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# Probiotics: An innovative bioactive ingredient in cosmeceuticals

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## ABSTRACT

Probiotics have emerged as innovative bioactive ingredients in cosmeceuticals due to their ability to modulate the skin microbiome, enhance barrier function, and improve dermatological conditions. It is shown that possibility of using probiotic microorganisms of genera Bifidobacterium, Lactobacillus, Lactococcus, Bacillus and their metabolites can be used for making the cosmetic medical remedies for different skin types. As patients shift toward natural, microbiome-friendly skincare, topical probiotics, postbiotics, and para- probiotics have gained significant attention in the cosmetic industry. According to skin experts cosmetic products with probiotics based on living cells and their lysates not only make your skin healthy but also protect it from aging. This review summarizes the Functions of probiotic in maintaining human body, Overview of Skin Microbiome, Functions of a healthy skin microbiome, Types of Probiotics Used in Cosmeceuticals, Role of probiotics and skincare.

**Keywords:** Probiotics, postbiotics, para-probiotics, cosmeceuticals, Bifidobacterium, Lactobacillus, Lactococcus, Bacillus.

## 1. Introduction:

A cosmetic is defined as "a product (excluding pure soap) intended to be applied to the human body for cleansing, beautifying, promoting attractiveness, or altering the appearance". Cosmeceuticals are products that lie between cosmetics and pharmaceuticals, offering both aesthetic and therapeutic benefits. In recent years, probiotics—traditionally associated with gut health—have gained popularity as active components in skin and hair care formulations.[1]

Probiotics, defined as "live microorganisms that, when administered in adequate amounts, confer a health benefit on the host," are becoming increasingly popular and marketable. The skin microbiome, a complex ecosystem of microorganisms, plays a crucial role in maintaining skin health. As bioactive ingredients, probiotics exert functional effects on the skin by enhancing barrier function, modulating immune responses, reducing inflammation, and protecting against pathogenic microorganisms. Their incorporation into cosmetic formulations has opened new avenues for targeted skin benefits such as improved hydration, reduced sensitivity, anti-aging effects, and management of conditions like acne and atopic dermatitis.[2]

The global demand for natural, safe, and sustainable skincare has further accelerated the use of probiotics in cosmeceuticals that bridges the gap between cosmetics and therapeutic skin care.

### A. Probiotics:

Probiotics are "body-friendly" bacteria that boost the body's ability to stay healthy and enhance the immune system by balancing our "good" and "bad" bacteria. Probiotics are live bacterial cultures that affect the skin's microflora composition when applied topically. Probiotics are essential for maintaining the health of our digestive systems and can also be absorbed. Gut health can have a major impact on the appearance of our skin too, so it's crucial to care for your skin from the inside out as well as topically. The skin's barrier can be strengthened and rebuilt by probiotics. Sensitive skin may take a while to mend itself after damage but including probiotics into your skincare regime can speed up the process for rejuvenating skin. [3]

### B. Functions of probiotic in maintaining human skin:

i. To manufacture short-chain acids, such as acetic, lactic, and formic, which can operate as peristaltic stimulators supporting the large intestine.

ii. To maintain the normal macrobiotic balance (both digestive and cutaneous); colon health function with lowering the environment pH that makes the colon immune against the potential pathogens' growth, such microorganisms.

iii. To manufacture the metabolic components, bacteriocins, which instantly stop the vital action of pathogenic bacteria, hence reducing inflammation and skin illness; to lower the potentially dangerous nitrogen content in blood. [3][4]

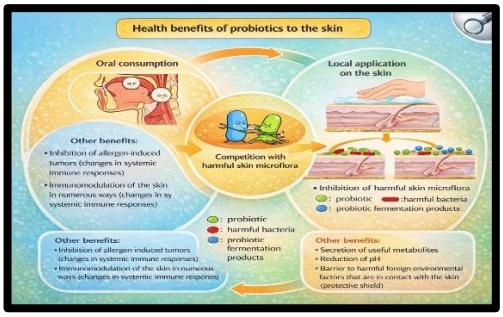



**Fig.1. Primary process by which probiotics promotes skin health**

## 2. Overview of Skin Microbiome:

Skin is the greatest external human organ that hosts a varied microbial ecosystem collectively known as the skin's microbiome. The skin microbiome consists of bacteria, fungi, viruses, and mites that live on the skin surface. Key microbial communities include:

i. Staphylococcus spp.
ii. Cutibacterium acnes
iii. Corynebacterium
iv. Malassezia yeasts[5]

### 2.1. Functions of a healthy skin microbiome:

The skin microbiome is a diverse community of beneficial microorganisms that plays a crucial role in maintaining skin health and homeostasis. By protecting against pathogens, regulating immune responses, strengthening the skin barrier, and maintaining optimal hydration and pH, a balanced microbiome supports resilient, healthy, and well-functioning skin. Following are few functions of a healthy skin microbiome:

i. **Protects against pathogens-** Beneficial microbes on the skin prevent harmful bacteria from colonizing by competing for space and nutrients. They also produce antimicrobial substances that inhibit the growth of pathogens. This natural defense mechanism reduces the chances of infections and irritation.

ii. **Regulates immunity-** The skin microbiome interacts with immune cells to train the immune system to distinguish between harmful and harmless organisms. This prevents unnecessary inflammation and helps the skin respond appropriately to threats, maintaining overall skin health.

iii. **Maintains barrier function & Controls inflammation-** Certain microbes support the production of ceramides, lipids, and proteins that strengthen the skin's outer layer. A strong barrier keeps moisture inside and prevents entry of irritants, allergens, and pollutants. Balanced microbiota ensures the barrier remains intact and functional.

iv. **Influences hydration and pH-** Microbes help maintain the skin's slightly acidic pH (around 4.5–5.5), which discourages harmful bacteria and supports healthy skin enzymes. They also influence natural moisturizing factors that keep the skin hydrated and prevent dryness.[6]

### 2.2. Types of Probiotics with significant mechanisms used in Cosmeceuticals:

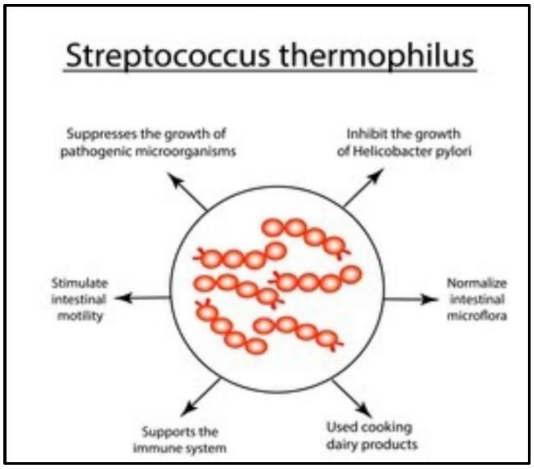
#### a. Streptococcus thermophilus:

Streptococcus thermophilus is a beneficial probiotic bacterium that produces lactic acid and is commonly used in cosmeceutical products. It is added to skincare formulations because it helps improve the skin barrier and maintain a healthy skin microbiome.

One of the most important actions of *S. thermophilus* is that it increases ceramide production in the skin. Ceramides are natural fats present in the outermost layer of the skin (stratum corneum). They help the skin retain moisture and prevent water loss, keeping the skin soft and hydrated.

*S. thermophilus* also helps maintain a balanced skin microbiome by producing organic acids and antimicrobial substances. These substances stop the growth of harmful bacteria such as *Staphylococcus aureus*, which can cause skin problems.

In addition, *S. thermophilus* has anti-inflammatory properties. It reduces the release of inflammatory chemicals (cytokines) in the skin, which helps to reduce redness, irritation, and skin sensitivity. [7]

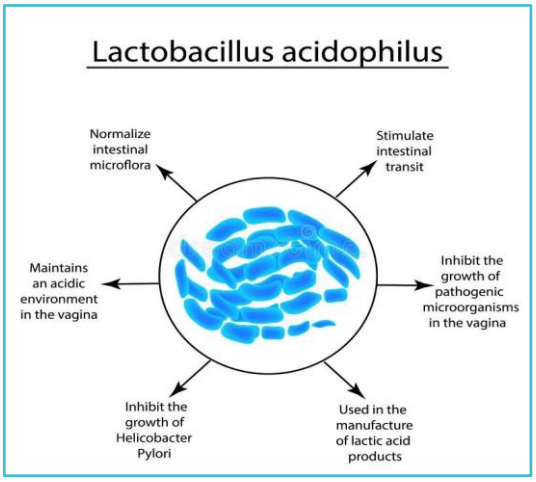


**b. Lactobacillus acidophilus:**

Lactobacillus acidophilus is a well-known probiotic lactic acid bacterium that is widely studied and commonly used as a bioactive ingredient in cosmeceutical products. In skincare formulations, it can be used in different forms such as live bacteria, heat-killed bacteria (paraprobiotics), bacterial lysates, or fermented extracts. All these forms help improve skin health by balancing the skin microbiome, strengthening the skin barrier, and supporting the skin's immune response.

One of the main functions of *L. acidophilus* in cosmeceuticals is its role in maintaining a healthy skin microbiome. It prevents the growth of harmful microorganisms by competing for space on the skin surface and stopping pathogens from attaching to the skin.[8]

*L. acidophilus* also produces useful substances like lactic acid, bacteriocins, and biosurfactants, which have antimicrobial activity. These substances lower the skin pH, making the skin environment unsuitable for harmful bacteria such as *Staphylococcus aureus* and *Cutibacterium acnes*. This helps restore microbial balance and prevents skin problems caused by microbial imbalance (dysbiosis), such as acne and infections.[9]




**a. Lactobacillus rhamnosus lysates**

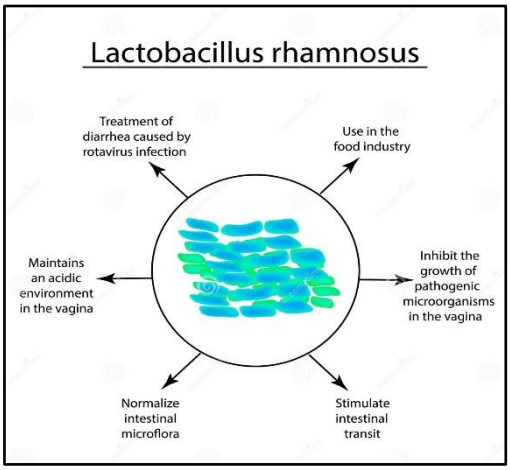
Lactobacillus rhamnosus lysates are commonly used in cosmeceutical products as postbiotics or paraprobiotics. Instead of using live bacteria, the bacterial cells are broken to form lysates, which makes the product more stable, safer, and easier to use in skincare formulations.

These lysates contain many active components such as parts of the bacterial cell wall, proteins, and useful metabolites. When applied to the skin, these components directly interact with skin cells and help improve overall skin health.

One of the most important actions of *Lactobacillus rhamnosus* lysates is their effect on the skin immune system. The active components bind to special receptors present on skin cells (called Toll-like receptors, TLR2 and TLR4). This interaction helps the skin's immune system respond in a controlled and balanced way.

As a result, excessive inflammation is reduced. The levels of inflammatory substances such as interleukins (IL-1β, IL-6, IL-8) and tumor necrosis factor-α (TNF-α) decrease, while substances that reduce inflammation increase.

Because of this anti-inflammatory action, *Lactobacillus rhamnosus* lysates are especially useful in sensitive, reactive, and inflammation-prone skin.[10]




**d. Bifidobacterium longum sp. lysates**

Bifidobacterium longum (B. longum) is commonly used in cosmeceutical products because of its strong anti-inflammatory and soothing effects on the skin.

The active components of *B. longum*, such as cell wall sugars (polysaccharides) and peptidoglycans, interact with special receptors present on skin cells called Toll-like receptors (mainly TLR2). These receptors are found on keratinocytes and

Langerhans cells of the skin. When *B. longum* components bind to these receptors, they help reduce excessive immune reactions in the skin.
As a result, the release of inflammatory substances like interleukins (IL-1α, IL-6, IL-8) and tumor necrosis factor-α (TNF-α) is decreased. This leads to less skin inflammation, redness, irritation, and discomfort. Therefore, *B. longum* is especially helpful for sensitive, reactive, and easily irritated skin. [10][11]

In addition to its soothing effect, *B. longum* also helps strengthen the skin barrier and improve skin hydration. It supports the normal growth and maturation of skin cells (keratinocytes) and increases the production of important skin proteins and lipids. This improves the structure of the outer skin layer (stratum corneum).

A stronger skin barrier reduces water loss from the skin (transepidermal water loss), helps the skin retain moisture, and protects it from environmental factors such as pollution and allergens.[12

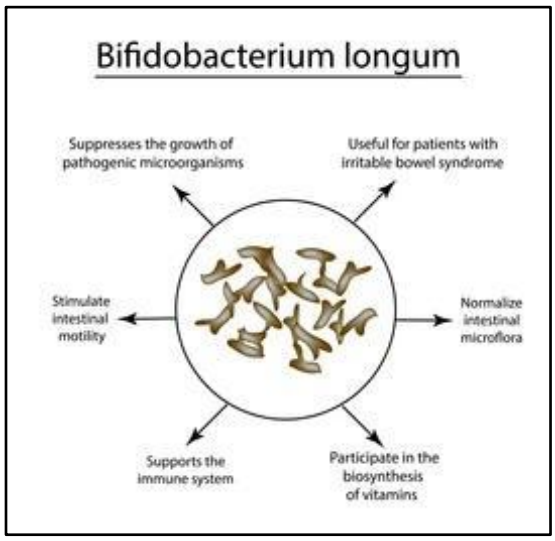



**Table.No.1. Common probiotics used in cosmetics.**

| Sr. No | Probiotics | Properties | Cosmetic Products |
|---|---|---|---|
| 01. | Streptococcus thermophilus | Enables skin hydration, rendering an antioxidant effect and pH control | Moisturising creams and lotions, Anti-aging creams and serums, Anti-wrinkle creams, Under eye creams |
| 02. | Lactobacillus acidophilus, Lactobacillus bulgaricus lysates | Antiacne and antimicrobial properties | Anti-acne creams, Anti acne facewash. |
| 03. | Lactobacillus rhamnosus lysates | very effective exfoliating and moisturizing agent, | Prevent skin damage from UV radiation |
| 04. | Bifidobacterium longum sp. lysates | Showed positive effect for reactive skin at in vivo experiment, decreasing skin sensitivity. | Skin hydrating gels and serums, soaps. |
| 05. | Lactobacillus paracasei | Imparts antibacterial properties reducing dandruff | Antidandruff shampoos. |

## 3.Use of probiotics in skin diseases:

### a. Acne:

Acne is among the most common dermatological conditions. Probiotics have emerged as a potential adjunct therapy for acne. When applied topically, they may act as a protective barrier, preventing acne triggered by pathogenic microorganisms. Regular use of a topical combination of *Lactobacillus* species and *Enterococcus faecalis* has been shown to decrease acne lesions, likely by inhibiting *C. acnes* growth and reducing its production of pro-inflammatory mediators. Similarly, studies using *Lactobacillus plantarum* in aqueous formulations demonstrated dose-dependent reductions in lesion size.[13]

### b. Skin Whiting:

Skin lightening has gained significant attention in recent years, and most brightening products aim to reduce melanin content and suppress excessive pigment production. Although melanin is photoprotective and shields the skin from ultraviolet (UV) radiation, its overproduction can lead to uneven skin tone and various pigmentary disorders such as freckles and melasma[14]

Melanin synthesis (melanogenesis) is a complex biochemical process regulated by multiple enzymes. The three key enzymes involved are tyrosinase, tyrosinase-related protein 1 (TYRP-1), and tyrosinase-related protein 2 (TYRP-2), with tyrosinase being the essential rate-limiting enzyme. Many skin-whitening formulations are designed to specifically inhibit tyrosinase activity, thereby decreasing melanin formation and producing a brightening effect.[15]

Recently, probiotics have emerged as promising ingredients in skin-brightening products. Their effectiveness is closely linked to their strong inhibitory action on tyrosinase, which helps reduce melanogenesis and promote a more even skin complexion.[16]

**c. Skin Moisturization:**

Healthy and beautiful skin mainly depends on proper skin hydration. When the skin has enough water, it looks smooth and healthy. Therefore, scientists are always searching for substances that can keep the skin moisturized.

Probiotics are helpful in improving dry skin. They reduce transepidermal water loss (TEWL), which means they prevent excess water from escaping from the skin. Probiotics also strengthen the skin barrier, helping the skin retain moisture for a longer time.

Studies have shown that oral supplementation of *Lactobacillus plantarum* HY7714 increases the level of ceramides in the skin. It does this by increasing the activity of an enzyme involved in ceramide production and decreasing the enzyme that breaks ceramides down. Ceramides are important lipids that help maintain the structure of the skin barrier and keep the skin hydrated. When ceramide levels increase, TEWL decreases and skin hydration improves.

Another study found that topical application of *Lactobacillus acidophilus* IDCC 3302 improves skin hydration. Using ELISA, researchers observed increased levels of hyaluronic acid (HA), which is a natural moisturizer in the skin. As a result, skin dryness was reduced and TEWL was lowered, leading to better skin moisture.[19]

**d. Photoaging and Skin Ageing:**

Reactive Oxygen and Nitrogen Species (ROS/RNS) are produced at the exposed surface of skin when it is directly exposed to environmental stressors, such as UV radiation, which induces oxidative stress.[17]Compared to UV-B, prolonged exposure to UV-A causes photoaging, the generation of free radicals, and damage to the dermis and epidermis.Both Lactobacillus and Bifidobacterium strains were able to reduce lipid peroxidation through autoxidation of ascorbate, metal-chelation, scavenging superoxides and other reactive species, and their corresponding cell-free extracts containing antioxidant enzymesAlso,Lactobacillushelveticus supernatant, when applied on the surface of skin, shows antioxidant activity.[20]

**Conclusion:**

It can be concluded from the article that probiotics will continue to expand in applicationsof cosmeceuticals due to their multifaceted role in maintaining skin health through modulation of the skin microbiome, enhancement of barrier function, and regulation of inflammatory and immune responses. Evidence from recent studies highlights the beneficial effects of probiotic strains and their derivatives (postbiotics and paraprobiotics) in improving hydration, reducing acne and sensitivity, inhibiting melanogenesis, and protecting against photoaging and oxidative stress. The incorporation of microorganisms such as *Lactobacillus*, *Bifidobacterium*, *Streptococcus*, and *Bacillus* into cosmetic formulations offers a safe,

natural, and innovative approach to skincare. As consumer demand for microbiome-friendly and sustainable products continues to grow, probiotics are expected to play an increasingly important role in the development of next-generation cosmeceuticals that bridge cosmetic care and dermatological therapy.

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