

THE IMPACT OF SOAPS AND COSMETIC PRODUCTS ON SKIN MICROBIOTA AND IMMUNE MODULATION

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ABSTRACT

The human skin microbiota is a complex ecosystem of microorganisms that plays a major role in the maintenance of skin health and immune modulation [1], [2]. Our modern hygiene and nutrient, such as soaps and cosmetic products, are applied very frequently and directly disrupts this skin wall of equilibrium. Accordingly, consideration in the present review is given to the multilayered skin microbiome impacts of these products in terms of dysbiotic mechanisms, immune modulation, and systemic health implications. This paper integrates prominent studies with a comprehensive survey of the literature, presenting a subtly calibrated and complex relationship between microbial diversity, chemical agents, and immune pathways. In fact, this investigation indicates the need to re-evaluate current practice: microbiome-compatible formulations and personalized therapeutic approaches may mitigate deleterious effects and bolster the skin barrier against insult. The cross-field initiative must also do its due diligence to preserve that wellness as aligned with scientific verity regarding skin and microbiome research.

Key words: *Skin microbiota, Immune function, Dysbiosis, Skincare products, Microbial diversity, Skin barrier, Microbiome-*

friendly formulations

1. Introduction

The human skin is recognized as one of the most intricate and multifunctional organs metabolism-wise, acting as one of the most critical windows that links the internal body and the outside world, as well as being a changing environment for multitudes of communities of microbes collectively termed as skin microbiota (Grice & Segre, 2011; Kong & Segre, 2012). This microbiota, consisting of bacteria, fungi, archaea and viruses, is most crucial in preserving the structure of the epidermis, inhibiting pathogen encroachment as well as through immune regulation (Byrd et al., 2018).

Table 1: Composition of The Skin Microbiota

Skin Type	Actinobacteria	Firmicutes	Proteobacteria	Bacteroidetes	Fungi	Other
Dry Skin	~50%	~25%	~15%	~5%	~3%	~2%
Moist Skin	~25%	~30%	~35%	~5%	~3%	~2%
Sebaceous Skin	~60%	~15%	~15%	~3%	~5%	~2%

The physical aspects of the skin microbiome, which include genetic factors, hormonal changes, age and even lifestyle, such as the environment and skin care practices, affect the functional features of the skin (Proksch et al., 2008).

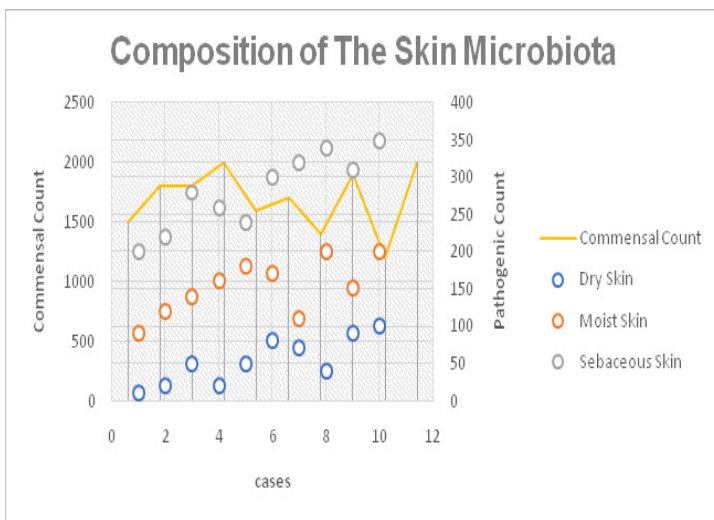
In the past decade, there was development of more and more confident concern associated to the potentially damaging effect of traditional soaps and cosmetics, as the influence of skin microbiota on dermatological, as well as, on systemic health has been found to be significant. Such products, even those meant to cleanse, protect and beautify the integument have added substances which alter the existing microbial status.

The disbalance of the microbiome caused by diminished diversity and proliferation of opportunistic pathogens has been associated with inflammatory skin conditions as well as generalized dysfunction of the immune system. These associations are important to follow in course of developing

novel strategies for the improvement of the skin and general health supporting the microbiome.

2. The Skin Microbiota: Composition and Functional Contributions

The four major bacterial phyla that characterize the skin microbiota are Actinobacteria, Firmicutes, Proteobacteria, and Bacteroidetes (Sanford & Gallo, 2013). Many of these notable genera of the four phyla live in defined niches created within the varied micro-environments existing on the skin. Other essential members include the fungal populations, primarily by the genus *Malassezia*, as well as archaea. Bacteriophages and other viral components make the microbiota more complex (Belkaid & Segre, 2014).



The functional contributions of the constituents of the skin's microbiome are numerous and include the following:

A critical function, such as immune modulation is to be discussed. There, commensal microorganisms interact with the host's PRRs. Such forms of interaction have implications for both innate and adaptive immune responses, promoting tolerance and regulating inflammatory pathways. Thus, it ensures the correct balance in which the immune system does

not overreact to innocuous stimuli but responds to harmful pathogens appropriately (Cogen et al., 2008; Prescott & Björkstén, 2007).

One more critical function that the skin microbiome performs is its ability to reinforce the epidermal barrier. SCFAs and ceramides, two types of microbial metabolites, maintain this barrier by reducing the water loss across the epidermis. Furthermore, these metabolites strengthen the major defenses of the skin, allowing it to better endure injuries and withstand environmental stress. The structural integrity of the epidermis has to be maintained through the existence of these metabolites (Egert & Simmering, 2016).

The skin microbiome also protects the body against pathogens by inhibiting their growth and activity. In this regard, commensal microbes suppress pathogenic microorganisms by competing for nutrients with these pathogens and releasing bactericidal peptides, like defensins, which may directly kill harmful bacteria. This results in a skin ecosystem that remains balanced and less susceptible to possible infections, as it continues to act as a barrier (Grice & Segre, 2011).

Table 2: Common Skin Microbiota Phyla and Their Functional Roles

Phylum	Genera	Functional Contributions
Actinobacteria	Cutibacterium, Corynebacterium	Skin homeostasis, pathogen suppression, production of antimicrobial peptides
Firmicutes	Staphylococcus	Immune modulation, antimicrobial peptide production
Proteobacteria	Pseudomonas, Acinetobacter	Pathogen competition, inflammatory response
Bacteroidetes	Bacteroides	Short-chain fatty acid production, skin barrier reinforcement

Changes in these functions caused by factors inside or outside the body, can throw off the balance of microbes. This imbalance plays a role in skin problems that cause inflammation (like

eczema and psoriasis), makes it easier to get infections, and can affect the whole body leading to autoimmune and metabolic issues.

3. How Soap and Cosmetic Products Affect Skin Microbes

Soaps and cosmetics, while key for staying clean and caring for skin often have ingredients like surfactants, preservatives, and scents that mess up the balance of microbes on the skin (Zeeuwen et al. 2013). The main ways they do this include:

Overuse of harsh cleansers and soaps severely diminishes microbial diversity of the skin. These chemicals remove natural oils and helpful microbes, such as *Cutibacterium acnes* and *Staphylococcus epidermidis*, that are vital in keeping the skin healthy. Leyden et al. (1975) and Sanford and Gallo (2013) emphasized how such loss desynchronizes the natural ecosystem of the skin and renders it more susceptible to environmental insults as well as infections.

And once the protective microbes are eradicated, pathogenic microorganisms often occupy their niche. Without commensal microbes, pathogens that cause harm, like *Staphylococcus aureus* and *Candida albicans*, can more easily colonize the skin. The result is hypergrowth resulting in increased risk of infection and inflammatory response, further compromising the health and balance of the skin (Findley & Grice, 2014). As these on the periphery fall away or suffer from overgrowth, the chance for infectious and inflammatory responses increases, further weakening skin health and balance (Findley and Grice, 2014).

Numerous cleansers and soaps also disrupt the pH of the skin by being too alkaline. The skin's natural acidity is responsible for the balance of microbes and for maintaining the integrity of the skin barrier. Proksch et al. (2008) showed that a disruption of the skin's pH using alkaline soaps damages both the microbial community and the barrier function of the skin, reducing its capacity to defend against external insults.

Table 3: Effects of Triclosan on Skin Microbial Populations

•Microbial Genus	Control Group	After Triclosan Exposure
Staphylococcus epidermidis	20%	15%
Cutibacterium acnes	30%	22%
Candida albicans	5%	20%
Staphylococcus aureus	1%	10%

4. Case Study: Triclosan's Role in Dysbiosis

Parlet et al. Triclosan's Impact on Gut Bacteria Balance - Triclosan, a common antimicrobial ingredient in soaps is impactful in decreasing the diversity of microbes and facilitates the proliferation of micropes with a resistant gene. 2019). Prolonged use can potentially damage skin strength and encourage pathogenic contamination. certain antimicrobials, e.g., chlorhexidine, are not commonly used but have the potential to disrupt the balance of microbiota, and therefore should be carefully applied.

5. How Microbiota Dysbiosis Affects Immune Function

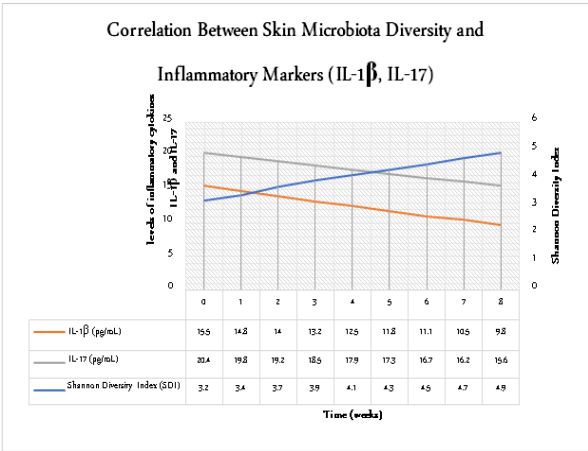
The skin microbiota and immune system work together to keep both local and overall balance. When this balance is upset, it leads to:

The immune system and the skin microbiota work in concert to achieve both systemic and local homeostasis. But, when this homeostasis is disrupted, it can have a variety of undesirable effects. Chronic inflammation is one of the byproducts. Overgrowth of pathogenic microbial communities can lead to overproduction of pro-inflammatory cytokines, including IL-1 β and IL-17, which contribute to skin inflammatory diseases like psoriasis and atopic dermatitis. This overwhelming of the immune mechanisms emphasizes the need for an optimal balance required for maintaining skin homeostasis (Prescott & Björkstén, 2007; Zhu et al., 2018).

Dysbiosis of the skin microbiota also disrupts natural immunity of the skin. This derangement diminishes the level of antimicrobial peptides that are one of the key components of the skin immune defense system. When proper amounts of these peptides are not present, the skin becomes exposed to infections, as its ability to fight off harmful microbes becomes compromised (Sanford & Gallo, 2013).

Moreover, skin microbiota composition changes may have extra-cutaneous effects that are related to the development of systemic immunological diseases. These alterations have been linked to autoimmune diseases like lupus and rheumatoid arthritis and to metabolic problems. This association demonstrates that the skin microbiota is involved not only in local immunity but also in broader physiological processes that shape general health (Belkaid & Segre, 2014).

New studies point out a skin-gut connection where skin imbalance affects gut microbiota and overall immune responses. Neuroinflammatory pathways also show the two-way link between skin health and mental well-being.



6. Highlighted Studies

Dysbiosis is exacerbated by immune dysregulation and disturbances in the function of the skin barrier itself, which have been shown to be relevant in congenital ichthyosis

[116–118]. Studies by Ho et al. (2024) demonstrated that the respective effects are mediated through the JAK/STAT signaling pathway. In addition to compromising the skin's physical barrier function, the abnormal epidermal barrier may also create a permissive environment for microbial dysbiosis, resulting in increased immune dysregulation that worsens disease severity.

They are also involved in the destruction of the Tonus of skin microbiome. Studies have shown that pH-disruptive cleansers can take a toll on microbial diversity. Proksch et al. (2008), alkaline soaps affect the skin's natural pH and thus eliminate its potential to maintain a balanced population of healthy microbes. The skin becomes susceptible to external irritants and the general defence of the skin weakens.

Moreover, cosmetic and personal care products that often contain preservatives like parabens and sulfates have been recognized to alter the human skin microbiota. Gilbert et al. (2018) described the manner in which such chemical agents lead to suppression of commensal populations with the risk of opportunistic microbial overgrowth. This kind of imbalance can also have negative implications for overall skin health and even poses risks for infections or inflammatory responses which highlights the need for the formulation of microbiota-compatible formulations.

7. Strategies for Preserving Microbial Homeostasis

Several approaches can mitigate the adverse effects of soaps and cosmetics on the skin microbiota:

At that point, there is a need for pH balanced formulations to stabilize the skin because healthy microbial stability depends on maintaining natural pH balance of the skin. A product with a pH of around 5.5 is formulated to follow the skin's natural environment, increasing the chances of a balanced skin microbiota. This method does preserve the microbial diversity and the natural defenses of the skin (Egert & Simmering, 2016).

Table 4: Comparison of pH Levels in Various Soap Formulations

Product Type	pH Level	Impact on Skin Microbiota
Alkaline Soap	9.0	Disrupts microbial balance, increases pathogen growth
Neutral pH Soap	7.0	Moderate impact, some disturbance in microbial equilibrium
Acidic pH Soap	5.5	Supports natural skin pH, minimal impact on microbiota

A second innovative approach for improving skin health is probiotic and prebiotic skincare products. These products deliver live beneficial bacteria or nutrients to encourage these microbes to grow. Probiotic and prebiotic products improve the skin’s protective barrier against intruding pathogens and its overall homeostasis by encouraging a more diverse and resilient microbial community (Belkaid & Segre, 2014). Plant-based natural antimicrobials are a more subtle way of preserving the health of skin microbiota than synthetic chemicals. And some ingredients, including tea tree oil and colloidal oatmeal, have been shown to kill the bad microbes without causing imbalances in the good ones. Unlike synthetic agents like triclosan, these natural options support the balance of the delicate skin microbial ecosystem (Parlet et al., 2019). Moderation in product use is just as important for a healthy skin microbiome. Overwashing, or using too many germ-killing products, can upset the microbial balance – risking certain skin problems. Using mutagenic cleansers and anti-microbial agents lessens the chances of imbalance of the microbiota, allowing the skin to use its natural barrier functions. This minimalist approach to skincare helps maintain a healthy microbiome long-term.

8. Future Research and Innovations

Moving microbiome-friendly skincare forward needs teamwork from different fields:

The effect of routine “cosmetic” habits on the skin microbiome

needs to be better understood, further research with a long-time assessment for the “skin health” is required. Grice and Segre (2011) considered that the daily routines and product usage should be studied over long-time periods to further analyze their influence on the microbial diversity. This research may help more adequately maintain a microbiota balance and avoid skin conditions.

Personalized skin-care products based on a person’s unique skin microbiota offer a tremendous opportunity to enhance outcomes. Research by Byrd et al. (2018) noted the potential of custom formulations tailored to each person’s microbial profile.

Therapeutic approaches that deliver beneficial bacteria and their metabolites to the skin are showing potential for restoring microbial homeostasis. Gilbert et al. (2018) investigated the probiotics and microbial by-products as therapeutic agents; they showed their ability to repair the dysbiosis and restore the skin condition. It is likely these treatments will form an integral part of managing microbiota-associated diseases.

Coordinating worldwide rules and standards for skin care product formulation that integrate skin microbiota is a key step in this direction. Standards will have to be created that encourage microbiota-friendly ingredients and formulations, leading to safer, more effective products. Not only would such standards drive up product quality, but they would also create consumer trust in microbiome-oriented skin care solutions.

9. Conclusion

This is, of course, a simplification of the complex relationship between skin microbes and immune function, and the efficacy of soaps and cosmetics on skin microbes and shows that we have to be aware of the microbiome when it comes to our personal care. These products are vital to our cleanliness and skin care, but they can also wreak havoc. So, we have to be mindful when we make and use them.” Advances in microbiome science, plus bespoke skincare regimens, may provide new solutions for achieving skin health and general well-being.

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