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A REVIEW ON PROBIOTICS IN SKIN CARE FORMULATION

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ABSTRACT

Probiotics are live microorganisms that have demonstrated health benefits when taken in sufficient amounts. Due to the increasing availability of probiotic products, the selection of appropriate strains for specific applications remains challenging. This review helps to understand the most commonly used probiotics. How they act in the body. Probiotics are live beneficial microorganisms that help maintain skin health. This review explains how probiotics improve the skin barrier, reduce acne, control inflammation, and support the skin microbiome. Various probiotic species such as Lactobacillus and Bifidobacterium are used in modern cosmetic formulations. The article also discusses delivery methods like creams, lotions, and masks, along with their stability issues. Overall, probiotics show strong potential in safe and effective skincare products.

KEYWORDS: Probiotics, Skin microbiome, Lactobacillus, Bifidobacterium, Cosmetic formulation, Anti-inflammatory activity.

INTRODUCTION

Probiotics are characterized as “living microbes which, whenever delivered in sufficient quantities, exert beneficial health effects on the recipient” 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. Probiotics are a mixture of microorganisms that are reported to improve immune system function, reduce inflammation, and speed up wound healing, among addition positive impacts on the human body. 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 Three needs have to be achieved for probiotic products. 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. The product has to have an equivalent quantity of alive microorganisms to those shown in clinical research to to favorable to the indicated targetsite at the time of applications. Human studies should be performed to determine the delivery procedure, dosage and period of utilization if humans are the target audience. The use of probiotics. 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.[1]

The most common genera of probiotics are Lactobacillus, Bifidobacterium, Saccharomyces Streptococcus, Enterococcus, Escherichia, and Bacillus, with species of Lactobacillus and Bifidobacterium being used most often. Probiotics are 'good' bacteria that live naturally in your digestive system (gut). They are part of your gut microbiome.[2]

Figure 1. The words used in the claims of cosmetics marketed as probiotics. Word cloud generated using a compilation of the claims cosmetic products claiming to contain probiotics.

SKIN MICROBIOME

The human microbiome refers to the plethora of microbes found in and on the body. These microbes form ecological communities called microbiota; the human microbiota includes hundreds of species of bacteria, fungi, mites and viruses. Although research is ongoing, increasing evidence highlights the importance of the skin microbiota.but scientists and formulators are becoming increasingly interested in the skin microbiota since each square centimetre of the skin has approximately one million microorganisms meaning that they must have a significant influence on our general health and the health of our skin.[4]

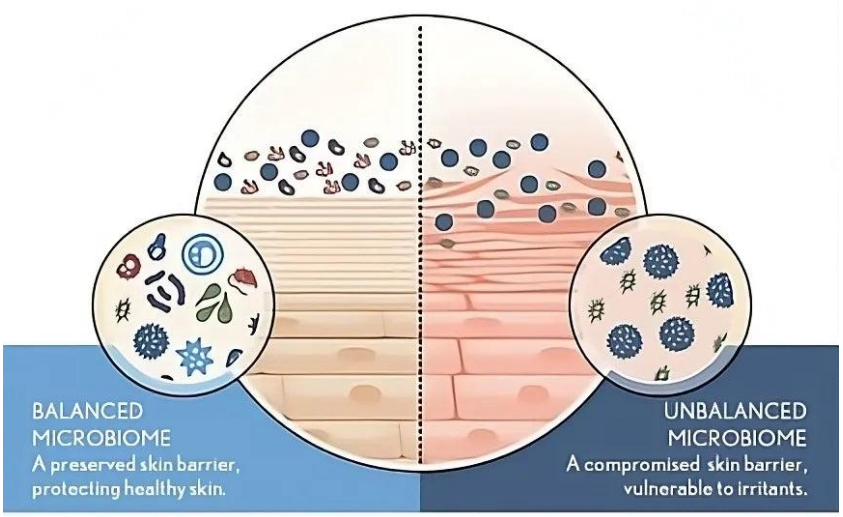

Fig. 2 Probiotics on Healthy Skin Microbiome.

Good Bacteria = Good Skin

Probiotics are more than just a trend they're a science-backed solution for healthier, more balanced skin. Especially in a world filled with pollution and stress, your skin needs all the support it can get. Add probiotics to your skincare routine to restore calm, build strength, and reveal your natural glow.

Choose natural for probiotic-powered skincare that respects your skin, supports your microbiome, and celebrates natural wellness.

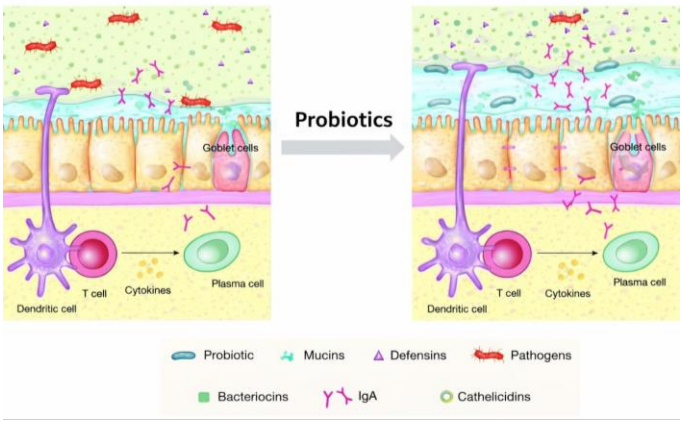

Figure 3. Mechanism action of probiotics.

TYPES OF PROBIOTICS

True probiotics/live probiotics

These are living microorganisms specifically, bacteria and yeasts. When taken in sufficient amounts, probiotics can promote health benefits like supporting gastrointestinal health and digestion.

Source: Beneficial, living microbes are found in fermented foods, such as yogurt, kimchi, miso, sauerkraut, and kombucha—although if the label does not list which strains are present and CFU, there's no way to know whether you are consuming microbes in meaningful amounts. For this reason, there's no way to know if they actually meet the official definition of a probiotic. A probiotic supplement that lists strains and CFU can help you meet clinically studied intake levels.

Examples: All probiotic bacteria will be classified by genus, species, and strain, meaning that a probiotic will have three words in its name. (The first word in the name may just be a letter, since it's customary to abbreviate it.)

Benefits**:** Their benefits are as diverse as the bacteria themselves. Some probiotics focus on digestive comfort, helping with bloating or irregular bowel movements. Others target immune system support, and many offer benefits we're still discovering through ongoing research.[5]

Bifidobacteria

Bifidobacteria are widespread in the environment and in the intestines of many animals, including humans. They’re the first colonizers of the infant gut microbiota.

Some common species include

B. bifidum

B. animalis

Bifidobacteria have been associated with positive health impacts in the GI tract, including improved lactose digestion. This probiotic may also prevent or reduce diarrhea and could reduce symptoms of irritable bowel syndrome (IBS). They've also been linked with improved lipid levels.[7-8]

Lactobacillus

Lactobacilli are arguably one of the most important probiotics for the body, a genus of Gram-positive, catalase-negative, non-spore-forming, rod-shaped bacteria that produce lactic acid as the major end product of fermentation. They play roles that range from protecting the body from infection, training the cutaneous immune system to defend itself, and supplying the skin with immunomodulatory effects that revitalises the skin. Topical application of these bacteria has been linked to reduced inflammation & symptoms of common skin conditions like acne vulgaris & atopic dermatitis.

Lactobacilli can interact with host keratinocytes (skin cells) to promote skin rejuvenation, strengthening the lipid barrier and stimulating increased skin cell growth and tissue repair during wound healing.[9]

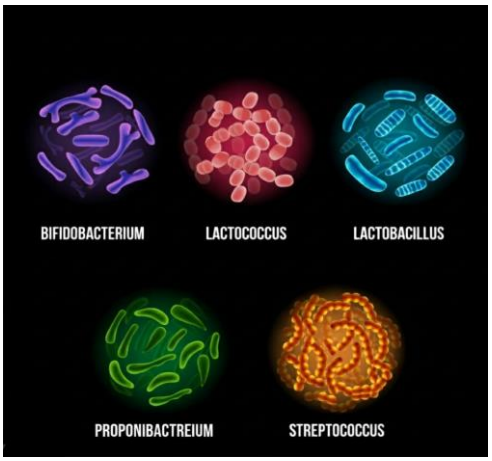

Figure 4: Types of bacteria in Probiotics.

Prebiotics

Prebiotics are components from foods that can feed the microbes in the gut, such as non-digestible fibers that end up being fermented by your gut bacteria—a process that promotes growth of more beneficial microorganisms.

Source: Prebiotics are found in fruits, vegetables, whole grains and legumes.
Examples: Specific prebiotics include xylo-oligosaccharides (XOS), fructo-oligosaccharides and galacto-oligosaccharides.

Benefits: Prebiotics serve as food for the bacteria in your gut microbiome. Fermentation of prebiotic fibers results in the production of beneficial short-chain fatty acids such as acetate, butyrate, and propionate.

Parabiotics

Parabiotics are non-viable (inactivated) probiotics – meaning dead or inactivated microbial cells (or their cell components) that provide health benefits to the host without being alive.

Sources: Parabiotics are obtained from
1. Traditional fermented foods yogurt, kefir, buttermilk kimchi, sauerkraut, fermented vegetable 2. Industrially grown probiotic cultures which are later intentionally killed/inactivated 3. Parabiotic-based formulated supplements (capsules, sachets, drinks)

Examples

Some common bacterial species used as parabiotics
Bacterial Species form Used
Lactobacillus rhamnosus heat-killed cells
Lactobacillus plantarum cell wall components
Lactobacillus casei lysates (broken cell parts)
Bifidobacterium breve inactivated cells
Bacillus coagulans heat-treated.

Postbiotics

Postbiotics are inactivated bacteria and the compounds released by bacteria. Postbiotics are very shelf-stable.

Source: Postbiotics are inactive microbes or compounds secreted by bacteria, so you'll find them in fermented foods that contain(ed) living microbes, like sauerkraut and tempeh.

Dried yeast and heat-treated bacterial strains (often designated as "HT §" before the strain name) are examples of postbiotics. Other types include peptides and short-chain fatty acids.

Benefits: Postbiotics offer different benefits depending on the strain or specific components. Some focus on digestive comfort while others support various aspects of overall health.[9-13]

DERMAL BENEFITS OF PROBIOTICS

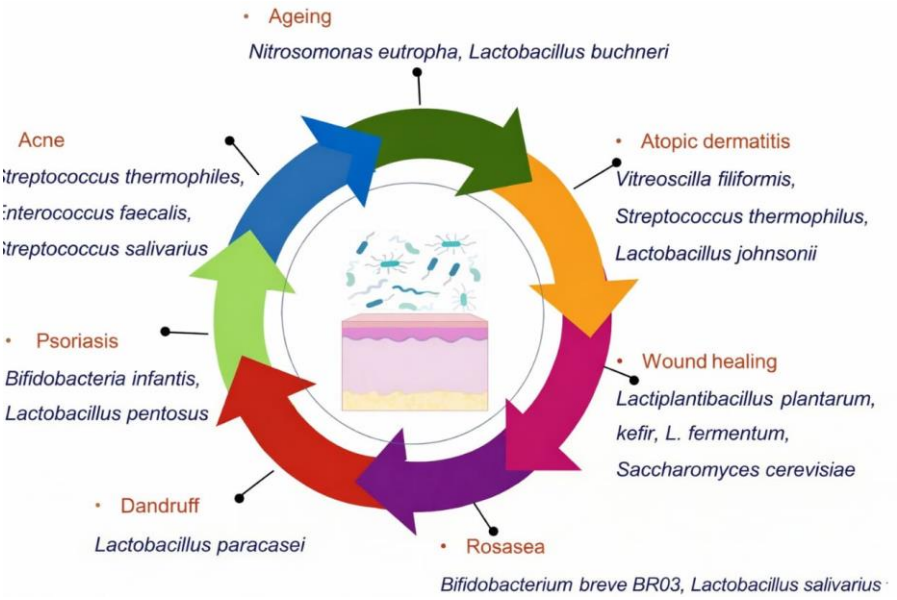

Figure 5: Topical advantages of probiotics.

It protects our delicate skin barrier: As our immune system's first line of defence, our skin plays an important role in protecting us from pathogens and infections with research showing how the microbes on our skin can actually influence our overall immune health. Not only a physical barrier, the skin barrier is also an immunological barrier and plays an important role in wound healing and combating inflammatio Probiotics such as bio-fermented Lactobacillus are antimicrobial and therefore play an important role in bolsteringour skin's natural defences helping to protect us from environmental damage and free radicals and have also been proven to help with inflammatory skin conditions such as acne breakouts, eczema and rosacea.[15]

It smooths and brightens: Thanks to the presence of naturally-occurring alpha-hydroxy acids (AHAs), The Beauty Chef's Probiotic Skin Refiner, acts as a natural exfoliant, encouraging cell turnover to smooth the skin andboost skinhealth. Unlike harsh chemical exfoliants, natural AHAs help to remove dead skin cells and balance your skin's microflora without damaging your skin's delicate dermal barrier.

Anti-ageing: When itcomes to fighting the signs of premature ageing such as fine lines, dry skin and pigmentation, AHA's will soon become your new best friend. In fact, research has shown AHA's to be effective in essential considering our natural production of collagen slows as we age. There is also research to show that topical application of probiotics may also assist with skin elasticity helping to maintain our skin's ability to stay firm, plump and strong.[19]

It hydrates: Interestingly, lactic acid also helps with hydration and combating dryness by balancing the skin's natural moisture levels. When used as a toner, it works by protecting the skin's natural barrier, its stores of hydrating hyaluronic acid and ups the skin's own natural defences, thereby preventing moisture loss.

It realances the skin: Glowing skin requires ph levels that are also in balance and probiotic skincare like our Probiotic Skin Refiner does just that! Literally feeding the skin with live bacteria, topical probiotics help to nourish the skin's surface and maintain its optimal PH particularly important for those with sensitive skin.

Probiotics-for-ecezema-management

The chronic, systemic inflammation that manifests as skin irritation, redness, or swelling is associated with eczema and many other inflammatory skin conditions. Probiotics are recommended for eczema treatment as they can help modulate the immune system to reduce skin inflammation.

Anti Inflammatory Probiotics

Specific molecules produced by probiotics can contribute to the improvement of host health by promoting specific physiological functions, in the same manner of live probiotics, although the precise mechanisms are not completely elucidated. Postbiotic supernatant collected from probiotic bacterial cultures could be used to achieve an immune modulation without the possible risks related to living microorganisms such as infections in immune-deficient patients. It is well known that the effect of probiotics can be mediated by their metabolites, such as short-chain fatty acid (SCFA) in particular propionate, acetate, and butyrate that may exercise anti-inflammatory effects. SCFAs are produced by bifidobacilli, lactobacilli, and several commensal bacteria. These postbiotics exert their action by binding to specific receptors on intestinal epithelial cells. In this way, the NF-κB pathway, Treg cell suppression, and pro-inflammatory cytokine production by neutrophils and macrophages are

inhibited; consequently, the inflammation state is prevented, and an anti-inflammatory effect is produced Butyrate may exert a beneficial effect in controlling gut inflammation through the induction of Treg cell differentiation.[22]

Acne

Growing evidence from laboratory research and clinical studies suggests that probiotics play a useful role in acne management. Acne develops through several mechanisms, including abnormal keratinization, excessive sebum production, colonization by *Propionibacterium acnes*, and inflammation. Many topical acne treatments can disrupt the skin barrier, leading to dryness and irritation and reducing patient adherence. Probiotics help address these issues by inhibiting the growth of acne-causing bacteria, reducing inflammation, and strengthening the skin barrier. Certain probiotic strains increase ceramide production, which improves skin hydration and provides antimicrobial effects. By restoring healthy skin lipids and reducing treatment-related side effects, probiotics may improve overall acne outcomes and patient compliance.[24]

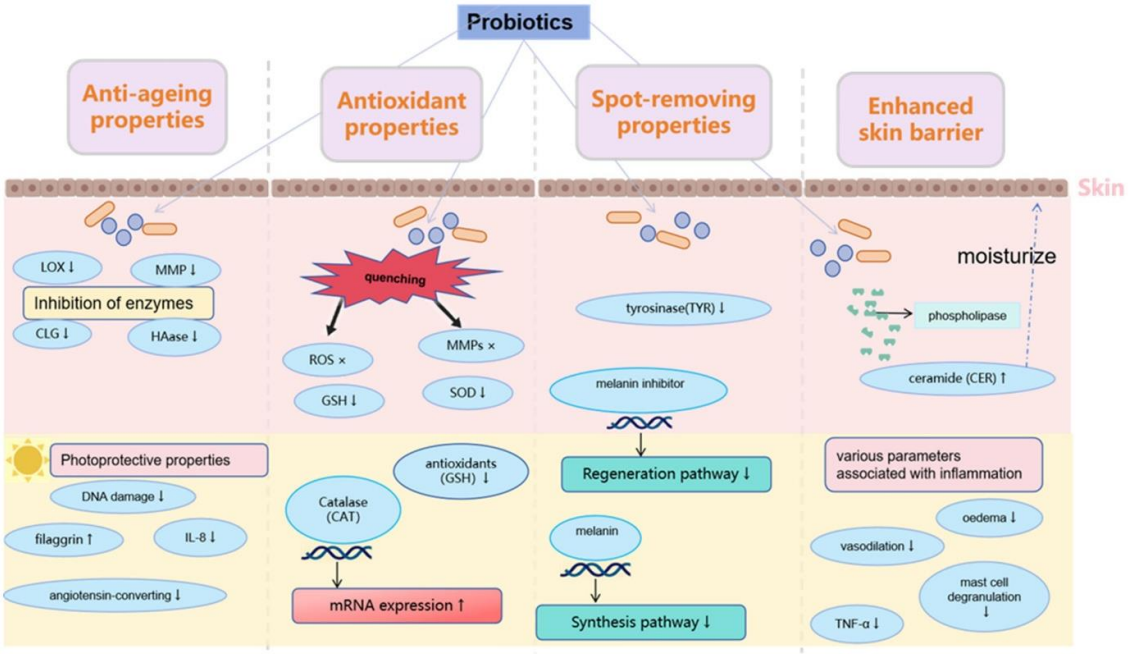

Figure 6: mechanism action of Probiotics.

FORMULATION TYPES CONTAINING PROBIOTICS

Creams

Creams are semi-solid emulsions (O/W or W/O).

Creams are semi-solid emulsion systems that provide partial occlusion, enabling extended contact between probiotic-derived components and the skin surface. The emulsion structure promotes even spreading and retention of lysates and postbiotics within the stratum corneum. Oil-in-water creams reduce transepidermal water loss, indirectly supporting a favorable environment for the skin microbiota. The lipid phase further enhances compatibility with the natural skin barrier.

Mechanism of action

- Strengthen the skin barrier by increasing ceramide and lipid synthesis reduce transepidermal water loss (TEWL)
- Probiotic lysates interact with keratinocyte toll-like receptors (TLRs), enhancing innate immunity
- Anti-inflammatory cytokine modulation (↓ IL-6, IL-8)

Applications: Dry skin, eczema-prone skin, anti-aging(25).

Lotions

Low-viscosity emulsions with high spreadability. lotions possess lower viscosity and higher aqueous content, allowing rapid spreading and absorption. This formulation facilitates quick deposition of fermented metabolites and postbiotics onto the skin without significant occlusive effects. As a result, lotions are well suited for routine application where microbiome maintenance and hydration are desired without altering skin permeability.

Mechanism of action

- Maintain skin pH favorable to commensal bacteria
- Postbiotics inhibit growth of pathogenic organisms (e.g., Staphylococcus aureus)
- Improve skin hydration through humectant synergy

Applications: Daily skin maintenance, sensitive skin.[27]

Serums

Lightweight, high-concentration formulations. Serums are designed as low-viscosity systems containing high concentrations of active ingredients. Their aqueous or hydro-alcoholic bases enable efficient delivery of probiotic lysates and metabolites to the superficial epidermal layers. Minimal use of occlusive agents allows rapid absorption and direct interaction of bioactive components with skin cells, supporting microbiome-related signaling processes.

Mechanism of action

- Rapid penetration of probiotic metabolites into the stratum corneum suppression of inflammatory pathways (NF-κB inhibition) enhancement of collagen synthesis via antioxidant activity.

Applications: Acne, inflammation, aging skin[28-31]

Gels

Non-greasy, aqueous formulations.Gels consist of a polymeric network that holds hydrophilic probiotic components in a uniform matrix. Upon application, these systems release postbiotics rapidly due to their high water content. Their non-greasy and cooling properties make gels particularly suitable for oily or inflamed skin, where they help create conditions favorable for microbial balance.

Mechanism of action

- Cooling and soothing effect reduces erythema
- Postbiotics regulate sebum production
- Antimicrobial peptides produced by probiotics inhibit acne-causing bacteria.

Applications: Oily and acne-prone skin

Face Masks

Sheet masks, hydrogel masks, and wash-off masks. Face masks operate by forming an occlusive or semi-occlusive layer on the skin, thereby increasing hydration and improving retention of probiotic-derived substances. Sheet and hydrogel masks generate a moist environment that enhances surface interaction between fermented ingredients and the skin microbiome during the application period.[33]

Mechanism of action

- Prolonged contact time allows effective interaction with skin cells
- Ferments improve skin hydration and elasticity
- Enhancement of skin microbiome diversity

Applications: Skin rejuvenation, hydration, calming effects.

Cleansers and Face Washes

Short-contact formulations. Cleansers are short-duration formulations that primarily rely on mild surfactant systems. While they rarely contain live probiotics, postbiotics and fermented

components are included to counterbalance cleansing effects. These ingredients assist in maintaining skin pH and minimizing disruption to resident microbial populations following rinsing.

Mechanism of action

- Gentle cleansing preserves beneficial microbiota postbiotics prevent overgrowth of pathogenic microbes support recovery of skin barrier after washing.

Applications: Daily cleansing, sensitive and acne-prone skin

Ointments and Balms

Occlusive, low-water formulations. Ointments and balms function primarily through strong occlusive action, forming a protective barrier over the skin. This reduces moisture loss and shields probiotic-derived ingredients from external degradation. The prolonged residence time supports sustained surface activity, particularly beneficial for damaged or compromised skin.

Mechanism of action

- Protect compromised skin from external irritants
- Enhance wound healing by stimulating antimicrobial peptide production
- Reduce inflammation and itching.

Applications: Atopic dermatitis, damaged skin.

Encapsulated and Advanced Delivery Systems

Includes microencapsulation, liposomes, and nano-emulsions. Encapsulation technologies, including microcapsules, liposomes, and nano-emulsions, protect probiotic components from environmental stress and preservative exposure. These systems allow controlled release upon application, improving stability, extending shelf life, and enhancing delivery efficiency across various topical formulations.

Mechanism of action

- Protect probiotics from oxygen, moisture, and preservatives
- Controlled and sustained release of active components
- Improved penetration and targeted delivery
- Enhanced stability and shelf life.

Powder and Dry Formulations

Dry formulations preserve probiotic stability by eliminating moisture during storage. Spray-dried or freeze-dried probiotic components remain inactive until rehydrated during use. This approach significantly improves shelf life and enables flexible incorporation into cleansers, masks, and professional skin-care products.[34]

PREPARATION AND MANUFACTURING OF PROBIOTICS

Step 1: Strain selection

The first and most important step in the production of probiotics is species selection. The strain you choose will be determined entirely by your goal for the specific probiotic supplement and for any potential health claims you may want to make. Whether we want to make a supplement to help with digestion, immune system health or a healthy response to periodic stress, you can do so. Each species has its own characteristics and advantages. Some species promote a healthy immune system, while others help with lactose digestion. This goes without saying that the production of high-quality supplements requires high-quality probiotics raw materials. To demonstrate efficacy, selected species must live in the womb.

Step 2: Media planning

Selecting naturally occurring bile and acid-resistant species, along with an effective formula for the optimal amount of raw materials, is critical. It is also advisable to test them for intestinal capacity. The selected strains are then fermented and stabilized. Study the probiotic strain in a bioprocessing lab to see what adjustable parameters and nutrients can be adjusted for growth. This research will be assisted by the probiotic manufacturer. Large-scale production begins after a specific combination of nutrients and process parameters has been determined.

Step 3: Fermentation

Probiotics can be made with ingredients collected worldwide. Furthermore, probiotics are made in order to maintain freshness and quality. Bacterial culture can take up to 6 weeks. As cultures grow, you cannot speed up the cultivation process. Specific strain ID numbers are often unique to the material provider. As a result, you're relying on the same vendor because no one else can provide you with the same strain IDs. Furthermore, some raw materials may not be readily available in the required quantity with the contract manufacturer, thereby prolonging the turnaround time.[5]

All nutrients and equipment are sterilized during fermentation to prevent unwanted and accidental contamination. In a large tank, the strain is added to the media. In a nutrient and warm material bath, the pressure is multiplied until the desired calculation (CFU-colony-forming units) is achieved. Metabolites, which are by-products of the bacterial nutritional metabolism, are also produced during this process. Probiotics are difficult to work with throughout the manufacturing process and require large amounts of overuse to ensure that each species supplement label is satisfied.[35]

Step 4: Centrifugation

It separates probiotic species from metabolites once cultures are prepared. Probiotic stability is another key component in the probiotics production process that requires special attention. Instant probiotic items are packed; they begin to lose their consistency and freshness. For long-term care, several approaches are used to ensure supplement stability and effectiveness. These steps are crucial and influence the viability and applicability of probiotic species.

- **Refrigeration:** The probiotic bacteria are frozen at very low temperatures.
- **Avoiding hot/humid situations:** This prevents bacteria from being exposed to humidity. Several drying processes are used in this step.
- **Freeze drying:** A more time-consuming yet gentler method.
- **Spray drying:** A faster process with greater temperatures that aren't too high for bacteria to live. After these processes, the probiotic is then transformed into a dry powder.

Step 5: Blending and bottling

The powder above contains the same species. Other probiotic powders combined with the multi-ethnic composition created an evenly distributed, balanced mixture. Other important ingredients are added to the probiotics, such as prebiotics, flavorings, and binders to provide other dosage forms, probiotics that complement the health focus and so on .The mixture is prepared in final dosage forms such as tablets, capsules and powder.

Temperature, humidity and light are all important factors for probiotics to thrive. These conditions are different for stress and affect the production expiration date. As a result, they need to be wrapped and carefully transported. Avoid direct sunlight, high temperatures and humidity.

STABILITY ASPECTS OF PROBIOTICS FORMULATION

Stability is indeed a critical aspect of probiotic formulations, as it directly affects the viability and effectiveness of probiotic bacteria over the products shelf life. It is essential for manufacturers to consistently Monitor and enhance their formulations and storage guidelines to ensure consumers derive the benefits from probiotic products. Ensuring stability remains a continuous priority for manufacturers. They must regularly assess and enhance their formulations and storage Guidelines to maximize the benefits consumers receive from probiotic Products The technology used for formulating probiotics is often proprietary Within the industry. However, a fundamental requirement is that Probiotic product should maintain stability in a powdered form, Typically with a spore concentration of around 1×109 Spores per Gram. Formulation technology for probiotics is frequently Proprietary in the industry. Nonetheless, a crucial criterion is that the Probiotic product should remain stable in a powdered form, typically Containing a spore concentration of approximately 1×109 Spores per gram. Hence, maintaining the stability of probiotic product. During formulation process and industry relevant storage conditions Is a crucial requirement for its successful commercial application. Ideally, the shelf life of such a product should be no <2 years.[36]

REGULATORY ASPECTS OF PROBIOTICS IN TOPICAL SKIN CARE AND THE CHALLENGES

Since there are several potential applications for probiotics in management of skin related disorders, a proper regulation of the labelling and marketing standards is essential. Almost all of the probiotic containing topical formulations have yet not gone beyond the personal care product category. Additionally, these topical care products are non-sterile and may contain antimicrobial preservatives that may affect the probiotic strain viability and further alter the microbiota of the recipient in an already diseased state. Therefore, regulations of probiotics primarily need to be concerned with safety. At present, there are no specific guidelines for commercializing probiotics, and products are regulated according to their final use either as a drug, medical device, food, dietary supplement, or cosmetic. Probiotic-based products with health claims could be notified as pharmaceuticals or medicines. If the product contains non-viable microorganisms, it will be considered as a medical device. Probiotic skin care products are a very recent innovation and there is a lack of scientifically validated clinical data about the efficacy and safety of topically applied probiotics. Additionally, the sharp demarcation between foods, drugs, and cosmetics, makes the development and notification of probiotic cosmetic products a challenge.

DEVELOPMENTS IN PROBIOTICS RESEARCH

Considerations for probiotics research genetic characterization and Modification of probiotics. Bioinformatics and in silico approaches contribute to a more detailed understanding of beneficial microorganisms, thereby allowing their targeted usage and safety assessment. As whole genome sequencing (WGS) is available at a reasonable cost, we advise that qualitative WGS and rigorous annotation should become the standard practice prior to marketing new probiotic strains. Newly sequenced genomes should be deposited and made publicly available via standard central databases. A rigorous sequence quality control and annotation should be carried out identifying the mobile and other genetic elements (e.g., CRISPR arrays) and predicting their functional properties, thereby estimating the safety of probiotic candidates regarding virulence factors and possible antibiotic resistance gene transfer. The European Food Safety Authority (EFSA) and recent publications recommend WGS to improve the monitoring of foodborne antimicrobial resistance and workflows to assess risk-related gene traits based on WGS are available S. WGS is also useful to assess genetic instability and ensure the retention of regions linked to the strain's health benefits.[37]

CONCLUSION

Probiotics have shown promising results in maintaining skin health, preventing diseases, and promoting overall wellbeing .This study investigated the effects of probiotics on skin care. Studies showed that probiotics on fermented foods or pure supplements can benefit skin health and diseases. More clinical studies are needed on how fermented foods and probiotic supplemented products work on skin care. However, there are limitations and safety concerns associated with using probiotics in skin care products. Since probiotic safety has not been established for all age groups and high-risk individuals, their potential use should be carefully evaluated. In addition, despite challenges in preserving the viability and activity of live bacteria when applied topically on the skin, topical probiotics can impact skin care. Furthermore, the current research has limitations, including the need for larger, well-designed clinical trials to confirm these findings. To ensure transparency and accuracy, legal requirements for clear labeling and information provision in skin care products are necessary for consumers and researchers. Future investigations could focus on safe probiotic strains, dosages of probiotics, probiotic products, probiotic metabo-lites, and delivery methods to optimize their efficacy for different skin condition.

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