

“LIVING” AND “PROBIOTIC” COSMETICS: MODERN VIEW AND DEFINITIONS

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Abstract. In the presented article, based on the detailed analysis of scientific sources and many years of own experience in production of the probiotic foods, the definition of “probiotics” in cosmetics, as well as the definition of “living” and “probiotic” cosmetics is proposed.

The skin is a complex barrier organ that has a symbiotic relationship between microbial communities and host tissue via complex signals provided by the innate and the adaptive immune systems. It is constantly exposed to various endogenous and exogenous factors – physical, chemical, bacterial and fungal, as well as the effects of the hormonal disorders, which affect this balanced system potentially leading to inflammatory skin conditions comprising infections, allergies or autoimmune diseases. In opposition to the gut and stool microbiome, which has been studied and described for many years, investigations on the skin or scalp microbiome lasts only for last 10 years. Therefore, the screening of effective means of correcting and/or maintaining the human normoflora for the preservation of healthy skin microbiome today is an urgent task.

It is well known that probiotics and prebiotics are helpful for specific disorders in the human body. Skeptics wonder: can the probiotics and prebiotics be scientifically applied in cosmetics? Different clinical studies indicated that they have special effects in cutaneous apparatus directly or indirectly, which can be considered from different aspects. Probiotic bacteriotherapy can have great potential in accelerating wound healing, in preventing and treating the skin diseases including eczema, atopic dermatitis, acne, allergic inflammation or skin hypersensitivity, UV-induced skin damage and cosmetics products. Therefore, some firms are already incorporating bacteria and/or their lysates into skin creams with the promise of «rebalancing» the community of bacteria that live in the human body and delivering healthier, more radiant-looking skin. However, such parameters as the type of probiotic, the form in which it is added to the formulation (living bacteria, lysates, etc.) and the recommended concentrations of these ingredients in cosmetic products that are safe and effective are still not defined. Due to currently widespread use of probiotic cosmetic products in the world beauty industry, the concept of “probiotic” in the cosmetic industry requires a clear definition.

Key words: skin, microbiome, probiotic, «living cosmetics», «probiotic cosmetics», bifidobacteria, lactobacteria.

«ЖИВА» ТА «ПРОБІОТИЧНА» КОСМЕТИКА: СУЧАСНИЙ ПОГЛЯД ТА ДЕФІНІЦІЇ

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Анотація. У представленій статті на основі детального аналізу літературних джерел та багаторічного власного досвіду щодо створення пробіотичних продуктів харчування запропоновано визначення «пробіотиків» у косметичці, а також визначення «живої» та «пробіотичної» косметики.

Шкіра є складним бар’єрним органом, у якому існують симбіотичні зв’язки між мікробними спільнотами та тканинами-хазяями через складні сигнали, передбачені вродженою і адаптивною імунними системами. Вона постійно піддається впливу різних ендогенних і екзогенних факторів – фізичних, хімічних, бактеріальних, грибкових, а також впливам гормональних порушень, що призводять до змін у цій збалансованій системі, потенційно ведуть до запальних захворювань шкіри, які включають інфекції, алергії або аутоімунні захворювання. На відміну від мікробіома кишечника і випорожнень, які були вивчені й описані протягом багатьох років, дослідження мікробіома шкіри або волосної частини голови тривають лише останні 10 років. Тому скринінг ефективних засобів корегування та/або підтримання нормофлори людини для збереження здорового мікробіома шкіри сьогодні є актуальним завданням.

Ключові слова: шкіра, мікробіом, пробіотик, «жива косметика», «пробіотична косметика», біфідобактерії, лактобактерії.



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Introduction. Formulation of the problem

The skin is a complex barrier organ made of a symbiotic relationship between microbial communities and host tissue via complex signals provided by the innate and the adaptive immune systems. It is constantly exposed to various endogenous and exogenous factors – physical, chemical, bacterial and fungal, which affect this balanced system potentially leading to inflammatory skin conditions comprising infections, allergies or autoimmune diseases. In opposition to the gut and stool microbiome, which has been studied and described for many years, investigations on the skin or scalp microbiome only started recently. Therefore, the screening of effective means of correcting and/or maintaining the human normoflora for the preservation of healthy skin microbiome today is an urgent task [1,2].

Pro- and prebiotics have become ingrained in dietology and healthy diet system. Due to their high efficiency, last years they became very popular among consumers worldwide as an efficient and secure way to support or restore human health. Most of scientific researches related to probiotic, prebiotic and symbiotic products are focused on human digestive tract [3]. However, during the last decade opportunities of applying pro- and prebiotics locally – on skin, that is to use them as a part of hygienic items and cosmetics – generate interests of scientists from the whole world [2].

Skeptics wonder: can the probiotics and prebiotics be scientifically applied in cosmetics? Different clinical studies indicated that they have special effects in cutaneous apparatus directly or indirectly, which can be considerable from different aspects. Probiotic bacteriotherapy can have great potentials in preventing and treating the skin. Therefore, some firms are already incorporating bacteria and/or their lysates into skin creams with the promise of “rebalancing” the community of bacteria that live in the human body and delivering healthier, more radiant-looking skin [1,2].

Is production of cosmetic products with living cultures of probiotics and/or lysates it possible in Ukraine? What are special features of probiotic cosmetics technology? For which innovations should producers be ready to offer a brand new product to a consumer – cream, scrub, lotion, toner, shampoo, gel or decorative cosmetics with probiotics? Moreover, how can we prepare the consumer to market appearance of such cosmetics in Ukraine? We hope, we will manage to give an answer to these and other questions in the offered article.

The purpose of the study is to summarize modern ideas about the nature of a microbiome of the human skin and the influence of the cosmetic products with probiotics on the healthy condition of the skin; defining the concept of «probiotic» in the beauty industry; the distinction between the definitions of “living cosmetics” and “probiotic cosmetics”.

Task of the research:

- give characteristics to skin microbiome and to identify its function in support of skin health;
- to characterize features of probiotic cultures of lactic and bifidus bacteria with respect to skin;
- to analyse existing cosmetic products and ingredients for their production with probiotics and/or their lysates, to identify effect of probiotics cosmetics on skin health;
- to define the term “probiotic” in the cosmetic industry;
- to differentiate the concepts of “living” and “probiotic” cosmetics.

Data and methods of the research

Framework of the research is methods of scientific cognition, system approach, and consolidation of existing scientific and technical information. In the research, such general scientific methods as analysis, synthesis, induction, analogy, abstracting, and specification are used. The definition of the “probiotic” in the cosmetic industry, the wording of the requirements for “living” and “probiotic” cosmetics, results of recent 15-year researches related to use of probiotic cultures of lactic and bifidus bacteria in technologies of special and functional dairy products were used [4–6].

Skin microbiome: concept of the microbiome, its functions, meaning in support of skin health

Human skin is an immunogenic organ working as the first protective and biological sensor against outdoor allergen. Main skin function is to protect human organism against environmental effect creating a physical barrier. In addition, skin also exercises additional functions that include regulation of body temperature; control of sweat production; sensing; keeping of lipids and water [1,2]. Reinforcement of the barrier function is especially important in case of inflammatory diseases when this function is disordered, such as atopic dermatitis, eczema, acne, dry skin, aging, etc. Being a connecting link between internals and environment, human skin is everyday effected by environmental, chemical or physical factors (ultrasonic irradiation, pollution, high and low temperatures, air conditioning, low humidity level, etc.), psychological stresses and/or deficit of required nutrients in food [7]. Healthy and flesh complexion of skin is a result of sense of well-being and continuous care. Recent researches related to control of skin barrier functions prove close connection physical, immunological, and cell biological characteristics of skin and its bacterial population [8].

Scientists became interested in colonization of skin by microorganisms starting from the first microscopic study of Antoni van Leuwenhoek in 1683. However, the detailed researches of human microbiota in dermatology were started due to Kligman in the 1950es[9], opposite to gut microflora that was studied in details long ago [10, 11]. In 2000, the Nobel laureate

Joshua Lederberg suggested using the term “human microbiome” to describe the collective genome of our indigenous microorganisms (microflora) colonizing the whole body [12,13]. Starting from this time, microbiologists and dermatologists joined their efforts to identify and describe different microorganisms colonizing human skin to estimate a number of each population and to understand, which microbial variety can cause one or another dermatological condition [14–16].

The “microbiota” term is referred to any microorganism present in human body, and on it – in intestinal tract, nose, and tunica mucosa of mouth, mucous coat of lungs, head and body skin [17]. It should be noted that in general, about 200 microorganisms were

found out and characterized as actually pathogenic ones. The rest part of microbiological world should be considered as compensationally or optionally pathogenic. Recent researches show that a microbiome can be decisive in diagnosing an infection [18]. These observations support a concept of so-called “holo-genome” [19].

In general, the microbiome is defined as a collective genome of microorganisms [12]. Thus, skin microbiome is a genome of microorganisms present on skin, in which microorganisms support complex relations [16,20]. According to held researches, three groups of microorganisms colonizing human skin are singled out (Fig. 1).

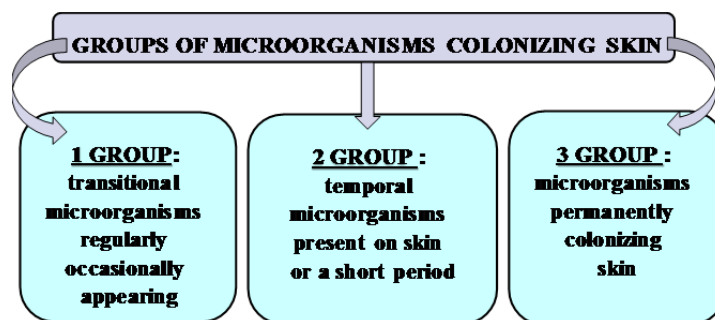


Fig. 1. Classification of microorganisms colonizing human skin [1]

Most microorganisms found on human skin are not dangerous for human health. Some of them are even necessary for skin health. They release antibacterial substances, prevent pathogenic colonization of skin and effect its immunity.

Microorganisms permanently compete for their “place in the sun”, and the fact that permanent residents of skin do not let “strangers” in their living space, is one of the most important and efficient ways of protection against diseases [1,2].

Recent researches proved that the healthy microbiome of human skin is stable for a long period despite of external factors [21]. Possibly, one of reason for skin microbiome stability is that the latter is settled by more diverse number of microbial colonies than any other epithelial surface [22].

In the context of bacteria, our skin can be deemed a cultural environment composition of which is mainly a result of our genetics, diet, way of life and a region where we live. Therefore, human skin is unique and accordingly, skin microbiome of each person is also unique [1].

In the context of macroscopy, skin is a composite surface relief with a large number of intrusions, pockets, and niches. Each anatomic niche ensures ecologically excellent microenvironment to which microorganisms are adapting. There are three main types of environments present on human skin (Fig. 2): humid, lardaceous, dry and very humid areas that include armpits, inner elbow or an inguinal fold [15,16]. Lardaceous areas include forehead, wing folds (nostrils side), and retroauricular fold (behind the

ear) [22], while dry areas include, for example, upper surface of buttocks [23]. Sweat glands, hair follicles, and dermal balls are referred to other microenvironments [24].

Today scientists have found 19 main types of bacteria on skin of a healthy adult. They include *Actinobacteria* (51.8%), *Firmicutes* (24.4%), *Proteobacteria* (16.5%) and *Bacteroidetes* (6.3%) [2]. *Corynebacterium*, *Propionibacterium* and *Staphylococcus* are most widespread [15]. Each microbial population has a preferable environment of existence in different skin microenvironments [1,25]. Additional researches show that physiologically similar areas settled by similar microbial communities, for example, moist armpits, umbilical cavern, and poples have similar microbial composition: they are mainly settled by *Corynebacterium species*, though it is present *Staphylococcus species* [15], and lipophile types such as *Propionibacterium* adopted to the anaerobic environment rich with lipids [26–28]. In areas with intensive sebaceous excretion on the face *Propionibacterium species*, *Staphylococcus species* prevail. Axillar area includes mainly Gram-positive bacteria of *Staphylococcus*, *Micrococcus*, *Corynebacterium*, and *Propionibacterium* types [29]. On the contrary, in dry area, skin microbiome includes β -*Proteobacteria* and *Flavobacteriales* [25,30]. On the microscopic level, even small different life environments such as eccrine and apocrine glands, oil glands and hair follicle are possibly connected with their own unique bacterial population [29]. Microorganisms are “attached” to a current body area, and if to reseat them from one environment to another

one, for example, from tongue to the forehead, they will not be able to colonize the new territory or to change the existing microbial community in this area [1,2].

Several independent methods of identification show that bacteria are present not only on skin surface but they are also found in deeper epidermis layers and even in dermis and skin fatty tissue [24]. These areas have specific profiles of the microbiome and include a great number of special types of cells such as dendritic cells, melanocytes, and Langerhans' cells, each of which actively response to effect of bacteria metabolism products. There is a hypothesis that microbial population settling upper skin layers can move to sub-epidermal tissues of phagocytes. However, penetration mechanism of such microbes has not been yet identified [24].

Most of researches are aimed at study of bacterial composition of the microbiome, but viruses, fungi, and arthropods also make an important part of the skin microbiota. Researches have established that a prevailing genus of fungi in skin is *Malassezia*, specifically *M. globosa*, *M. Restricta* and *M. Sympodialis* [27,31,32]. *Malassezia* fungi are lipophile, often connected with skin areas rich with sebum [33]. As in case of bacteria, distribution of *Malassezia* depends on features of each particular life area. For example, *M. Globosa* prevails on the back, hindhead, and inguinal folds, while *M. Restricta* is found in hairy part of the head [11], external acoustic meatus, postaural folds, and glabellar area [27]. Other skin areas, for example foot, are colonized by a great variety of microorganisms (for example, *Aspergillus*, *Rhodotorula*, *Cryptococcus* and *Epicoccum*) [27].

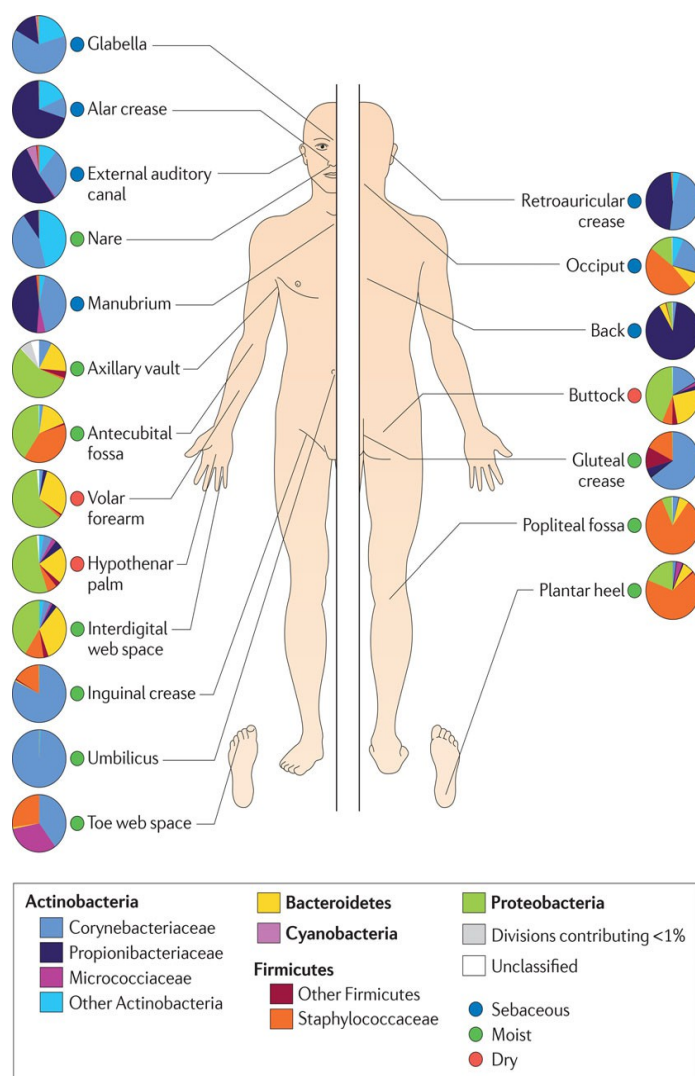


Fig. 2. Topographical distribution of bacteria on skin sites [16]

Other eukaryotes settling human skin are referred to arthropod genus. As *Malassezia* fungi, *Demodex* might also colonizes fat skin areas [34]. Now, two types of mites with length of 0.2–0.4 mm residing on

human skin are known. *Demodex folliculorum* is found in hair follicles in a group with other mites of the same genus. Small *Demodex brevis* is rarely found in oil or tarsal glands located on eyelid margins [35].

Human virome is least studied. Despite of methodological difficulties, the last research held by a metagenome sequencing method with high throughput, involving five healthy patients and one patient having Merkel cell carcinoma, found availability of a great variety of DNA viruses on human skin [36]. However, due to insignificant scope of the research it cannot be surely stated that these viruses are a part of typical skin microbiome or they provide mutualistic benefit to a host. There is an interesting hypothesis according to which acknowledged pathogenic viruses such as human papilloma virus is a normal part of skin microbiome [36–40].

Skin barrier and microbiota act like a shield protecting the organism against harmful effect of outdoor environment. There is well-balanced interaction between permanent and temporary populations on skin. This balance continuously depends on internal and external (including environmental) factors that change composition of microbial population on skin and a function of host's skin barrier. Change of this balance is characterized as dysbacteriosis occurrence of which can worsen such chronic skin diseases as atopic derma-

titis and psoriasis [41–44], or acne [23,24,45,46]. However, dysbacteriosis can be observed not only among bacteria, misbalance between bacteria and commensal fungus strain on head skin is observed in cases of patients disposed to dandruff [47,48].

In general, a large microbial variety is considered more beneficial as a diverse ecosystem is more sustainable. The variety and condition of the skin's microbiome depend on the sex, age, season, ethnicity, as well as various stress factors, including physiological trauma and psychological anxiety, which contribute to the development of endocrine and metabolic changes in the skin, directly affecting the metabolic processes and pathogenicity of various microorganisms [49–51]. The skin microbiome is essentially influenced with such factors as the climate, including temperature and ultraviolet rays, as well as lifestyle, including alcoholism or nutrition. Ultraviolet rays are known to be bactericidal [52,53], meanwhile the excessive consumption of alcohol and meals' vitamins deficiency (especially under various dietary regimes or irrational nutrition) render effects on the skin microbiotic balance decreasing its resistance to infections [28].

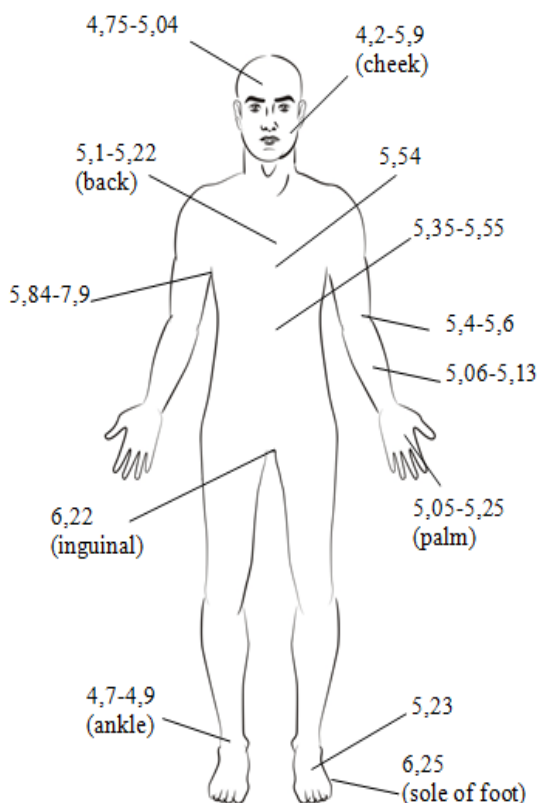


Fig. 3. Distribution of pH of a healthy human skin [54]

However, not only external factors contribute to microbial population, both pH and body skin various areas temperature also can play their role at microorganisms' growth or progress deceleration. According to data given at fig. 3, the human body pH varies between 4.2 and 7.9 [54]. Therefore, an excessive use of detergents involves alternation in skin pH, thus involving the irritation with changes in microbiome especial-

ly at hand's skin [55]. Cosmetology and hygienic-purpose products, makeup and moistening products also modify the skin microbiome [15,16,26,56,57].

An excessive use of antibiotics, which as previously remain an efficient tool in remedying all types of bacterial infections, involved the appearance of several types of antibiotics-resistant pathogenic strains thus rendering impossible to cure corresponding infectious

diseases consecutively enabling a steady disequilibrium in colon and skin microbiotic balance [59,60].

Both radiotherapy and chemotherapy used to cure the cancer also can produce effect onto microbiota [61].

However, not only external factors misbalance the healthy skin's microbiota. The internal ones, as, e.g. an excess in skin's fat, typical for pubescence period, activate the *P. acnes*, their hypercolonisation potentially capable to produce the skin acne and non-balanced microbiotic state.

It is necessary to note that there are also the sex-related variances of skin microbiotic composition, depending on physiologic and anatomic specificity, in turn bound to such skin characteristics as hormones production, perspiration, skin fat production, skin pH and thickness, hair growth and use of cosmetics [62]. While human epidermis studies, essentially more varied set of microorganisms has been found at females, when compared to males, that being due to lower skin surface acidity together with the use of cosmetic products [62].

Manipulations with microbial population aimed to increasing the population of useful bacteria kinds are hotly debated in the medical science.

Such manipulations can assist us, maintaining the health level and/or reducing the index of undesirable pathogens. Numerous researches prove the crucial importance of healthy colon microbiome [63]. Its microbiotic components render essential influence to the whole body health, its immunity characteristics and clinical bodily response to the specific immunotherapy, when curing cancer etc. Many experimental researches established that the colon probiotic micro flora produces a specific effect on epithelial and immunity cells bearing antiallergic potential [64]. Several clinical studies carried out in 2002 and 2006 [65,66] proved that the probiotics induce the system effects extended further beyond the colon even influencing several functions of skin. That is why during this decade the researchers seek to define the adaptive pattern between colon and skin for accurate estimation of probiotics' niche in the system of healthy skin microbiome maintaining [14].

Probiotics: properties of lacto and bifidobacteriae probiotic cultures respectively to skin

After the emergence in global markets of Dannon's probiotic yoghurts "Actimel" and "Essensis" maintaining women natural beauty through favourable effects not only for colon health but also for skin, there took start also the products-for-skin series based on yoghurts with probiotics. The first Company that fabricated skin care series based on lactobacteries was Payot. These products did not cause allergic reaction; therefore, the producer's consultants advised the line even for women having very sensitive skin [67].

The researchers of the cosmetic company Pupa created a cosmetic products line that perfectly moistures the skin together with age-protection, skin nourishment and anti-wrinkles effect due to the lactic acid presence. Use of these products increases the skin's resistivity to environmental factors; it restores the condition much faster after a continued solar irradiation or peeling and scrubbing. Several cosmetic companies initiated the hair care products with probiotics that enriched hair with vitamins, better clean and replenish its condition with nutrients. Today, the probiotic-based products make part to the production series of such cosmetics manufacturers as Decleor, Clinique, Lancome, Burts'n Bees, Christina, Amala, Payot and Dr.Pierre Ricaud [67].

So, what are the probiotics? The probiotics are live microorganisms, consuming of which provide certain health-contributed effect that rendered additionally to the basic meals' effect [68]. Using probiotics within nutritional ration gives a curing effect aimed on intestinal flora normalization. Probiotic microorganisms are selected following strict criteria with reference to both security features and obligatory clinical studies [69–72]. They shall meet such basic requirements: being regularly present at the digestive-intestinal system at the same time never bearing pathogenic nor toxic character; being actively involved into metabolism and bearing an adhesive capacity, synthesizing bactericide factors with prevention of pathogenic flora progress, and, being safe at nutritional and clinical intake regimens to produce a clear, expressed and clinically confirmed positive effect on human and animal body health [69–72].

The most widely used and recognized probiotics are [69–72]:

- *Enterococcus* (typical representative *E. faecium*);
- *Lactobacillus* (*L. acidophilus*, *L. casei*, *L. paracasei*);
- *Bifidobacterium* (*B. bifidum*, *B. longum*, *B. breve*, *B. infantis*, *B. adolescentis*).

The probiotics' functions in the human body [71,72]:

- to maintain the normal macrobiotic balance (both digestive and dermal);
- to produce short-chain acids – acetic, lactic, formic, which can act in peristaltic stimulators assisting the large colon health function with decreasing the environment pH that makes the colon immune against the potential pathogens' growth, such microbes as coliforms, clostridia etc. (cosmetology application as components of skin tonifying lotions and for pH correction after alkali-containing skin washing products; also used as peeling composition components);
- to lower the potentially risky content of nitrogen in blood;
- to produce the metabolic factors, bacteriocins, immediately inhibiting the pathogenic bacteria vital activity (that reduces the inflammation and skin disease

through the use of tonics, lotions, creams containing probiotic bacteriocins);

- to take active part in the colon (or skin) normal microbiota restoring after the therapy with antibiotics;

- to inhibit the production of secondary biliary acids at the digestive-intestinal system;

- to synthesize vitamins of group B, K, excreted extracellularly and absorbed into the blood at the intestine (or transepidermally, when added to cosmetic products);

- to activate the whole body (or skin covers) immunity system and protective functions;

- to act as tumours prevention factor that activity is related to immediate or intermediary reduction of procancerogens' quantity as well as to those bacteria immunomodulatory action;

- to render the hepatoprotective, rachitis preventive, antianemic and antiatherogenic effects.

With respect to the aforementioned probiotics properties, their following basic properties are identified considering the epidermis (and every day more and more new prospects to their application are revealed) [73,74]:

Antimicrobial properties: several metabolites of probiotic bacteria demonstrate the antimicrobial features, particularly, *Lactobacillus acidophilus* produces the Acidocin B; *Bifidobacterium sp.* produces the Bacteriocins N5; *Lactobacillus casei* produces the Caseicin; *Enterococcus faecium* – Enterocin A, Enterococin; *Lactobacillus plantarum* – Plantaricin A and C, Pediocin AcH. Therefore, the probiotics can assist in elimination of harmful, pathogenic microorganisms that involve skin inflammation and diseases;

Calming effect: the probiotics' interaction to skin cells renders calming effect on cellular receptors actuated with pathogens presence as "alarm factor" detected. The "healthy" signals produced by probiotics prevent actuating the immune response against "attack" that would result acne or rosacea inflammation;

Anti-age effect: numerous studies data witness an evidenced lifting effect produced by probiotics thus increasing the skin's regeneration and reparation processes, reducing wrinkles' number and depth and restoring the skin vital tonus at the same time that deliberating skin from toxins.

Under contemporary conditions, series of unfavourable factors exhaust the skin microbiome's natural balance; therefore, the use of cosmetic products with prebiotics represents a promising innovative trend in cosmetology and cosmeceutics. The cosmetic companies develop creams, douche gels, shampoos, and other skin care products on probiotics basis. Most often, such products contain the bacteria DNA fragments, parts of their cell wall, ferments and non-living bacteria. Even such "cocktail" pattern is adequately capable to involve the skin's positive immune response thus improving its condition [73].

Advantages of prophylactic and/or therapy with probiotics refer to the fact that these methods are highly efficient for patients never causing any adverse or by-side effects. The probiotics contribute into skin's health acting immediately through epidermis or indirectly, when taken with dietary supplements and improving the intestinal microflora. So, the skin therapy with probiotics can be potentially approximated as a standard treatment method [2].

Influence of the probiotic cosmetic products on skin health condition

Numerous cosmetic companies in the last years add probiotics to their anti-age creams and special product lines for sensitive skin. Nevertheless, at food industry the term "probiotic" defining the physiologically functional nutritive ingredient is widely used, the cosmetic industry (as an independent branch) does not use some standardized definition for probiotics. Therefore, the consumers cannot understand what they should expect from probiotic-based product [67].

When food industry uses the probiotic strains, additional conditions arise: metabolism type, strength to technological processing, maintaining the admissible organoleptic characteristics, phage resistance, ability to grow with certain substrates (e.g., milk environment), biological properties' stability at storage etc. [69–72]. In addition, there are some technical hindrances for live probiotics inclusion to usual skin care products with respect to a required storage period. Mostly, the cosmetic products include a high content in water that prescribes using of preserving agents for product non-deterioration; consecutively, the marketable products cannot contain live culture. However, such leading trademarks as Clinique with its Redness Solutions line, containing *Lactobacillus Ferment*, found a reasoned way to solve the problem adding those cultures' lysates – probiotic ingredients, which are not live or viable for colonies forming, just at the end of the technologic process. This non-expensive solution does not require any substantial changes in preservatives use or in any other product composition [67].

Today leading scientists proved the usefulness of cosmetic products manufactured with probiotic bacteria lysates. The researches [75–78] mark a positive effect of lysates of probiotic cultures *Lactobacillus delbreuckii*, *Lactobacillus rhamnosus*, *Lactobacillus salivarius*, *Lactobacillus paracasei*, *Bacillus subtilis* in the composition of cosmetic products for atopic dermatitis curing. It is noted that the lysates of *Lactobacillus delbreuckii* cultures enabled the atopic dermatitis' progress inhibition [76], and the *Bacillus subtilis* lysates are used to the atopic diseases' prophylactic [75], the *Lactobacillus salivarius*, *Lactobacillus rhamnosus*, *Lactobacillus paracasei* lysates were used at the atopic dermatitis therapy [77–78].

Several researchers studied the probiotic lysates' effect on acne disease: the skin clinical condition was im-

proved, when *Lactobacillus acidophilus* and *Lactobacillus bulgaricus* lysates used [79]. The *Bifidobacterium spec.* bacterial lysates provided the prophylactic of skin diseases due to immunity anomalies as well as improved the condition of sensitive skin [80]. Inflammation curing with skin sensitivity lowering are registered, when *Lactobacillus delbreuckii* and *Lactobacillus casei* lysates applied [81, 82]. An accelerated skin barrier function restoring has been produced by lysates of cultures *Lactobacillus paracasei* [83], and the *Lactobacillus rhamnosus* lysates maintained the prophylactic of UV-radiation skin damage [84]; the lysates of *Lactobacillus reuteri* protected the epidermal keratinocytes [85]. Mixed lysates culture *Lactobacillus bulgaricus* + *Streptococcus thermophilus* completed with inulin prebiotic resulted in 70%-reducing of *Staphylococcus aureus* population within 24 hours on the skin at the same time stimulating the skin microbiome's natural microflora growth, i.e. *Staphylococcus epidermidis* [86]. The probiotic lysate *Bifidobacterium longum sp.* had a positive effect for reactive skin at *in vivo* experiment with 66 volunteers, decreasing skin sensitivity [7].

The skim milk fermented with *Streptococcus thermophilus* culture enables skin hydration, rendering an antioxidant effect and pH control. Additionally, this ingredient cells protection effect was proved with the latest researches. Aloe vera, fermented with *Lactobacillus plantarum*, selected from among 119 lactobacteria strains, produces the skin hydration effect 4 times augmented in comparison to A. Vera fermented juice. The soya milk fermented with *Bifidobacterium breve* increases the hyaluronic acid production by human body cells, and *S. thermophilus YIT 2084* is capable to produce the hyaluronic acid by itself [87].

Another proof of successful probiotics use at cosmetic products is embodied with two brands example: South-African company ESSE and North-American company, Mother Dirt, which, one step ahead of others, produce market products with live probiotics. Quoting Trevor Stein, a Chief executive director of ESSE, the company's turn out amounted to 3.5 mln USD in 2015 that cipher increasing under impressive rate of 300% annually. Currently ESSE trades with two basic products: sensitive serum and probiotic serum (at price of €70 and €150 respectively), containing live microorganisms inactivated through sublimation and stabilization with encapsulation technique. The probiotic bacteria are activated, when contacting to moistured skin. The company develops a new technology that will allow ESSE to stabilize live microorganisms on water-containing cosmetic products basis [67]. Mr. Stein expects that during the following 10 years, the commercialization of accessible technologies allowing characterizing human skin microbiome will open a completely new cosmetic probiotics market. For example, the customers will get opportunity of fast and relatively non-expensive analysis of skin microbiome condition with further main symbiotic species restoring through use of personally identified probiotic scheme to optimize the skin health.

Mother Dirt is trading with such cosmetic products as AO+Mist (USD 49), first of its kind containing live

ammonia oxidizing bacteria (AOB). Quoting Jasmine Aganovich, President of the Mother Dirt, currently the company investigates the bacteria potential to remedy eczema, rosacea and other skin inflammatory diseases. They are very enthusiastic as to AOB potential advantages in this aspect as the White House in May 2016 launched the «National Microbiologic Initiative» involving AOBiome, the scientific partner of Mother Dirt. This Initiative will play a key role in application of skin microbiome studies results to create the consumer products (cosmetics inclusive) innovating technologies.

Products, containing fermented and probiotic ingredients are mainly oriented on beauty market premium sector. Retaining probiotics alive along production and distribution way is a complicated task. These products shall be sold under aseptic conditions, also required is bacteria preventing from excessive insolation, humidity, low temperatures. That implies a set of operational problems limiting type of packaging that can be used. Therefore, ESSE selected the reusable double glass pack, with inner polypropylene bag containing the product, and Mother Dirt uses a completely reusable plastic package of pharmaceutical type. AO+Mist, sold by Mother Dirt, shall be kept in a cool storage before their first application and the skin care products of ESSE allow storage at ambient room temperature [67].

Well aware of several probiotic cosmetics' market success, the producers developed and commercialized such probiotic ingredients as Bonicel – local application probiotic manufactured by Ganeden Biotech Inc. and others. The composition of Crème de la Mer several decades ago created by Estée Lauder contains the fermented algae, and premium brands such as Murad (Unilever) and SK-II (Procter & Gamble), Sulwashoo developed by Southern Corea cosmetic industry giant AmorePacific and SU:M37 elaborated by LG Household & Healthcare, already along several years sell products containing fermented and probiotic ingredients. Such well-known brands as Oskia (GB) and Tula (USA) also commercialize products based onto fermented and probiotic ingredients [67].

No doubt arises as to the high profitability of “probiotic” ingredients for numerous cosmetic manufacturers. Nevertheless, considering recent wide forbiddance in EU of “probiotic” word use on food packing, such ingredients manufacturers shall be informed about the possible regulatory prescribed changes possible in a mid- and long-time perspective thus influencing the application of probiotic components in cosmetic compositions. Up to this time, such probiotic parameters as the type, form introduced (live bacteria, lysate etc.) and recommended concentrations at the cosmetic composition proven to be both effective and safe are pending to be determined. However, as the probiotic cosmetics is really on the trend top due to the wellness trend in beauty industry progressing, the definition of «probiotic» concept for the cosmetic industry is an actual need [67].

Defining of “living” and “probiotic” cosmetics

To our opinion, in cosmetics and cosmeceutics the “probiotics” should be classified as live microorganisms and/or their lysates, which being used at cosmetic products within recommended amounts, provide a positive effect onto human skin additionally to the characteristic main product’s effect. When probiotics used as cosmetic products components, the healing effect shall be directed on skin microbiome normalization or maintaining.

With respect to possible variances of use at cosmetic products of both vital probiotic cells and the lysates, it would be convenient to differentiate between “living cosmetics” and “probiotic cosmetics”.

The «living cosmetics» shall include cosmetic products (compositions) containing live probiotic cells within recommended amounts clearly defined for the last storage date. Such “living cosmetics” shall not include additives of preservatives or other antibacterial substances, it shall be borne with a strictly defined storage limits and conditions, and clear recommendations shall specify their packing. The “living cosmetics” microbiological safety shall be provided at the expense of innovative technological solutions on raw material preparing and processing as well as high antibacterial properties of used probiotics. Considering the above, supposing the more probiotic strains are present at the “living cosmetic” composition, the higher will be the created composition antibacterial properties (at standard precondition of symbiotic multiprobiotics use).

Then, the “probiotic cosmetics”, in our view, shall refer to cosmetic products (compositions), containing probiotic lysates within recommended amounts. These cosmetic compositions can include preservatives or other antibacterial substances to provide the required product microbiology parameters.

From technological viewpoint, the “probiotic” cosmetics manufacturing is simpler and the existing production lines can be used for these series without tech-

niques modernization. Nevertheless, the acute interest to “live” cosmetics shall serve in stimulus for the cosmetic industry for the arrangement of new technological production lines, and for researchers engaged into search for efficient live probiotic cells stabilization techniques to be used at cosmetic products.

Conclusions

1. A skin microbiome is described, the groups of microorganisms that colonize the human skin, their importance in maintaining a healthy skin condition and the occurrence of certain diseases are identified and analysed. The influence on the stability of the skin microbiome of external factors is described.

2. The concept of probiotic in the food industry is described, the list of basic probiotic microorganisms is given; the properties of the probiotic cultures of lactoid bifidobacterium in the human intestine are described. The antibacterial, soothing and anti-age effect of probiotic bacteria in relation to human skin is considered in detail.

3. The analysis of existing cosmetic products and ingredients for their production with viable cultures of probiotics and/or their lysates is carried out, the influence of cosmetics with probiotics on the state of sensitive and reactive skin, on the skin health in various diseases (atopic dermatitis, acne), as well as immune abnormalities.

4. The concept of “probiotics” in cosmetics is defined as living microorganisms and/or their lysates, application of which in cosmetic products in recommended quantities provide a positive effect on the human skin in addition to the characteristic of the main influence of the product.

5. The definition of “living” and “probiotic” cosmetics is given, the possibilities of production of these two groups of cosmetic products with probiotics are described.

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«ЖИВАЯ» И «ПРОБИОТИЧЕСКАЯ» КОСМЕТИКА: СОВРЕМЕННЫЙ ВЗГЛЯД И ДЕФИНИЦИИ

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Аннотация. В представленной статье на основе детального анализа литературных источников и многолетнего собственного опыта по созданию пробиотических продуктов питания предложено определение «пробиотиков» в косметике, а также определение «живой» и «пробиотической» косметики.

Кожа является сложным барьерным органом, в котором существуют симбиотические связи между микробными сообществами и тканями-хозяевами через сложные сигналы, предусмотренные врожденной и адаптивной иммунной системами. Она постоянно подвергается воздействию различных эндогенных и экзогенных факторов – физических, химических, бактериальных, грибковых, а также влиянием гормональных нарушений, приводящих к изменениям в этой сбалансированной системе, которые приводят к воспалительным заболеваниям кожи, включающим инфекции, аллергии или аутоиммунные заболевания. В отличие от микробиома кишечника и выделений, которые были изучены и описаны в течение многих лет, исследования микробиома кожи или волосистой части головы делятся лишь последние 10 лет. Поэтому скрининг эффективных средств коррекции и/или поддержания нормофлоры человека для сохранения здорового микробиома кожи сегодня является актуальной задачей.

Ключевые слова: кожа, микробиом, пробиотик, «живая косметика», «пробиотическая косметика», бифидобактерии, лактобактерии.

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