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“Study on the Hair Loss Relief and Skin Moisturizing/Barrier Improvement Effects of 3'-Sialyllactose Sodium Salt”

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1. Abstract

3'-Sialyllactose Sodium Salt (3'-SL) is one of the functional oligosaccharides found in human breast milk and its oral intake has been extensively studied for its potential to improve gut health and immune function in the pharmaceutical and functional food sectors. However, research on its use as a cosmetic ingredient for alleviating hair loss and improving skin health has been relatively limited. This study aimed to evaluate the effects of 3'-SL, manufactured using unique synthesis and processing technology developed in Korea and recognized with FDA GRAS status, on hair loss mitigation, skin hydration and barrier improvement. *In vitro* experiments using cultured Human Follicle Dermal Papilla Cells (HFDPC) and a human application test using a cream containing 3'-SL were conducted. The results showed that 3'-SL significantly inhibited the expression of the inflammatory cytokine interleukin-1 α (IL-1 α) and promoted the expression of hair growth factors insulin-like growth factor-1 (IGF-1) and epidermal growth factor (EGF). Additionally, excellent efficacy was observed in enhancing skin hydration, strengthening the skin barrier and soothing skin irritation caused by external stimuli. This study confirms the potential of 3'-SL as a functional ingredient for alleviating hair loss and improving skin health, indicating its promising application as a major functional substance in various cosmetic formulations.

2. Introduction

3'-SL is a functional oligosaccharide abundantly present in human colostrum, but found only in trace amounts in bovine colostrum and absent from commercial milk products. Its chemical structure consists of sialic acid linked to lactose through an α 2,3-glycosidic bond. 3'-SL has been reported to exhibit various physiological activities in the human body, such as promoting the growth of beneficial gut microbiota, inhibiting the adhesion of pathogenic bacteria and

modulating immune responses. Continuous technological research and development in Korea have enabled its large-scale production and it has been certified with FDA GRAS status for use in functional foods. Recent studies have suggested that 3'-SL possesses anti-inflammatory, antioxidant and tissue regeneration-promoting activities. However, scientific evidence supporting its use in improving skin and hair health as a cosmetic ingredient remains limited. Hair loss can be exacerbated not only by genetic factors but also by inflammation and environmental stress, while impaired skin barrier function is closely associated with dryness, increased sensitivity and inflammatory skin disorders. Therefore, this study aimed to investigate the potential of 3'-SL in improving hair loss-related factors and enhancing skin hydration and barrier function through *in vitro* cell studies and clinical trials.

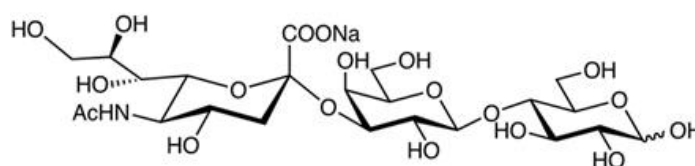


Figure 1. Structure of 3'-Sialyllactose Sodium Salt

3. Methods

In vitro hair loss-related studies were conducted using cultured HFDPC. Cells were maintained at 37°C under 5% CO₂ and cell viability was assessed using the MTT assay. Concentrations maintaining more than 90% cell viability were selected and the expression changes of hair loss-related inflammatory factors (IL-1α) and hair growth factors (IGF-1, EGF) were analyzed using qRT-PCR, compared with a negative control (medium) and a positive control (10 μM minoxidil).

The clinical trial investigating skin hydration and barrier improvement included 20 female participants with a mean age of 44.7 ± 9 years. Participants applied a cream containing 3'-SL 1% to the cheeks and forearms twice daily for two weeks. Skin hydration was measured using the Epsilon E100 and barrier improvement was assessed through transepidermal water loss (TEWL) measurements using the Tewameter TM300. Skin soothing effects against external stimuli (heat and mechanical irritation) were evaluated using the Antera 3D CS device. Statistical analysis was conducted by comparing the results before and after product use.

4. Results

In vitro studies related to hair loss showed that 3'-SL exhibited no cytotoxicity, maintaining over 90% cell viability up to a concentration of 1% (Figure 2a). qRT-PCR analysis revealed

that IL-1 α gene expression decreased by 42.2% compared to the negative control (Figure 2b). Moreover, IGF-1 gene expression increased by 85.3% (Figure 3a) and EGF gene expression increased by 83.3% (Figure 3b) in the 3'-SL-treated group compared to the control.

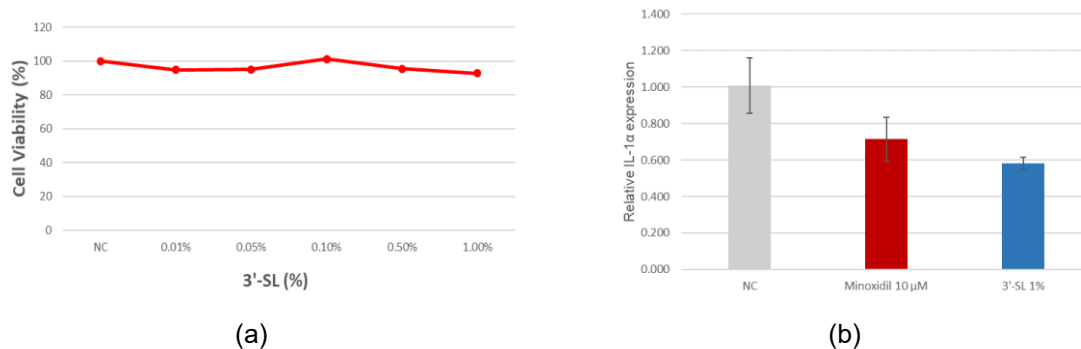


Figure 2. Results of cytotoxicity and inflammatory factor tests for 3'-SL (a) Cell viability at different concentrations of 3'-SL (b) Relative IL-1 α gene expression levels

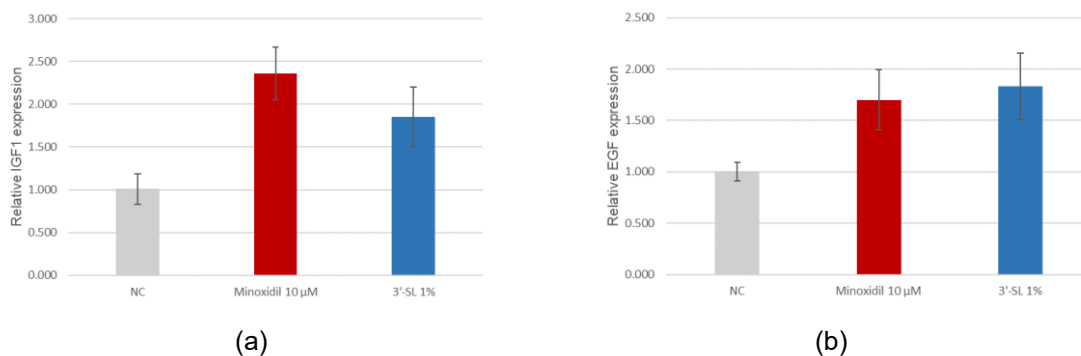


Figure 3. Results of hair growth factor tests for 3'-SL (a) Relative IGF-1 gene expression levels (b) Relative EGF gene expression levels

In the clinical study evaluating skin hydration and barrier improvement, skin moisture levels increased by 100.9% immediately after a single use and by 24.5% after two weeks of continuous use (Figure 4a). TEWL decreased by 7.9% immediately after use and by 13.5% after two weeks (Figure 4b).

Regarding skin soothing effects against external stimuli, the skin redness value after heat stimulation decreased significantly by 4.6% (from 12.3 to 11.7) in the test group after a single use, while no significant change was observed in the untreated group (Figure 5a). After mechanical irritation, the skin redness value decreased by 22.1% following a single application of the test product (Figure 5b).

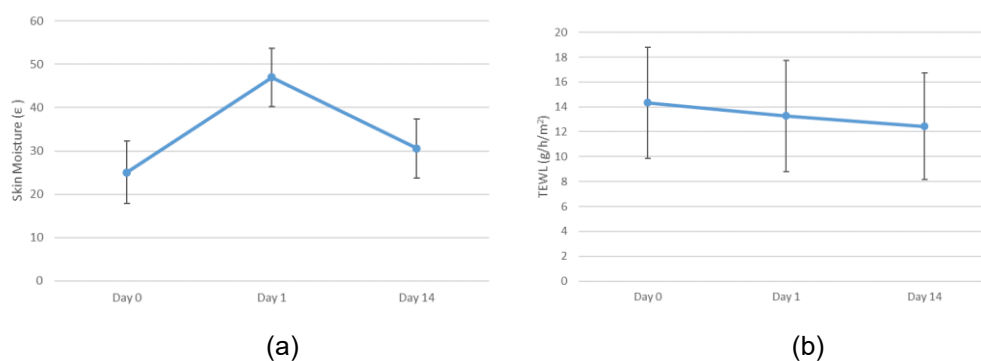


Figure 4. Results of skin hydration and barrier function measurements (a) Changes in skin hydration (ε values) (b) Changes in TEWL

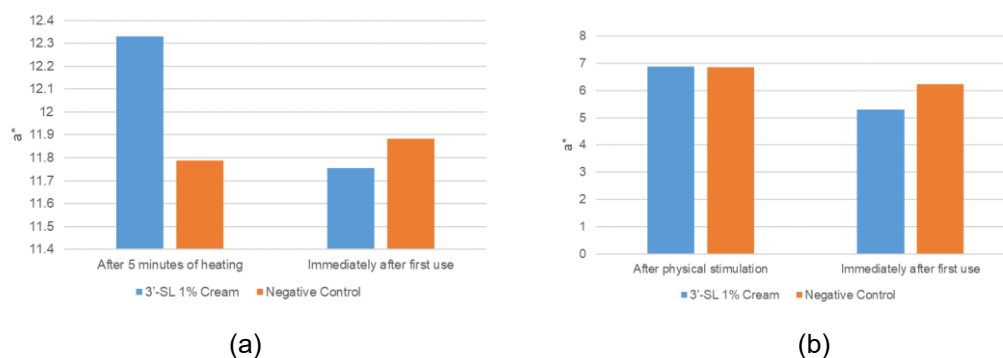


Figure 5. Soothing effects against external stimuli (a) Changes in skin redness value following heat stimulation (b) Changes in skin redness value following mechanical irritation

5. Conclusion

This study demonstrated that 3'-SL is an effective ingredient capable of simultaneously alleviating hair loss and improving skin hydration and barrier function. *In vitro* studies confirmed its potential through the suppression of inflammatory factor expression and the promotion of hair growth factor expression. In the human application study, significant improvements were observed in skin hydration, barrier reinforcement and soothing effects against external stimuli. 3'-SL offers a differentiated mechanism compared to existing cosmetic ingredients and shows promising potential for application in the development of new skincare and haircare formulations. Further research, including the development of various formulations and long-term safety evaluations, is warranted.

6. References

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