**Review**

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# The use of probiotic microorganisms in cosmeceuticals

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Normal microflora of human skin and the development of its representatives depending on the skin pH are considered in this article. It is shown a possibility of using probiotic microorganisms of genera *Bifidobacterium*, *Lactobacillus*, *Lactococcus*, *Bacillus* and their metabolites for making the cosmetic medical remedies for different skin types. It was revealed that the probiotic microorganisms' lysates contain a large amount of biologically active substances that contribute to the recovery of the skin epidermis and inhibit the development of pathogenic skin microflora.

**Keywords:** probiotics, cosmeceuticals, *Bifidobacterium*, *Lactobacillus*, *Lactococcus, Bacillus*

## Introduction

Probiotics using in cosmetology is a modern approach to the daily skin care because such cosmetics have natural basis and possess a therapeutic effect. Experts say that cosmetic products with probiotics based on living cells and their lysates not only make your skin healthy but also protect it from aging [1–4].

Cosmetics with probiotic microorganisms are suitable not only for mature but also for sensitive skin and skin exhausted by sun exposure (for example UV rays can destabilize the skin ecosystem and even temporarily reduce the skin immunity) [5–7].

Numerous studies have shown [7, 8] that the use of lysates of probiotic cultures in cosmetics increases the skin's ability to repair and regenerate, normalizes the microflora and pH and helps to restore skin immunity.

## Normal microflora of human skin

The microflora of healthy skin is the ecosystem quite resistant to external influences. Generally, antimicrobial properties of skin in-

clude mechanical rigidity (resistance) of the horny layer of the epidermis, the reduced water content, stratum corneum lipids and lysozyme. Normal flora of human skin is largely regulated by acidity (pH) of the skin [1, 4, 8, 9].

The microflora of human skin varies depending on the area of the body [1–3, 10]. *Corynebacteria (C. xerosis, C. minutissimum C. jeikeium)* are permanent residents of the armpits. The representatives of *Staphylococcus (S. epidermidis, S. hominis, S. capitis, S. saccharolyticus, S. saprophyticus*) are found usually on the face, upper body and head. There are yeast fungi of the genus *Pityrosporum* on the surface of follicle sebaceous glands. *Propionibacterium, Micrococcus, Brevibacterium, Dermabacter, Acinetobacter* develop mainly on the sebaceous glands, arms, axillary cavity and dry skin areas. The facultative types of skin microflora include bacteria *Streptococcus* (*S. pyogenes, S. viridans, S. aureus*), Mycobacterium, *E. coli,* Enterobacter*, Proteus, Pseudomonas*. *Bacillius, Clostridium* and fungal spores from the dust [3, 4, 10, 11].

Composition of the skin microflora depends on the age, density of hair cover, humidity, temperature, acidity, hygienic condition of the skin, skin and common diseases [2, 10, 12]. The skin condition (staying in hospitals, long term use of antiseptics, corticosteroids, cytostatics) greatly affects the composition of the skin microflora. Skin is unevenly populated by microorganisms; there are many microbes on the surface and under the first and second layers of keratinized epithelium and in the mouths of the hair follicles. In sweat and sebaceous glands, bacteria do not develop because of the antibacterial activity of fatty acids and lactic [1, 3, 6, 9, 11].

## Effect of pH on the development of skin microflora

It is known that in healthy human skin pH must be acidic (pH 4.5–5.5). The acidic pH of the skin facilitates the synthesis of natural antimicrobial peptides, promotes wound healing, regulates keratinization and desquamation, promotes rapid bacterial growth in the axillary folds associated with the development of body odor [1, 3, 8, 10].

Normal microflora of human skin is a source of antibacterial components (proteins, lipids, peptides). For example, bacteriocins formed by bacteria *Staphylococcus epidermidis* are partially active against other staphylococci, and especially effectively suppress the growth of *Staphylococcus aureus* [3, 4, 11, 13].

The alkaline skin pH (pH 8–9) promotes the development of the permanent skin flora, particularly Gram (-) and propionic bacteria (*Propionibacterium acnes*), which are the causative agents of acnes. At normal skin pH 5.5 *Propionibacterium acnes* hardly reproduce.

Increasing population of *Brevibacterium epidermidis,* which is a source of unpleasant body odor, can be slowed only by decreasing the pH to 5.0 or below [14].

## The use of probiotic microorganisms lysates and their metabolites in medical cosmetology

Regular use of cosmetic products with probiotics restores the balance of the skin microbial composition and maintains it creating a normal skin pH and other conditions that confer a normal operation of skin [3, 5, 15].

## The use of bacteria of the genus *Bifidobacterium*

Bacteria of the genus *Bifidobacterium* with their multifunctional role are the most important representatives of the normal microflora. They dominate in the normal flora of adults of all ages [9–11, 16]. Most of them are located in the colon of healthy people ($10^9$–$10^{10}$ CFU/g). Usually in the human gastrointestinal tract there are *Bifidobacterium bifidum*, *Bifidobacterium longum, Bifidobacterium adolescentis, Bifidobacterium breve, Bifidobacterium infantis, Bifidobacterium animalis, Bifidobacterium catenulatum, Bifidobacterium pseudocatenulatum etc.* [8, 10, 16, 17].

Bifidobacteria are gram-positive acid-fast polymorphic bacterium that do not form spores and are motionless. Location of cells can be isolated, pair, V-shaped, sometimes in the form of chains or outlets [5, 15].

At present bifidobacteria lysates with their metabolites are often used in the production of cosmetics [15–17]. This is because bifidobacteria lysates are "universal probiotics", which are composed of a large number of biologically active substances. An important function of bifidobacteria is their ability to raise protective tissue barrier for toxic substances, pathogenic and conditionally pathogenic microorganisms [7, 15, 18].

Bifidobacteria lysates primarily create and maintain a healthy balance of the skin, normalize the number of "useful" microorganisms on its surface increasing its protective function and immune system, and accelerate recovery of hydro lipid film [7, 17]. The presence of lactose in lysates facilitates the moisturizing of the skin and helps to restore its lipid layer. Probiotic bacteria are able to synthesize vitamin B, vitamin C, folic and nicotinic acids involved in the restoration of the skin, as well as vitamin A, which protects it from aging and aggressive influence of environment. Bifidobacteria lysates contain also essential amino acids and organic acids, including lactic acid, that restores skin cells and aligns skin structure. Bacteriocins synthesized by probiotic bacteria can inhibit the growth of pathogenic organisms.

## The use of bacteria of the genus *Lactobacillus*

*Lactobacillus* and *Bifidobacterium* belong to the basic human microflora, they are found almost in all biotopes of the digestive tract. Lactobacilli greatly vary in shape and size, they can be short or long filamentous rods located singly, in pairs or in short chains [10, 16, 17, 19].

Because lactobacilli are able to synthesize organic acids (lactic, acetic), polyhydric alcohols, glycosidase enzymes and lipases, bacteriocins, vitamins A, B, C and K, their lysates are used as a component of cosmetic creams for the care of sensitive and problem skin in the external treatment of hyperfunction of sebaceous glands. Lactobacillus lysates are also added to masks and cosmetic creams for the skin to regenerate and restore the skin with weakened immune protection, to improve skin turgor, elasticity and resilience, to recover the stratum corneum and for comprehensive skin care, including nutrition, hydration, prevention of aging [7, 10, 16, 18, 19].

To create medical cosmetics, *Lactobacillus acidophilus, L. amylovorus, L. casei, L. rhamnosus, L. brevis, L. crispatus, L. delbrueckii (subspbulgaricus, lactis), L. fermentum, L. hel-*

*veticus, L. gallinarum, L. gasseri, L. johnsonii, L. plantarum, L. reuteri, L.salivarius, L. alimentarius, L. curvatus* or a mixture of several different kinds are often used. Recently, a mixture of Lactobacillus and Bifidobacterium lysates is used to improve the therapeutic effect [3, 16, 19, 20].

## The use of bacteria of the genus *Lactococcus*

*Lactococcus* are gram-positive bacteria that neither form spores and capsules, nor have flagella. They locate singly, in pairs, clusters or chains. The members of this genus tend to have polymorphism, resulting in the formation of circular or partially extracted cells. In cosmetic-therapeutic agents, the species *Lactococcus lactis, Lactococcus garvieae, Lactococcus piscium, Lactococcus plantarum, Lactococcus raffionolactis* are used, because they are able to synthesize bacteriocins [3, 13, 19].

Lactobacilli bacteriocins are the protein components that adhere on the specific receptors of target cells and tend to have a wide spectrum of antimicrobial activity. They differ from other bacteriocin classes in amino acid composition and resistance to the action of proteases. The mechanism of biological effects of antibiotics is conditioned by violation of permeability of the cytoplasmic membrane,; in some cases bacteriocins cause lysis of cell membranes, seal of the nuclear material and partial ribosome change [13, 19].

In medical cosmetic products bacteria of *Lactococcus* family and their metabolites are used primarily to inhibit *Staphylococcus epidermidis, S. aureus, Streptococcus pyogenes, Propionibacterium acnes*, which can cause inflammation and acne formation [3, 13, 19, 21].

The researchers have also found [13, 19] that *Lactococcus* bacteriocins do not damage fibroblasts and proliferation of epidermal cells and do not cause an allergic skin reaction.

## The use of bacteria of the genus *Bacillus*

The benefits of probiotics for human health suggest the presence of different probiotic preparations containing live bacteria in the market, as well as the scientific publications that prove the mechanisms of their positive effects on the body. While most bacteria that have probiotic properties are members of families of *Lactobacillus* and *Bifidobacterium*, bacteria that form spores, especially *Bacillus* has been increasingly used in recent years [14, 22–25].

Genus *Bacillus* is a large group of obligate aerobic and facultative anaerobic gram-positive chemoorganotroph rod-shaped microorganisms that can form heat-resistant endospores [14, 20, 24, 25].

*Bacillus* bacteria usually live in the soil, but they are also separated from water, dust and air, so a human every day contacts with these microorganisms [8, 20, 26].

*Bacillus* bacteria have a high and diverse range of biological activities, in particular, antagonistic properties to pathogens. They are able to produce the enzymes, which lyse starch, pectin, cellulose, fats, proteins, amino acids and synthesize various antibiotics [14, 24, 25].

In the manufacture of medical and cosmetic products, the spore biomass of *Bacillus cereus, B. subtilis, B. coagulans, B. licheniformis* together with the products of their metabolism are used to care for oily skin with large pores and a tendency to the acne forma-

tion [24, 26], to care for mature skin, to maintain its elasticity and reduce wrinkles, to protect against herpes, burns and to restore the vaginal flora. Medical cosmetics also include bacillary probiotics with antifungal, antiacne, antipustular action.

## Conclusion and future prospects

The use of probiotic microorganisms of genera *Bifidobacterium, Lactobacillus, Lactococcus, Bacillus* and their metabolites is the most perspective to create cosmetic remedies for different skin types.

Bacteria of the genus *Bacillus* are used for the care of oily skin with tendency to form acne; *Lactobacillus* are added to the protective cosmetic creams for skin care with weakened immune protection and comprehensive skin care products for aging prevention; *Lactococcus* are used for suppression of staphylococci, which can cause inflammation of skin and acne; *Bifidobacterium* are considered as "universal probiotics" which are components of a large number of biologically active substances, and can be used in cosmetics for all skin types.

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**Використання пробіотичних мікроорганізмів у косметиці**

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У статті розглянуто нормальну мікрофлору шкіри людини та її розвиток залежно від pH шкіри. Показано можливість використання пробіотичних мікроорганізмів пологів *Bifidobacterium*, *Lactobacillus*, *Lactococcus*, *Bacillus* та їх метаболітів для виготовлення косметичних засобів для різних типів шкіри. Встановлено, що лізати пробіотичних мікроорганізмів містять велику кількість біологічно активних речовин, що сприяють відновленню шкірного епідермісу та пригнічують розвиток патогенної мікрофлори шкіри.

**Ключові слова:** пробіотики, космецевтика, біфідобактерії, лактобактерії, лактококи, бацили.

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