postbiotics in skincare, their mechanisms of action, benefits, and considerations for their use in cosmetics. Postbiotics are essentially the bioactive compounds generated by probiotics as they interact with the skin or gut microbiome. These compounds include a range of substances such as short-chain fatty acids (SCFAs), antimicrobial peptides, and cell wall components. In the context of skincare, postbiotics are employed for their ability to influence the skin microbiome positively, even after the probiotics themselves are no longer active. One of the primary mechanisms through which postbiotics benefit the skin is through their anti-inflammatory properties.

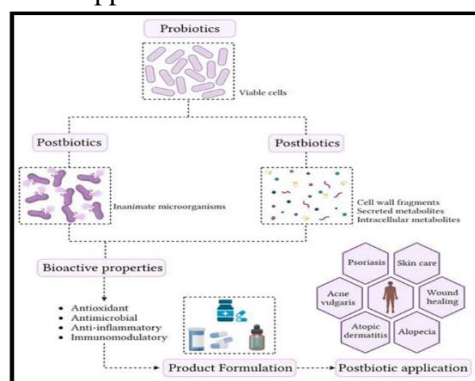


Fig 1.5: Schematic representation of Postbiotic in Skin Health [25]

Postbiotics, including SCFAs like lactic acid and acetic acid, can help modulate the skin's immune response. These compounds reduce inflammation and soothe irritated skin, making them particularly useful in managing conditions such as acne, eczema, and rosacea. By mitigating inflammatory responses, postbiotics contribute to a calmer and more balanced skin environment. Additionally, postbiotics play a role in reinforcing the skin's barrier function. For instance, certain postbiotic compounds help to enhance the synthesis of ceramides and other lipids that are crucial for maintaining the skin's protective barrier. A strengthened barrier function is essential for preventing moisture loss and shielding the skin from environmental aggressors, thereby supporting overall skin health and resilience. Another significant benefit of postbiotics is their ability to maintain and restore a balanced p^H on the skin's surface. Postbiotics, particularly SCFAs, can help lower the skin's p^H , creating an environment that supports the growth of beneficial microorganisms while inhibiting pathogenic ones. This p^H balance is crucial for sustaining a healthy

microbiome and preventing microbial imbalances that could lead to skin issues. Postbiotics also contribute to skin hydration. By supporting the production of natural moisturizing factors and enhancing the skin barrier, postbiotic compounds help to retain moisture and prevent dryness. This hydration is vital for maintaining smooth, supple skin and reducing the risk of irritation and discomfort. Formulating with postbiotics presents unique challenges. Stability is a key consideration, as the effectiveness of postbiotic compounds can be influenced by environmental factors such as temperature and light. Ensuring that postbiotics remain active and effective throughout the product's shelf life requires careful formulation and stabilization techniques. Moreover, compatibility with other ingredients in cosmetic formulations is essential. Postbiotics must be integrated in a way that preserves their efficacy and does not interact adversely with other components, including preservatives and active ingredients.[10]

p^H Balance In Microbiome-Friendly Cosmetics

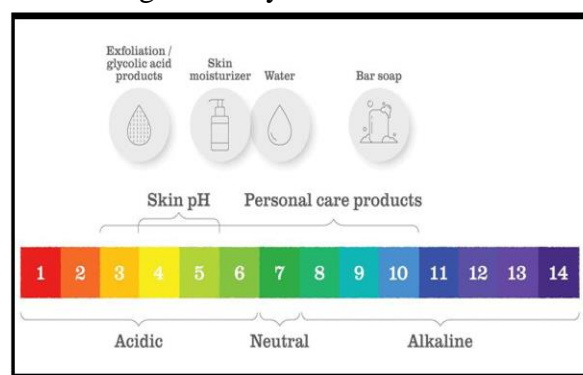


Fig 1.6: p^H scale of Skin [26]

Maintaining the right p^H balance in microbiome-friendly cosmetics is essential for supporting skin health and promoting a thriving skin microbiome. The skin's natural p^H typically ranges from 4.5 to 5.5, creating a slightly acidic environment known as the acid mantle. This balance is crucial for protecting the skin and supporting beneficial microorganisms. When the skin's p^H is within this

optimal range, beneficial microbes, such as *Staphylococcus epidermidis* and various lactobacilli, thrive, while harmful pathogens are inhibited. Conversely, when p^H levels shift towards alkalinity, it can lead to dysbiosis, a state where harmful bacteria proliferate, increasing the risk of skin issues such as acne, eczema, and infections. Many conventional cosmetics can

disrupt the skin's natural p^H . Alkaline products, often found in certain soaps and cleansers, can strip the skin of its natural acidity. This disruption not only affects the skin barrier but also harms the microbiome, making it essential to choose products formulated with p^H balance in mind. Microbiome-friendly cosmetics are specifically designed to maintain or restore the skin's natural p^H . Key strategies in these formulations include using p^H -balanced ingredients, such as mild surfactants and natural acids like lactic or citric acid, which help preserve the skin's acidic environment. Additionally, incorporating prebiotics and probiotics can nourish beneficial microbes and promote their growth while stabilizing p^H levels. These products also avoid harsh chemicals, including strong preservatives and synthetic fragrances, which can disrupt p^H and irritate the skin. The benefits of using p^H -balanced, microbiome-friendly cosmetics are substantial. These products enhance skin barrier function by reducing transepidermal water loss (TEWL) and increasing hydration. Furthermore, they support overall skin health by minimizing the incidence of conditions related to microbial imbalance. Users often notice improved skin appearance, characterized by a more radiant and even complexion. Educating consumers about the importance of p^H in skincare is crucial for making informed choices that promote long-term skin health. By understanding how to select products that respect and maintain the skin's natural p^H , individuals can contribute to a healthier skin microbiome and overall skin condition. Thus, prioritizing p^H balance in microbiome-friendly cosmetics is vital for enhancing skin health and resilience in the face of environmental stressors.[27]

Benefits Of Microbiome-Friendly Cosmetics

Supports Skin p^H Balance: Microbiome-friendly cosmetics help maintain the skin's natural p^H , which typically ranges from 4.5 to 5.5. This

slightly acidic environment is essential for fostering beneficial microorganisms while inhibiting harmful bacteria, reducing the risk of skin issues like acne and eczema.

Nourishes Beneficial Microbes: These products often contain prebiotics and probiotics. Prebiotics serve as food for beneficial bacteria, promoting their growth, while probiotics introduce beneficial microorganisms directly to the skin. This dual approach enhances microbial diversity and overall skin health.

Gentle Formulation: Microbiome-friendly cosmetics typically avoid harsh chemicals, synthetic fragrances, and aggressive preservatives that can irritate the skin and disrupt the microbiome. Instead, they use natural, soothing ingredients that respect the skin's ecosystem and minimize irritation.

Strengthens the Skin Barrier: By promoting a healthy microbiome, these products help strengthen the skin barrier, which is crucial for preventing transepidermal water loss (TEWL). A strong barrier enhances hydration, improves skin texture, and protects against environmental stressors.

Reduces Inflammation and Sensitivity: Many microbiome-friendly products are formulated to calm and soothe the skin, making them ideal for sensitive or reactive skin types. They can help reduce inflammation and redness, promoting an even skin tone.

Long-Term Skin Health: By supporting the skin's natural defenses and maintaining microbial balance, these products contribute to long-term skin health. This approach can mitigate the effects of environmental aggressors, such as pollution and UV exposure, leading to healthier skin over time.

Improved Overall Skin Appearance: With consistent use, microbiome-friendly cosmetics can enhance skin texture, tone, and hydration, resulting in a more radiant and youthful appearance.



Empowers Consumer Choices: The rise of microbiome-friendly cosmetics has fostered greater transparency in ingredient sourcing and formulation. This empowers consumers to make informed choices about their skincare, understanding the importance of the microbiome in maintaining skin health.

Helps Prevent Premature Aging: By promoting a balanced microbiome and a robust skin barrier, these products can reduce signs of premature aging, such as fine lines and dullness, by maintaining skin hydration and elasticity.[28]

Challenges And Considerations Of Microbiome-Friendly Cosmetics In Skincare

Regulatory Uncertainty: The field of microbiome-friendly cosmetics is still evolving, and regulatory frameworks are not yet fully established. This can lead to confusion regarding claims made by brands about their products, potentially misleading consumers.

Lack of Standardization: There is no universal standard for what constitutes a “microbiome-friendly” product. This lack of standardization can make it difficult for consumers to identify truly beneficial products versus those that merely use the term as a marketing tactic.

Variable Efficacy: The effectiveness of prebiotics and probiotics in skincare can vary significantly based on formulation, concentration, and the specific strains used. Not all microbial strains are beneficial for skin health, and incorrect formulations can lead to ineffectiveness or adverse reactions.

Consumer Education : Many consumers lack a clear understanding of the microbiome and its role in skin health. Educating consumers about the importance of microbiome-friendly products and how to use them effectively is crucial but can be challenging.

Potential for Skin Reactions : Although microbiome-friendly products are often gentler, some individuals may still experience allergic

reactions or sensitivities to certain ingredients, including natural ones. Patch testing is advisable, but it may not always be practiced.

Formulation Stability : Products containing live probiotics can face challenges with stability and shelf life. Ensuring that these live cultures remain viable until use can complicate formulation and manufacturing processes.

Environmental Factors : External factors, such as pollution and climate, can influence the skin microbiome. Microbiome-friendly cosmetics may not fully counteract these external stressors, necessitating a more comprehensive skincare approach.

Cost Considerations: Microbiome-friendly products can sometimes be more expensive due to the specialized ingredients and research involved in their development. This cost can be a barrier for some consumers, limiting accessibility to these beneficial products.

Individual Skin Variability : Each person’s skin microbiome is unique, influenced by genetics, diet, lifestyle, and environment. What works for one individual may not be effective for another, making it challenging to create universally effective products.

Sustainability Concerns : The sourcing and production of natural ingredients used in microbiome-friendly cosmetics can raise sustainability issues. Consumers increasingly demand eco-friendly and ethically sourced ingredients, requiring brands to balance efficacy with environmental responsibility.[29]

Future Directions For Microbiome-Friendly Cosmetics In Skincare

Advanced Research and Development : Continued scientific research into the skin microbiome will drive the development of more effective and targeted microbiome-friendly products. Studies focusing on specific strains of probiotics and their effects on various skin



conditions will lead to better formulations tailored to individual needs.

Personalized Skincare: The future of microbiome-friendly cosmetics is likely to embrace personalization. Innovations in technology, such as genetic testing and microbiome profiling, could allow consumers to receive customized skincare products that align with their unique skin microbiome composition and needs.

Enhanced Formulation Techniques: Advances in formulation science will improve the stability and efficacy of probiotics and prebiotics in cosmetic products. New encapsulation techniques and delivery systems will ensure that beneficial microorganisms remain viable and effective until the point of application.

Integration of Artificial Intelligence: AI can play a role in analyzing consumer data and predicting skincare needs based on environmental factors, skin type, and lifestyle. This could lead to the development of smart skincare solutions that adapt to changes in the microbiome over time.

Sustainability and Ethical Sourcing: As consumers become more environmentally conscious, the demand for sustainably sourced ingredients will increase. Future microbiome-friendly cosmetics will likely prioritize eco-friendly practices, such as using renewable resources, biodegradable packaging, and transparent supply chains.

Expanded Education and Awareness: Increased consumer awareness about the skin microbiome

will drive brands to invest in educational initiatives. Companies will need to communicate the science behind microbiome-friendly products clearly and effectively to build trust and understanding.

Collaboration with Dermatologists and Researchers: Partnerships between cosmetic brands, dermatologists, and microbiome researchers will facilitate the development of clinically validated products. Collaborative research can lead to new insights and innovative solutions that address specific skin concerns linked to microbiome health.

Focus on Holistic Approaches: Future products may incorporate holistic principles, considering not just topical applications but also diet, lifestyle, and overall well-being. This comprehensive approach can enhance the efficacy of microbiome-friendly cosmetics and promote long-term skin health.

Regulatory Advances: As the field matures, we may see more defined regulatory frameworks that standardize what constitutes microbiome-friendly products. Clear guidelines will help consumers make informed choices and encourage manufacturers to adhere to high standards.

Diverse Product Offerings: The market will likely see a broader range of microbiome-friendly products, including cleansers, moisturizers, sunscreens, and even makeup. This expansion will cater to various skin types and concerns, making microbiome-friendly options more accessible to all consumers.[30]

Table 1.1 : Marketed Examples of Microbiome Friendly Cosmetics in Skincare [31]

Brand	Product Name	Description
Dot and Key	Prebiotic skin renewing moisturizer	To balance skin's microbiome and boost hydration.
The Mom Co.	Natural prebiotic body wash	To nourish and protect the skin's natural microbiome.
Esse Skincare	Esse probiotic serum	Harnesses the power of probiotics to enhance skin health and balance while providing hydration and support for skin's microbiome.

Skinkraft	Skinkraft Barrier Repair Serum	A nourishing serum designed to strengthen the skin's natural barrier, restore hydration, and improve overall skin texture for healthy, radiant complexion.
Minimalist	Minimalist Sepicalm 3% Oat Moisturizer	A soothing moisturizer infused with 3% Sepicalm and oat extract, designed to calm irritation, hydrate the skin and enhance its overall resilience.
Vaadi Herbals	Vaadi Herbals Prebiotic and Postbiotic Moisturizer	To nourish the skin, support its microbiome and promote a healthy, balanced complexion.
Cetaphil	Cetaphil Gentle Skin Cleanser	A mild non-irritating cleanser, remove dirt and makeup, maintain skin's natural moisture balance, suitable for all skin types.

CONCLUSION

In conclusion, microbiome-friendly cosmetics represent a pioneering approach that harmonizes scientific innovation with consumer needs. As the industry evolves, embracing research, sustainability, and personalization will be essential for brands aiming to thrive in this dynamic landscape. By fostering a deeper connection between skincare and the microbiome, we can look forward to healthier skin and a more sustainable beauty future. The rise of microbiome-friendly cosmetics marks a transformative shift in the skincare industry, reflecting a deeper understanding of the intricate relationship between the skin microbiome and overall skin health. By prioritizing the balance of beneficial microorganisms, these products offer a holistic approach to skincare that moves beyond traditional methods focused solely on surface-level solutions. As research continues to unveil the complexities of the skin microbiome, the formulation of cosmetics incorporating prebiotics and probiotics will become increasingly sophisticated. This innovation will empower consumers to nurture their skin in a way that enhances its natural defenses, reduces inflammation, and promotes overall well-being. By creating products that

respect the skin's natural p^H and support microbial diversity, brands can help mitigate common skin issues such as acne, eczema, and sensitivity. Furthermore, the trend towards personalization in skincare is set to redefine consumer experiences. With advancements in technology, individuals will have access to tailored solutions that cater to their unique microbiome profiles. This level of customization promises to optimize the effectiveness of skincare routines, leading to better outcomes and increased consumer satisfaction. Sustainability will also play a critical role in the future of microbiome-friendly cosmetics. As consumers become more environmentally conscious, brands will need to prioritize ethically sourced ingredients and eco-friendly packaging. This commitment not only addresses consumer concerns but also aligns with the broader movement towards responsible beauty practices.

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