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Role of probiotics in skin health: Current trends and future perspectives

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Abstract

The human skin is a complex ecosystem that plays a crucial role in maintaining overall health and well-being. In recent years, there has been a growing interest in the potential benefits of probiotics in promoting skin health. Probiotics are live microorganisms that confer health benefits when administered in adequate amounts. Probiotics have been shown to have a positive impact on the skin microbiome, promoting the growth of beneficial microorganisms and inhibiting the growth of pathogens. In addition to their effects on the skin microbiome, probiotics have also been shown to have anti-inflammatory, antioxidant, and immune-modulating effects, which may contribute to their beneficial effects on skin health. Their role in skin health is a relatively new area of research. This review aims to provide an overview of the current state of knowledge on the role of probiotics in skin health, including their potential benefits, mechanisms of action, and future perspectives.

Keywords: Probiotics; Probiotics in skincare; Inflammatory Bowel Disease; Cancer

1. Introduction

Probiotics are characterized as "living microbes which, whenever delivered in sufficient quantities, exert beneficial health effects on the recipient" [1]. Probiotic and postbiotic substances are employed in cosmetic product formulations to prevent UV radiation impacts and to maintain or restore the balance of the cutaneous microbiota because of their anti-oxidant and/or anti-inflammatory qualities [2]. It is a mixture of microorganisms that are claimed to improve immune system function, reduce inflammation, and speed up wound healing, among additionpositive impacts on the human body [3]. Because probiotics have an herbal foundation and a therapeutic effect, utilizing them in cosmetics is a contemporary approach to routine skin care. The opinions of experts, probiotic-based skincare made with living cells and their lysates not only improve skin health but also reduce aging [4]. Three needs have to be achieved for probiotic products. I) The strain must be described genetically and phenotypically and supported up by experiment outcomes published in journals with peer review to be able to be applied to its intended purpose. II) The product has to have an equivalent quantity of alive microorganisms to those shown in clinical research to be favorable to the indicated target site at the time of applications. III) Human studies should be performed to determine the delivery procedure, dosage and period of utilization if humans are the target audience [5]. Recurrent UTIs tend to in women can be effectively prevented via the use of probiotics [6]. In addition to developing barrier functions, keeping the growth of pathogens, and cleansing and moisturizing skin surfaces, cosmetic and personal care products are often intended to provide vitamins and protection to the skin, its flora, and associated cells [7].

2. History of Probiotics

The German scientist Werner Kollath established the idea of "probiotic" in 1953 to refer to "active molecules that are important to a healthy development of life." The phrase evolved from the Latin pro and the Greek bios, which transfer at present, the regulatory frameworks regulating the cultivation and claim substantiation of probiotics are not

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internationally regulated. "Lilly and Stillwell invented this term in 1965 in reference to" substances created by one organism that accelerate the development of another"[8]. Ilya Ilyich Metchnikoff proposed an academic rationale for the medical advantages of the yogurt in 1907, proposing the fact that Bulgarian's life span was caused by the intake of yoghurt containing lactobacillus species. In this case, the US Pharmacopeia (Rockville, Maryland, US) established up a panel of probiotic professionals that will provide advice and suggestions on quality-related issues, like the identification, enumeration, and regulations for contaminating microbes as they deal with probiotic nutritional supplements [9].

At present, the regulatory frameworks regulating the cultivation and claim substantiation of probiotics are not internationally regulated. Moves that a third party validate the quality of goods would be extremely helpful from both manufacturers and consumers. In this case, the US Pharmacopeia (Rockville, Maryland, US) established up a panel of probiotic professionals that will provide advice and suggestions on quality-related issues, like the identification, enumeration, and regulations for contaminating microbes as they deal with probiotic nutritional supplements [10].

3. Classification of Probiotics

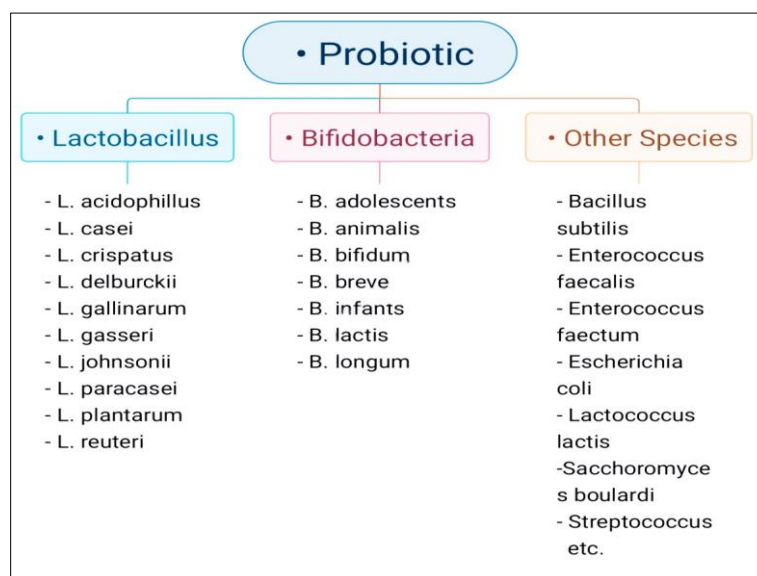


Figure 1 Classification of Probiotics [3]

4. Characteristics of Probiotics

Probiotics could provide multiple benefits. The variety of microbial activities that might cause physiological outcomes made this believable [10]. Probiotics prevent inflammation and hazardous bacteria on the skin's surface, raise clarity, decrease dryness, and promote anti-aging effects by acidifying the skin's environment while minimizing the growing number of microbes. It serves as a protective layer to protect the skin [3]. Recently, probiotics have been integrated into routine skin treatments. Inert organisms and remnants of cell walls might be detected in cosmetics such face creams, soothing lotions, supplements, body washes, products for hair, and beauty masks [5]. Therefore, consuming foods which include alive microorganisms could be an effective dietary recommendation. Based to the panel's summary, it isn't always viable to clarify a distinction amongst the food matrix's and the living organisms' involvement in such types of inquiries [11].

5. Probiotics in Cosmetics

By focusing upon skincare, the cosmetics industry has moved into this particular market. This concept contains plenty to offer and is extremely beneficial in numerous ways. A minimum of fifty items are already being advertised with statements that the items contain probiotics, as per an assessment of the webpages of two prominent North American cosmetics vendors [12]. Because probiotics have a natural base and a therapeutic effect, their inclusion in cosmetics is a modern approach to routine skin care. On the basis of experts. Probiotic-based products that include cells that live and their extracts not only promote skin health but also defend it towards antiaging. Constant use of probiotic-containing cosmetic products assists to maintain and restore the balance of the skin's microbial beauty products, which leads to a healthy skin pH and other scenarios which encourage normal skin processes [13, 4]. "Makeup products" are

interpreted as "any substance along with the mixture directed to be laid together with some the outermost layers of the human body (the outer layer, hair system, nails, the lips, and the external organs of genitals) alongside teeth and the soft tissues of the oral cavity with the exclusive or chief intent of cleaning, perfuming, modifying how they appear, securing them, continuing their condition, or correcting body odors" [14]. The long-term effects of probiotics are largely unknown, and additional randomized trials are needed to address this question [15].

6. Topical Probiotics and Skincare

The application for orally and dermal antibiotics for hygiene and the management of skin conditions has gained prominence all over the past ten years. Teams of scientists have spent time trying to determine the efficacy, method of action, protection, and recommendations of new products when they are eventually provided with the market [1]. Topical probiotics in order are used for managing skin disorders, although their use primarily pertains to the "cosmetics" product category, which the FDA defines as commodities that are used to clean or promote the appearance of the body [16]. Probiotics are being examined by the personal care product business as "bioactive ingredients" that may enhance the skin's appearance as well as function. The overwhelming majority of information indicating the beneficial outcomes from probiotic organisms treated on the skin is circumstantial [17]. In along with controlling tyrosinase activity, probiotics can also reduce melanin levels in additional ways to produce a lightening effect [18]. Topical probiotics, who pass on laboratory-cultured live bacteria via a surface-appropriate dose to balance the skin microbiome and establish immunology homeostasis, first came up in 1912 as a treatment for skin diseases, especially acne and seborrhea. Although probiotics have numerous medical benefits, there may be limitations on their security, especially to individual with weaker immune systems, including elderly people, pregnant women and infants [19].

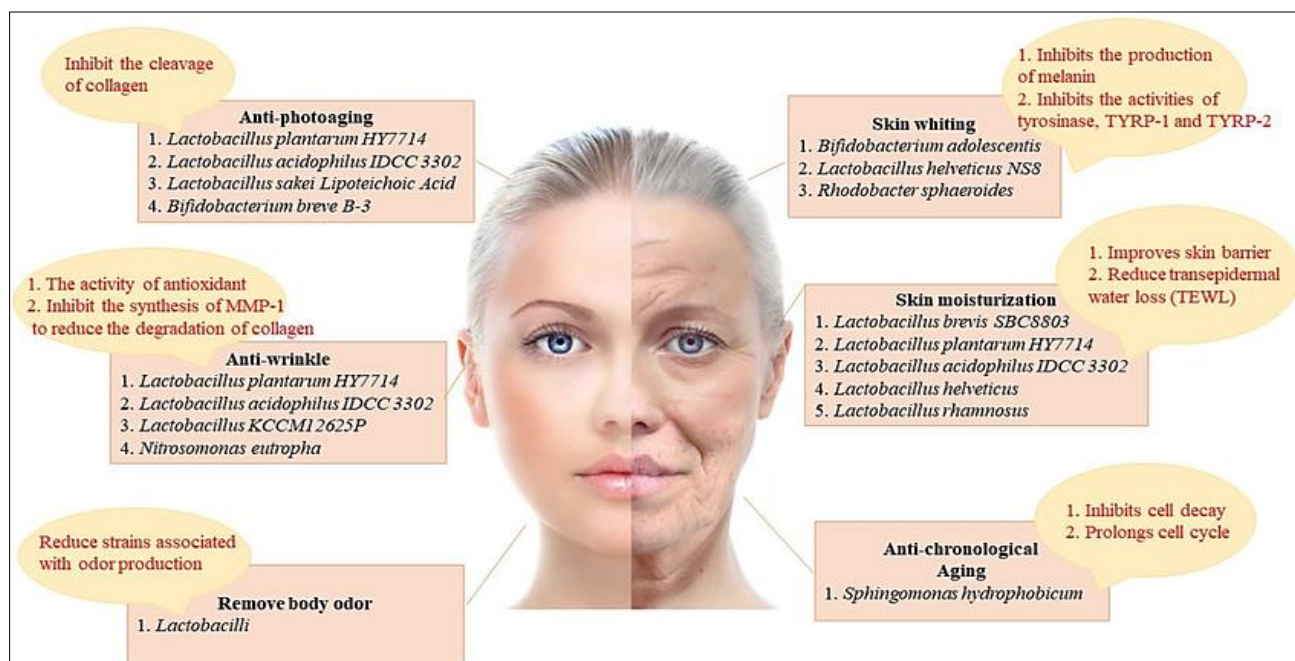


Figure 2 Skin improving Effects of Probiotics [18].

6.1. Acne

Acne is one amongst the most frequent skin problems with a lifetime the rate approaching 85%. Several factors cause it, involving alterations to follicular keratinization, higher and modulated output of sebum under androgen supervision, *Propionibacterium acnes* colonization of the follicle and elaborate inflammatory mechanisms including each innate as well as acquired immunity [1]. 85–90% of individuals with western dietary habits during the years of 12 to 35 struggle with acne. This illness has been described by some dermatologists as a common evolutionary process [20]. The severity of acne is usually the primary goal of treatment; skin kind, clinical classification, and the presence of earlier scars could all impact recommendations [21]. As a result of the increase in antibiotic resistance, classic acne medications, that include topical and oral antibiotics are becoming fewer effective. On the contrary, a recent 2-month pilot jury trial discovered that applied topically of 0.2% PS reduces papules and pustules by 89% [13]. Topical comedolytic medicines can have comedolytic effects and improve in the skin's absorbing topical drugs. Once administered topically, probiotics may operate as a barrier for avoiding acne set on by other kinds of microbes that infect the skin [5]. Probiotics are

demonstrated by many research studies to inhibit *C. acnes*, thereby lowers the severity for acne. Regular application of a topical mixture of *Lactobacillus* sp. and *E. faecalis* reduced acne lesions, possibly were attributed to *C. acnes* restriction and a decline in its production of proinflammatory components. In the same vein, tests utilizing *Lactobacillus plantarum* probiotics within water exhibited dosage-dependent drops in lesion size [22].

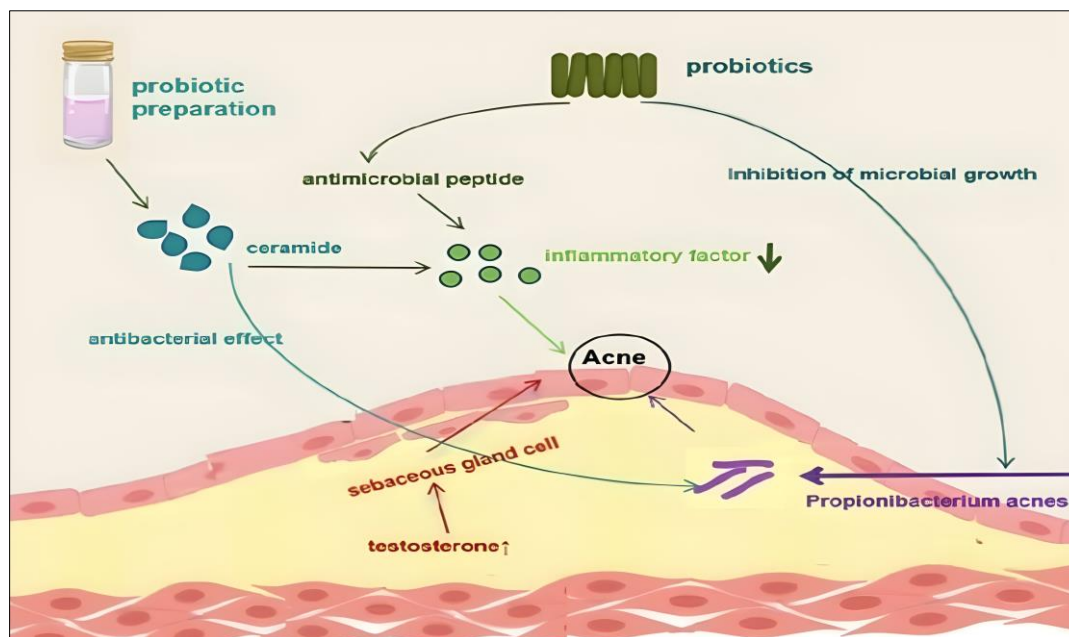


Figure 3 Probiotics in treatment of acne [5]

6.2. Atopic dermatitis

Scaly lesions and intense pruritus are both indications of atopic dermatitis (AD), an enduring inflammatory condition of the skin [1]. With an abundance of 1–20% globally, it is a prevalent dermatological condition that affects adults as well as kids. AD is conceived to be carried on by a mutation in filaggrin that alters epidermidis [21]. Hydration with emollients, minimizing particular factors, reducing inflammation with topically applied corticosteroids or calcineurin inhibitors, and controlling secondary infections are every element of the conventional medical technique for AD [13]. Patients with atopic dermatitis displayed a beneficial change in the clinical signs in an experiment testing the effects of lotions, including the subjected to heat probiotic species *Lactobacillus johnsonii* NCC, on *Staphylococcus aureus* colonization [18].

6.3. Photoaging

Compared to women in their 50s, women into the 20s had a typical greater amount of *L. plantarum* in their skin. Several anti-aging advantages associated with *L. plantarum*'s extracellular vesicles (EVs) are recently reported [5]. As people age, their skin's microbiome's composition changes, with older skin displaying greater diversity overall. Enhanced antimicrobial production and physiological reduction in the production of cutaneous elements, especially collagen and sebum, have also been correlated with old [23]. Indeed, aging is connected to several kinds of changes in the appearance of the skin, such the development of spots and lines and wrinkles, modified activity of the sebaceous glands and the formation of dermal molecules, all of which have an effect on the environmental conditions that used to exist for dermal microorganisms [24]. Patients whom used *Lactobacillus plantarum* HY7714 demonstrated increased skin elasticity and gloss, lowered wrinkle depth, and diminished epidermal moisture loss [18]. Based on studies for the bodily functions of skin and aging mechanisms, the primary ways that trendy probiotic cosmetics have anti-aging impact on skin tissues are by moisturizing and healing the skin barrier function, rejuvenating the skin's collagen and elastin, and supply antioxidants [19].

7. Probiotics used in preventing UV damages

When exposed to UV radiation, lichens, fungus, and cyanobacteria build mycosporine-like amino acids (MAAs), which occur naturally as photostable secondary class metabolites and UV-absorbing substances. MAAs are usually considered as multifunctional substances which offer resistance against oxidative, osmotic, and thermal stress in along with UV

radiation-induced damage [25]. Additionally, some of the microorganisms already exhibit anti-inflammatory and anti-oxidative properties in addition to direct UV radiation blocking or absorbent effects [26]. A novel approach to lessen or stop the affects of UV-induced skin damage is probiotics [3].

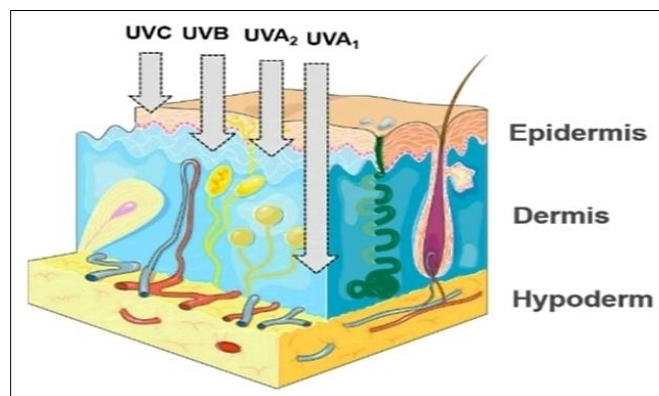


Figure 4 Impact of UV rays on skin microbiome [32]

7.1. Probiotics for female intimate /urogenital care

In general, an ideal uterine ecosystem is host to an abundance of lactobacilli. Bacteria vaginosis, infections of the urinary tract, candidiasis, and other conditions are brought about by a number of triggers which upset homeostasis, notably the use of douches and antibiotics, engaging several sexual partners, and the spread of pathogens into the area [12]. Probiotic dietary supplements, which can be taking by mouth via a beneficial bacteria food supplement, intravaginally as the genital tract suppositories, or topically as a gel, have been shown to restore the gut microbiota and/or modulate the surrounding intestinal immune reaction [6].

8. Probiotics used in various aspects

8.1. Gut microbiodata

The complex variety of microbial communities which make up the microbiota of the human gut have connections to intestinal health in individuals. It has been shown that the human intestinal microbiota modulates the composition of the microbiota by digesting apart and producing natural acids and short-chain fats (SCFAs) as propionate, acetate, and butyrate [27]. When comparing the parietal microbiome, microbes that exist in mucus and are attached to the intestinal wall with the luminal microbiology, microbes that live in food in transit and stools—the bacterial organizes as a concentrate ecosystem and vary from one region to another [28]. Athletes can benefit in a variety of ways from altering the gut microbiota with a probiotic supplement for improved barrier function. The integrity of the mucosal barrier, especially stops toxins and other molecules from moving from the gut into the circulation throughout the body, is impacted by the makeup and functions of the gut microbiota [29]. Through cross-feeding, antagonism, competition for supplies, and support of microbiota stability, microbial strains might communicate with the gut microbiota [30]. While probiotics are administered to patients with enteric disease, it may be impossible to distinguish the negative enteric affects from the real cause of the disease. Since probiotics have been designated as GRAS, it is logical to infer that the frequency of negative outcomes is very low [31]. Every one of these effects could be either non-microbiotamediated and may vary by species, or their effects would be mediated by an immediate relationship with commensal microbiota [32]. The enormous health care impact of FC (Functional Constipation) in spite of these recommendations highlights the need of exploring and assessing new therapeutic approaches. Probiotic treatment has become of the most promising techniques for tackling and avoiding pediatric FC [33]. Another viable strategy is applying probiotics to influence the immunotherapy response. Commercial probiotics indeed contain multiple of the organisms that are associated with enhanced immunotherapy response, among them *B. longum* and LGG (*Lactobacillus rhamnosus* GG) [34].

8.2. Inflammatory bowel disease

Long-term illnesses that are called inflammatory bowel disorders (IBD) are common around the world, however they are most prominent in developed and advanced countries in North America and Europe [35]. Rather than stimulating an inflammatory cascade, the immunologic and molecular basis for these effects has been thoroughly clarified and looks to exist based on preferential commitment with dendritic cells (as antigen-presenting cells) which ends up in the induction of regulatory T cells [36]. The beneficial outcomes of probiotics in IBD patients have been clarified through a

range of processes, notably the formation of antibiotics and the reduction of infections during competition [37]. Receptor antagonists or antibodies for pro-inflammatory cytokines Various animal studies also demonstrate that interventions that target pro-inflammatory cytokine signaling are successful approaches [38]. Here is an increasing enthusiasm for using microorganisms to treat and prevent IBD. In both the rat and mice as models of IBD, many research investigations have demonstrated the prospective usefulness of some probiotic strains for both prevention and treatment [39]. In line with previous investigations, *A. muciniphila* might reduce the level of cytotoxic T lymphocytes (CTLs) and colon infiltrating macrophages to treat colitis, but it may boost the count of anti-inflammatory Treg cells, or regulatory T cells, in mice fed a high-fat diet [40].

8.3. Probiotics in Cancer

One of the the main causes of sickness and death, cancer is an incurable disease with major medical consequences. It ranks as the planet's second leading cause of death. The host's immune cells, which include myeloid or natural killer cells (NK cells), or T helper type 1 (TH1) response, which helps create precancerous or anticancerous cells, can be induced by lactobacilli [41]. The ability of probiotics to secrete anticancer agents, their distribution as a growth biomarker, their antimicrobial and anti-biofilm activity towards carcinogenic pathogens, their immunomodulation effects that create apoptosis, and their antimetastatic activity constitute a few of their prominent roles in treatment of oral diseases [42]. The manufacturing of biologically important substances such as short-chain fatty acids (SCFAs), vitamin K, or B-group vitamins, as well as anti-inflammatory, anti-carcinogenic, and anti-mutagenic chemicals, may be a means by that probiotic bacteria accomplish these beneficial outcomes [43]. Although nearly every probiotic can be consumed orally and must pass via the gastrointestinal tract, it is not unexpected that the majority of reports on the carcinogenic action of probiotics show that they have a positive effect on colorectal cancer. Through a number different channels, like dysbiosis, inflammation, immunological modifications to toxins, and mutagens, a clear link between the microbiome and cancer has been documented [44]. It has been demonstrated that gut microbiota changes both the quality of life and the effectiveness of anti-cancer medications. Additionally, the microiotope can be utilized as a noninvasive predictive marker for timely identification of cancers which includes hepatocellular carcinoma and pancreatic cancer [45]. Painful oral mucositis may contribute to alter consumption of nutrients, poor oral hygiene, difficulties swallowing and eating, and an inferior standard of life. An undesirable prognosis can occur from severe oral mucositis, this may cause cancer treatment to be reduced or stopped [46]. Extra precautions and diligence are required because all HSCT patients experience immune suppression, and some HNC patients develop neutropenia as a result of anti-cancer treatment [47]. A lot of cancer vaccines are unsuccessful, and nonetheless cancer vaccines for therapy are a unique treatment that mainly targets TAAs. Here, investigators are looking at whether probiotics and cancer immunization might perform jointly more effectively [48].

8.4. Cardiovascular disorders

Cardiovascular disease (CVD) has become the most common cause of death internationally as a result of the record high incidence. In societies with high and a moderate income, this is especially evident. However, the development of preventative measures had been hampered by the numerous etiologies of CVD and its absence of a thorough knowledge of the fundamental processes [49]. Two prominent precursors for CVDs embrace hypertension and hypercholesterolemia. Recent study indicates an established connection between changes in the gut microbiota and its metabolites and hypertension and hypercholesterolemia in both humans and animal models [50]. Considering numerous risk factors, like hypertension, systemic inflammation frequently appears in CVDs. It is also recognized that oxidative stress plays a role in the formation of CVDs [51]. In connection to probiotics, an assortment of clinical examinations has been performed to figure out if probiotic supplements might decrease cholesterol among those with hypercholesterolemia. It has been made discovered that *Lactobacillus paracasei* may decrease cholesterol and prevent atherosclerosis [52]. The renin-angiotensin-aldosterone system and endothelial dysfunction are two ways that hypertension and hypercholesterolemia interact and affect the development of atherosclerosis [53].

8.5. Future Perspectives

The best approach for developing cosmetic products for all kinds of skin is the jobs of beneficial microbes from the groups *Bifidobacterium*, *Lactobacillus*, *Lactococcus*, and *Bacillus*, alongside their metabolites [54]. Companies are unable for marketing purposes the health benefits of their products based on the probiotic content since the European Food Safety Authority (EFSA) rejected almost every health claim with the beneficial effects of probiotic bacteria. Important lessons for the use with probiotics in products for personal care can be discovered in probiotic GI products, which currently set the standard in clinical trials and marketing [55]. In fact, multiomics techniques are becoming increasingly essential in microbiome research, helping to uncover complex microbial characteristics that they may be beneficial for humankind [56].

9. Conclusion

Probiotics have shown promising results in maintaining skin health, preventing diseases, and promoting overall well-being. Their applications in cosmetics, gut health, inflammatory bowel disease, cancer, and cardiovascular disorders highlight their potential as a therapeutic approach. Further research is needed to fully understand the mechanisms of action and benefits of probiotics, as well as to establish standardized protocols for their use in various applications. With continued research and development, probiotics may become a valuable tool in the prevention and treatment of various diseases, promoting a healthier and more balanced life.

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest to be disclosed.

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