Fermentation-Derived Oils: A Biotechnological Approach to Skin Renewal

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KEYWORDS: Fermentation-Derived Oils · Skin Renewal · Biotechnology

Author's Note: *The results described in this article are based on internal studies conducted by ÄIO in collaboration with an independent third-party research laboratory. The studies used transcriptomic analysis to investigate the effects of fermentation-derived oils on selected skin renewal and hydration pathways.*

The evolving landscape of cosmetic actives

The cosmetics industry is undergoing a transformation driven by several converging developments, including growing interest in natural ingredients, upcycled beauty, and biotechnology-based ingredient production. At the same time, consumers increasingly expect skincare solutions that combine efficacy, sustainability, traceability, and skin compatibility. In this context, fermentation-derived oils are attracting attention as a new class of functional cosmetic ingredients.

Retinol and the search for gentler approaches

Retinol remains one of the most widely used ingredients in anti-ageing skincare due to its well-established role in accelerating skin renewal, supporting collagen production, and improving skin texture. Retinoids act primarily through changes in gene expression in keratinocytes and fibroblasts, promoting epidermal turnover and extracellular matrix remodelling. However, their use is also associated with well-known limitations, including irritation, dryness, barrier disruption, and increased skin sensitivity. These limitations continue to drive interest in alternative approaches that may support skin renewal while preserving barrier integrity.

Biotechnology enables new ingredient pathways

Recent advances in industrial biotechnology have opened new possibilities for producing functional lipids through microbial fermentation. In such processes, oleaginous microorganisms convert organic substrates, including low-value agricultural or food-industry side streams, into lipid-rich biomass. The resulting oils may contain complex mixtures of fatty acids, carotenoids, sterols, and antioxidant compounds that can be difficult to obtain through conventional plant extraction alone.

Because fermentation takes place in controlled bioreactors, production can be less dependent on climate, land availability, and seasonal variability, while supporting consistent quality and traceability from raw material to finished ingredient.

Functional lipid composition and formulation relevance

From a formulation perspective, fermentation-derived oils offer several characteristics of interest. These ingredients may show good oxidative stability, compatibility with other cosmetic actives, and versatility across emulsions, serums, and anhydrous systems. Their lipid profiles often include oleic and linoleic acids, both of which are associated with skin barrier support, softness,

and the penetration of active compounds. In addition, naturally occurring carotenoids and polyphenols may contribute antioxidant protection against oxidative stress, an important factor in skin ageing.

Molecular insights from keratinocyte transcriptomics

Beyond formulation performance, the biological activity of fermentation-derived oils has also been investigated using keratinocyte transcriptomic analysis. This approach examines changes in gene expression in skin cells and can help map pathways linked to hydration, inflammation, extracellular matrix remodelling, and cell differentiation.

Findings from such studies suggest that certain fermentation-derived oils may modulate skin biology in ways that partially resemble retinoid activity, while maintaining a more balanced biological profile. Reported gene expression changes include stimulation of hyaluronan synthesis pathways, such as upregulation of HAS3, which may be associated with improved hydration and plumping effects. At the same time, increased expression of matrix-remodelling genes such as MMP1 and MMP9 suggests possible relevance for skin renewal and extracellular matrix turnover.

Supporting Skin Renewal While Maintaining Barrier Balance

Importantly, these responses appear to occur without the strong inflammatory signatures typically associated with retinoids. Comparative analyses indicate lower activation of stress- and inflammation-related pathways when fermentation-derived oils are applied to keratinocyte cultures. This may suggest a gentler mode of action that supports epidermal renewal while helping to preserve lipid barrier integrity and reduce irritation risk.

Rather than positioning these ingredients as direct alternatives to retinoids, the findings suggest that fermentation-derived oils may offer a more moderate biological response, balancing renewal-related activity with skin barrier support. Unlike traditional retinoids, which are often associated with stronger effects on differentiation markers and lipid metabolism, fermentation-derived oils appear to modulate these pathways in a more balanced way.

Sustainability and upcycled ingredient development

In parallel with their biological relevance, fermentation technologies align with current sustainability priorities in the cosmetics industry. By converting organic side streams into higher-value functional ingredients,

biotechnology can support the development of upcycled cosmetic raw materials with a reduced environmental footprint. Fermentation-based production may also allow more transparent supply chains, support traceability goals, and provide greater supply stability than agricultural systems subject to seasonal or regional variation.

A broader perspective on biotech-driven ingredients

As biotechnology continues to reshape ingredient development, fermentation-derived oils provide an example of how controlled microbial production and molecular analysis can come together in cosmetic research. Their combination of formulation functionality, biological activity, and sustainability relevance reflects broader directions in modern ingredient innovation.

Further research will determine how such ingredients may best be positioned within future skincare concepts, particularly where efficacy, skin compatibility, and environmental considerations need to be addressed together.

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