The Microbiome Revolution

How Science Is Shaping the Future of Advanced Cosmetics

THE EXPERTS

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History and context

The concept of microbiome has profoundly transformed how the cosmetic and food industries approach health and beauty.

Originally explored through the work of Elie Metchnikoff (1907) on lactic acid bacteria and longevity. Probiotics entered the scientific lexicon in the late 20th century, later formalized by FAO/WHO (2002) as "live microorganisms conferring a health benefit on the host"[1][2].

With the rise of metagenomic sequencing in the 2010s, projects such as the Human Microbiome Project revealed that the skin, our largest organ, hosts a diverse microbial ecosystem (the microbiota) essential to barrier integrity and immune balance[3]. It is crucial to distinguish the microbiota (the entire population of microorganisms inhabiting an organ) from the microbiome (the collection of all their genomes)[4,5]. This discovery shifted the paradigm of dermatology and cosmetics from targeting microbes as threats to recognizing them as vital partners in skin health.

Cosmetic research focuses on prebiotics, probiotics, and postbiotics, seeking to support the skin's natural flora rather than eliminate it.

However, the use of live microorganisms in cosmetics remains limited in Europe due to stability, contamination, and regulatory concerns[6][7]. Most brands therefore turn to inactivated microbial extracts or fermented ingredients, which offer microbiome benefits without breaching safety or classification rules.

The European cosmetic industry now faces a dual challenge: embracing microbiome science as a new frontier of efficacy and personalization, while ensuring full compliance with existing regulatory structures.

Scientific advances

In the past decade, microbiome science has evolved from descriptive field into cornerstone of cosmetic innovation.

Indeed skin health is closely linked to the exposome which is not just a list of chemical pollutants or medicines but also includes the cosmetics we use every day. The impact is not only on the layers of eukaryotic cells, but also on the microbiota that colonizes it. The microbiota-skin synergy stimulates cell renewal, immunity, pH maintenance and barrier function to limit skin infections.

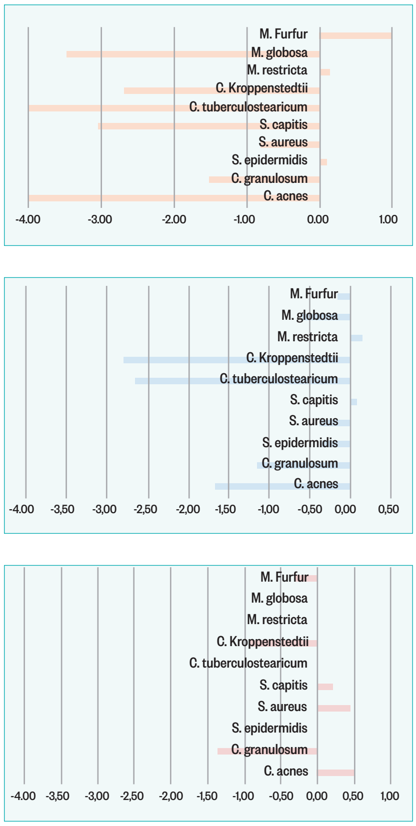
Analyses of the impact of dermocosmetic products on the composition of the microbiota are now regularly performed and have shown that the diversity of strains in the microbiota induces variations in sensitivity. These analyses can be performed using *in vitro* tests, which allow controlled evaluation of the impact of different products or ingredients on microbial growth and diversity. *In vitro* models provide reliable and reproducible scientific data, serving as a valuable tool to predict the effects of formulations and ingredients.

Advances in metagenomics, metabolomics, and *in vitro skin* models allow researchers to study not only which microorganisms inhabit the skin, but also how their interactions affect epidermal physiology and product efficacy[7][8]. Research now focuses on identifying bacterial strains or metabolites capable of restoring microbial homeostasis. For instance, lysates derived from *Lactobacillus plantarum* and *Staphylococcus epidermidis* have demonstrated anti-inflammatory and barrier

repairing properties in both *in vitro* and clinical models[9]. Meanwhile, postbiotics inactivated bacteria or their fermentation by products are gaining traction due to their stability and safety compared to live probiotics. Studies have shown that these postbiotic components can reduce oxidative stress, strengthen the stratum corneum, and promote the growth of commensal species[10].
Simultaneously, the integration of omics technologies has opened the door to a new generation of evidence-based formulations. A recent multi-omics investigation demonstrated that prebiotic and postbiotic skincare products can beneficially modulate both the microbiome composition and the metabolome of the skin, suggesting measurable biochemical improvements in skin health[11]. This type of data-driven research strengthens the scientific basis of microbiome cosmetics and encourages a more precise definition of active mechanisms.

Examples of possible studies

The first indicator of a healthy microbiome is its diversity of bacterial and fungal strains.
Tests were carried out by Byome Labs to investigate the impact of moisturizing creams and their ability to develop growth in the presence of creams (Table 1). The creams were applied in dilution to the microorganism suspensions and the ability to grow was monitored.
However, another parameter must be taken into account: the interactions between microorganisms and skin surface refer to as "biofilm," contribute to skin homeostasis and healing (Scalise et al. 2015). This microorganisms life style, as fixed in the environment as on the skin, names biofilms confers various advantages for the microbial population: to survive in hostile environments, by developing antimicrobial tolerance, by adapting more rapidly to variations, and through to an intercellular communication system, they can use secretions of small peptides or other molecules to detect their density, produce virulent factors, slow down their metabolism and thus persist on the skin surface (Brandwein et al., 2016 ; Cha et al. 2025)
Thus, to verify the impact of a product on the microbiome, the biofilm dimension is critical.
By taking this natural mode of development into account, we can measure a product impact score. 9 strains were selected from the bibliography and data from samples taken from healthy skins: *S. epidermidis, S. capitis, S. aureus, C. acnes, C. granulosum, C. kroppenstedtii, C. tuberculostearicum, M. restricta and M. globosa*. The strains were grown in biofilms until the beginning of the maturation phase. The products were applied to the biofilms and incubated for 4 hours. Impact is measured by counting the number of microorganisms in the biofilm after application of the treatment (Figure 1). ▶▶▶



▲ **Figure 1.** Impact of 2 moisturizers measured in Log10 variation.

	Staphylococcus epidermis	*Staphylococcus capitis*	*Staphylococcus hominis*	*Corynebacteriuma 1*	*Corynebacteriuma 2*	*Cutibacterium acnes*	*Cutibacterium granulosum*	*Malassezia restricta*	*Malassezia Globosa*
Moisturizer 1	+	+	+	-	-	+	-	-	-
Moisturizer 2	-	+	+	-	-	-	+	-	+
Moisturizer 3	+	+	+	+	+	-	-	-	-
Moisturizer 4	+	+	+	+	+	+	+	-	-
Moisturizer 5	-	+	-	-	+	+	+	-	ND
Moisturizer 6	+	+	+	+	-	-	-	-	ND
Moisturizer 7	+	+	+	+	+	+	+	+	ND
Moisturizer 8	+	+	-	-	-	-	-	-	ND
Moisturizer 9	+	+	+	+	+	+	-	+	ND

▲ **Table 1:** Examples of the diversity of strain growth observations in the presence of moisturizers*
(+) growth; (-) No growth; (ND) Not Determined

▶▶▶ The results reveal a high heterogeneity in the activity of formulations on microorganisms. We have identified antimicrobial effects that alter microbiome diversity, as well as a loss of biofilm-forming capacity, which could compromise microbiome preservation while others exhibit an overall neutral effect, with no significant impact on these parameters.
Just as toxicity testing on eukaryotic cell lines is required, safety testing on the commensal microbiota, considered to be a second skin, will eventually be necessary to ensure product safety.

EU Regulation
Within the European Union, the regulation of cosmetics and microbiome-related products is governed primarily by Regulation (EC) No 1223/2009, which established that all cosmetic products placed on the market must be safe for human health.
However, this regulatory framework was not conceived to address living microorganisms or their derivatives, which creates interpretative and classification challenges for products containing probiotics, prebiotics, or postbiotics[15].
Cosmetics ingredients containing non-viable microbial components are treated like any other biological raw material, provided their composition and safety can be documented. By contrast, formulations containing live microorganisms raise complex regulatory questions: they may risk microbial instability, contamination, or classification outside cosmetics, potentially as biocidal or medicinal products depending on their claimed effects[6][16].
For these reasons, most microbiome-based cosmetics marketed in Europe rely on postbiotics or fermentation-derived ingredients, which avoid the hurdles associated with live cultures while still offering measurable benefits for skin balance and resilience[5].
The European Scientific Committee on Consumer Safety (SCCS) regularly issues opinions and methodological updates that guide risk evaluation, including biological and biotechnological ingredients. With the EU's strong commitment to non-animal testing, most toxicological endpoints are now assessed using in vivo, in chemico, or computational models. These methods are particularly suitable for microbiome-derived ingredients, allowing the prediction of irritation, sensitization, and cytotoxicity without compromising ethical standards. ●

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