New Nobel Prize MicroRNA Technology Is Opening up a New Era of Precision Skincare

Youmin Zhu*, Yu Dai, Xiaojing Wang, Shengjie Zhu, Yuncai Tian, Yong Tian
Shanghai Zhizhen Zhichen Technology Co., Ltd., Shanghai 201109, China
DOI: 10.32629/ajn.v5i4.3237

Abstract: This review explores the enormous potential of microRNA, a cutting-edge technology that has won the Nobel Prize, in the field of skincare products. The aim is to inject innovative momentum into the field of skincare technology, providing a solid theoretical foundation and practical guidance. The review not only deeply analyzes the unique biological characteristics and mechanisms of microRNAs, but also innovatively proposes the cutting-edge concept of incorporating microRNAs as highly efficient bioactive ingredients into skincare products. By precisely regulating the expression levels of microRNAs, we can achieve precise regulation of skin cell functions and develop cosmetic ingredients with significant anti-aging, whitening, anti-inflammatory, and maintaining skin barriers. This innovative concept may open up a new research and development path for the skincare industry, and heralds the arrival of a truly precision skincare era, leading to an unprecedented transformation and leap in the development and application of cosmetic raw materials.
***Keywords*:** microRNA, skin, precision skincare

1. Introduction

The 2024 Nobel Prize in Physiology or Medicine was awarded to Victor Ambros and Gary Ruvkun for their discovery of microRNAs and their role in post transcriptional gene regulation. MicroRNAs can precisely regulate genes related to skin aging, pigmentation, inflammation, and repair processes, providing natural and safe skincare options, and have the potential to usher in a new era of precision skincare.

2. Basic characteristics and production process of microRNA

MicroRNA is a type of small non coding RNA widely present in eukaryotes. MicroRNAs are typically transcribed from DNA to produce a primary pri-microRNA, which is then trimmed into precursor pre-microRNA by RNase type III endonuclease and cleaved into mature single stranded microRNAs of approximately 22 nucleotides in length by Dicer enzyme[1].

3. The mechanism of action of microRNA

The first step for microRNAs to exert their regulatory effects is to recognize and localize specific sites of the target mRNA. Once microRNAs complement their target mRNAs, they are integrated into RNA induced silencing complexes (RISC). When the microRNA-RISC complex occupies a specific region of the target mRNA, it hinders the approach and binding of ribosomes, thereby blocking the initiation of translation. RISC's Ago protein also possesses endonuclease activity, which can cleave target mRNA under specific conditions, leading to mRNA breakage[2].

4. Research progress of microRNA in the field of skincare

4.1 Research progress of microRNA in anti-aging

In recent years, the anti-aging skincare market has shown a sustained growth trend, and consumers' demand for maintaining youthful skin is increasingly. Collagen is the main component of skin structure and is crucial for maintaining skin elasticity and firmness. As age increases, the synthesis of collagen slows down, leading to skin sagging and the appearance of wrinkles. MicroRNAs can promote collagen synthesis by targeting specific gene expression, thereby helping to maintain skin elasticity and firmness. Overexpression of miR-21 can significantly promote the proliferation activity of lung fibroblasts and enhance their ability to synthesize collagen. MiR-29 directly participates in the degradation of collagen and elastin fibers, affecting the elasticity and firmness of the skin. Overexpression of miR-29a reduces the expression level of collagen in human fetal scleral fibroblasts (HFSF). MiR-34a is a key regulatory factor in p53 mediated cellular aging. Inhibiting the expression of miR-34a can delay the aging process. As age increases, the expression level of miR-146a in skin fibroblast cells shows a significant downward trend, which can lead to a decrease in cell proliferation ability and a reduction in collagen I synthesis. At the same time, the reduction of miR-146a also promotes the accumulation of DNA damage and upregulates the expression of pro-inflammatory markers, further accelerating the aging process of the skin. MiR-125b mimetics can inhibit the expression of Collagen I and III, while miR-125b inhibitors can promote the expression of these collagen mRNA. MiR-10a can promote the expression of mRNA and protein of Collagen I, while its inhibitors can inhibit the expression of mRNA and protein of Collagen I. MiR-25 can promote the synthesis of type II collagen. MiR-23a can regulate its downstream target site AMBRA1 to affect cellular autophagy, thereby achieving anti-aging effects. MiR-130a is another biomarker associated with skin aging. Metformin can delay the senescence of renal tubular epithelial cells in diabetes nephropathy by regulating miR-130a-3p/STAT3 pathway. In diabetes patients, due to the increase of blood sugar level and the automatic oxidation of glycosylated proteins, the production of free radicals in the body will increase. Free radicals can attack DNA, proteins, and lipids within skin cells, leading to skin damage and aging. The glycosylation of sugar and protein in the body of diabetes patients will consume collagen in the skin, further accelerating skin aging. MicroRNA-21 is an important regulator of gene expression related to diabetes dermatosis. The construction of TF microRNA-mRNA regulatory network can reveal a new mechanism (miR-21-PARA-NCOA6) of dysregulation of proliferation, differentiation and migration of diabetes skin keratinocytes, which may provide new insights into the susceptibility of diabetes dermatosis[3].

4.2 Research progress of microRNA in whitening

Whitening has always been widely pursued by consumers. In whitening and spot lightening products, the role of microRNA is manifested by regulating the expression of genes related to melanin production, such as the tyrosinase gene (TYR). TYR can catalyze the conversion of tyrosine to dopa, which then undergoes a series of reactions to form melanin. The content and distribution of melanin determine the color of the skin. Therefore, the activity, expression level, and mutation of TYR directly affect skin pigmentation and color changes. TYRP1 is the target gene of miR-146a. Overexpression of miR-146a can reduce the expression of TYR, TYRP1, and TYRP2 in melanocytes. MiR-25-5p can regulate the expression of TSC2 through the CDS region. MiR-25-5p may play a key role in regulating melanin production through TSC2 induced organelle dysfunction. MiR-141-3p and miR-200a-3p are downregulated in melanocytes upon stimulation by α-MSH. They negatively regulate melanin production by inhibiting tyrosinase activity and targeting microphthalmia associated transcription factors (MITF) [4].

4.3 Research progress of microRNA in anti-inflammatory

With the increase of environmental pollution, UV exposure, and life stress, inflammatory skin problems have become a focus of global consumer attention. In skin biology, microRNAs are involved in the regulation of various skin inflammations. MiR-155 directly participates in the regulation of skin immune response and can affect the nuclear factor kappa B (NF-κB) signaling pathway, which is a key regulatory pathway of skin inflammation response. MiR-30a-3p is upregulated in patients with dermatomyositis, which in turn inhibits ANXA1 and promotes the expression of inflammatory factors. MiR-203 can regulate the NF-κ B pathway through competitive binding, upregulate inflammatory factors, promote microglial activation, induce neuronal apoptosis, and is a key regulatory molecule in neuroinflammation. MiR-146a is abnormally expressed in inflammatory skin diseases. It regulates inflammatory response by inhibiting the NF-κB pathway[5].

4.4 Research progress of microRNA in maintaining skin barrier

The skin barrier is mainly composed of the sebum membrane and stratum corneum, which play important roles in maintaining skin moisture, preventing water evaporation in the body, and resisting the invasion of foreign objects into the body. MicroRNAs are involved in the formation and repair of the stratum corneum, helping to maintain the integrity of the skin barrier. MiR-210 can protect human skin fibroblasts from apoptosis under hypoxic conditions by increasing autophagy, reducing ROS generation, and regulating the BDNF/NF-κB signaling pathway. MiR-203 is highly expressed in the epidermis. It promotes keratinocyte terminal differentiation by inhibiting p63. MiR-203 also regulates the expression of tight junction proteins and enhances skin barrier function[6].

5. Cases of using microRNAs in skincare products

Chanel, a well-known French brand, extracted the pure active factor 3.5-DA from precious golden vine, which can inhibit skin aging related microRNAs (miR-130a, miR-138, and miR-191), and added it to skincare products to achieve anti-aging effects by promoting the synthesis of youth protein. Est é e Lauder has applied baobab tree seed extract to various products such as the "High Energy Brown Bottle" and found that it can restore the level of miR-146a to a state close to youthful skin, thereby enhancing the skin's ability to regulate circadian rhythms and promoting the synthesis of collagen, elastin, and hyaluronic acid. LVMH, Claude Bernard University Lyon 1, and Ashland collaborated to develop a red tea extract rich in microRNAs, and verified its antioxidant effects on the skin, demonstrating its potential in anti-aging[7].

6. Summary and Prospect

By regulating relevant genes, microRNAs can achieve precise anti-aging, whitening, anti-inflammatory, and maintenance of the skin barrier. As the 2024 Nobel Prize is just announced, it is believed that microRNA related skincare products will become a major star in the skincare industry.

References

[1] Meister G. (2023) MicroRNA uses a gym to get fit for cuts by Dicer enzyme [J]. Nature, 615(7951):218～219.

[2] Janas MM, Wang B, Harris AS, et al. (2012) Alternative RISC assembly: binding and repression of microRNA-mRNA duplexes by human Ago proteins [J]. RNA, 18(11):2041～55.

[3] Liu C, Ram S, Hurwitz BL. (2022) Network analysis reveals dysregulated functional patterns in type II diabetic skin [J]. Sci Rep, 12(1):6889.

[4] Itoh T, Fukatani K, Nakashima A, et al. (2020) MicroRNA-141-3p and microRNA-200a-3p regulate α-melanocyte stimulating hormone-stimulated melanogenesis by directly targeting microphthalmia-associated transcription factor [J]. Sci Rep, 10(1):2149.

[5] Essandoh K, Li Y, Huo J, et al. (2016) MiRNA-Mediated Macrophage Polarization and its Potential Role in the Regulation of Inflammatory Response [J]. Shock, 46(2):122～31.

[6] Koury J, Ramirez A, Xie C, et al. (2019) Phosphodiesterase 4D, miR-203 and selected cytokines in the peripheral blood are associated with canine atopic dermatitis [J]. PLoS One, 14(6):e0218670.

[7] Moreau M, Naiken T, Bru G, et al. (2023) The impact of PSRTM (plant small RNA technology), tea extract, and its principle components on mitochondrail function and antioxidant properties in skin cells [J]. Cosmetics, 10:172.

Author Bio

Zhu Youmin, May 1984, male, Han Nationality, native place: Taian, Shandong province, education or professional title, intermediate professional title, engaged in research direction or work field, application of microRNA in skincare products.