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“Touching Beauty: Transforming Skin Smoothness with Oryza sativa and Lithothamnium calcareum Extract”

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1. Introduction

Touch, although not classified as an emotion, powerfully influences our physiology—modulating brain activity, hormone levels, muscular responses, and mood in ways reminiscent of emotional states. Universally, gentle touch—like caressing a baby or pet—is associated with affection and care. Beyond its emotional significance, touch plays a central role in personal care practices such as skincare and massage, where sensations of smoothness shape user experience and perception. Understanding the biological and sensory mechanisms behind touch not only deepens our grasp of human affective responses but also offers valuable insights for the cosmetic industry, particularly in designing and marketing products that appeal to our sense of touch.

In this study, we investigate skin smoothness using an innovative bioengineering device designed to mimic the tactile sensing capabilities of the human finger. When a finger touches a surface, mechanoreceptors in the fingertip convert surface-induced vibrations into neural signals interpreted by the brain. This human fingertip device replicates this process, measuring the intensity of friction-induced vibrations—expressed in decibels (dB)—as a proxy for skin roughness: the lower the vibration signal, the smoother the skin.

Our objective was to assess changes in perceived skin smoothness on the forehead following application of an extract combining amylopectin of *Oryza sativa and Lithothamnion calcareum* (OSLC), previously reported as a strong moisturizing ingredient, comparing short-term (1 hour), medium-term (14 and 28 days), and post-discontinuation effects (33 days) versus a placebo. We also explored the involvement of specific mechanoreceptor frequency ranges.

This study provides a novel, sensory-driven approach to evaluating cosmetic product performance, linking objective tactile measurements with the subjective experience of smoothness while highlighting the biological and perceptual relevance of high-frequency mechanoreceptor responses and age-related tactile difference.

2. Materials and Methods

Study Design

A double-blind, randomized, *in vivo* study was conducted to evaluate the skin smoothness efficacy of OSLC using the human fingertip device. The study included 44 volunteers (20 men, 24 women) aged 25–68 years (mean: 47 years) with dry facial skin (corneometer < 70). Participants represented Fitzpatrick phototypes II–VI.

Application Protocol

The test area was the forehead (hemiface design: OSLC vs placebo). Each subject applied the active formulation (3% OSLC) to one side and a placebo to the other, with application side randomized. Products were applied twice daily (morning and evening) for 28 consecutive days. Skin acceptability was confirmed throughout the study.

Instrumental Assessment

Smoothness was assessed using the human fingertip device, a patented bioinspired device developed by the Tribology and System Dynamics Laboratory (LTDS), Ècole Centrale de Lyon. The device mimics human touch by measuring vibration signals (1–500 Hz) during finger-surface interaction, translated into roughness values in decibels (dB) [1]. The human fingertip is a highly sophisticated device, engineered to be compact, portable, and ergonomic (Figure 1, left). Its key feature is a tactile sensor ring designed to fit perfectly on the index finger, this device is equipped with miniature vibration and tracking force sensors (Figure 1, right). An expert operator moves across the volunteer's forehead three times to take and record three separate measurements for each volunteer. The experiment's outcomes demonstrated a robust correlation between recorded vibrations and expert group-assigned sensory classifications [2]. Data is processed by LTDS' algorithms converting the sound vibrations captured by the sensors into a measurable vibration level expressed in decibels (dB) equivalent. Consequently, these vibration signals are represented in dB and are correlated with noise. A higher dB value indicates greater roughness, while a lower dB value signifies a smoother surface.

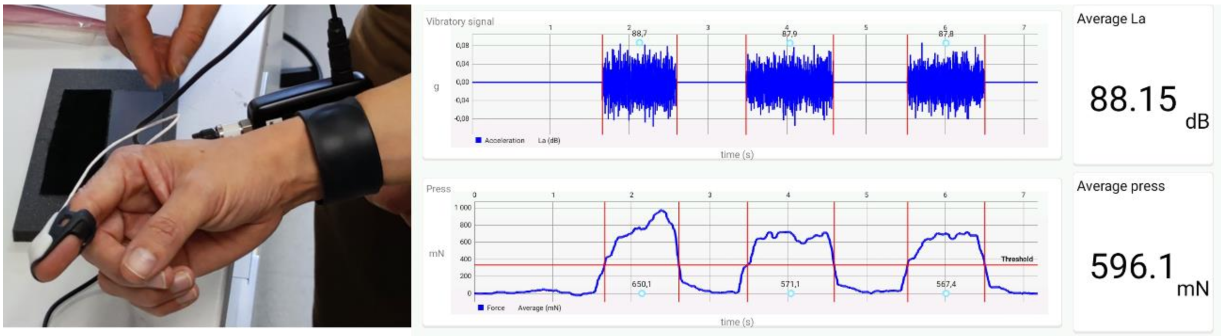

Figure 1. The human fingertipdevice, shown on the left, is inspired by the mechanics of the human finger and is designed to evaluate surface roughness. Shaped like a semi-circular ring, it fits onto the tip of the index finger, while a wireless transmitter worn around the wrist sends data to a tablet via Wi-Fi. On the right, an example of the data generated by the device is displayed.

Timepoints and Data Expression

Measurements were taken at T0 (baseline), T1h, T14d, T28d, and T33d (5 days post-treatment). Data were expressed as:

- Variation vs baseline: (Tn – T0)
- Difference in variation: OSLC (Tn – T0) vs Placebo (Tn – T0)

Statistical Analysis

Data were analyzed using Student's t-test for intra- and inter-group comparisons across timepoints. Significance was considered at $p < 0.05$.

3. Results

Skin Smoothness Evaluation Using human fingertip Technology

The *in vivo* assessment of skin smoothness was conducted using the human fingertip device, a bioinspired and sensor-equipped tool designed to mimic the tactile perception of a human finger. This study focused on comparing the skin's tactile properties following application of 3% OSLC versus a placebo formulation on opposing forehead hemifaces over a 28-day period, including a follow-up remanence evaluation at 33 days (5 days post-treatment discontinuation). The key parameter measured was the vibration signal expressed in decibels (dB), with lower values indicating smoother skinr. OSLC consistently demonstrated a reduction in vibration signal at all measured time points compared to placebo, indicating enhanced skin smoothness (Figure 2).

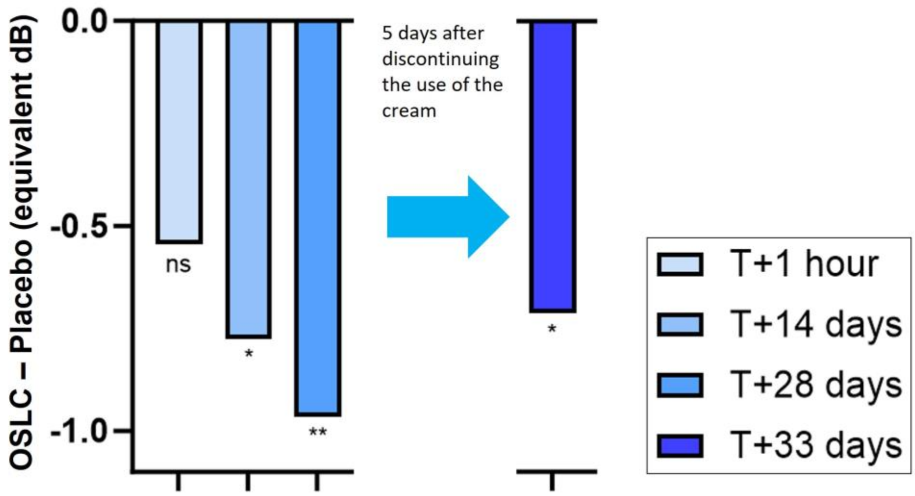

Figure 2. Skin smoothness revolution. This graph illustrates the subtraction of skin vibration signal (dB) between OSLC (Tn – $T0_{mean}$) and placebo (Tn – $T0_{mean}$) at all tested times: 1 hour (T+1), 14 days (T+14), 28 days (T+28), and 33 days (T+33) (remanence period, 5 days after the last application on day 28), where $T0_{mean}$ represents the mean of the triplicated values taken for each volunteer before the application cream (placebo or OSLC). Statistical analysis consisted in paired T-test. Statistical significance was set to * $p<0.05$ and ** $p<0.01$.

The reduction was evident from as early as 1 hour post-application (−0.54 dB), increasing at 14 days (−0.77 dB) and 28 days (−0.96 dB). Notably, the smoothness effect persisted even after discontinuation of the treatment, with a sustained decrease of −0.71 dB observed at day 33.

Frequency-Specific Mechanoreceptor Response

Physiological mechanoreceptors can be functionally categorized into two groups: rapidly adapting (RA) and slowly adapting (SA) mechanoreceptors [3, 4]. Meanwhile, LTDS correlates these mechanoreceptors with specific frequency ranges: low-frequency range (0.3 – 3 Hz) → Merkel cells; mid-Frequency Range (3 - 40 Hz) → Meissner's corpuscles; mid-High Frequency Range (15 - 400 Hz) → Ruffini endings; high-Frequency Range (100-500 Hz) → Pacini corpuscles. Vibrational analysis across the different frequency ranges associated with skin mechanoreceptors showed a significant decrease in noise levels. The most significant reduction occurred in the high-frequency range (100–500 Hz), which is linked to Pacinian corpuscles—mechanoreceptors that detect rapid skin vibrations and are key to sensing roughness [2]. In this range, noise levels dropped by −1.65 dB after 1 hour, −1.94 dB after 14 days, −1.99 dB after 28 days, and −1.54 dB after 33 days (Figure 3). These results strongly indicate an improvement in skin smoothness, as perceived by human touch.

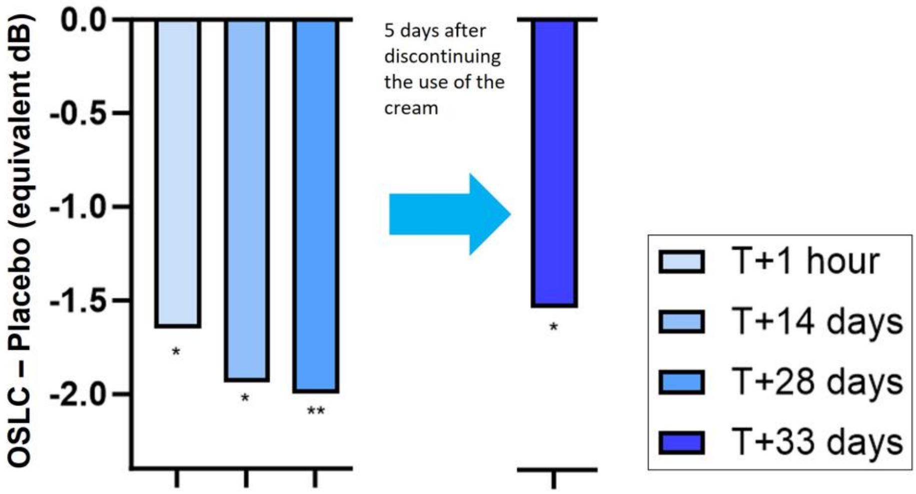

Figure 3. Skin smoothness evolution related to high-frequency range (100 – 500 Hz) associated with Pacinian corpuscles. This graph illustrates the subtraction of skin vibration signal (dB) between OSLC ($Tn - T0_{mean}$) and Placebo ($Tn - T0_{mean}$) at all tested times: 1 hour (T+1), 14 days (T+14), 28 days (T+28), and 33 days (T+33) (remanence period, 5 days after the last application on day 28). Statistical analysis consisted in paired T-test. Statistical significance was set to * $p<0.05$ and ** $p<0.01$.

Decibels in the Context of the human fingertip device measurements

To contextualize the significance of a 1 dB reduction in our human fingertip deviceresults, we conducted an analysis of baseline (T0) data collected from volunteers prior to the application of either placebo or OSLC. For comparative purposes, participants were divided into two distinct age groups: 25–39 years and 50–69 years. The analysis revealed an average difference in skin smoothness of approximately 1 dB between these two groups—a difference that was statistically significant (Figure 4).

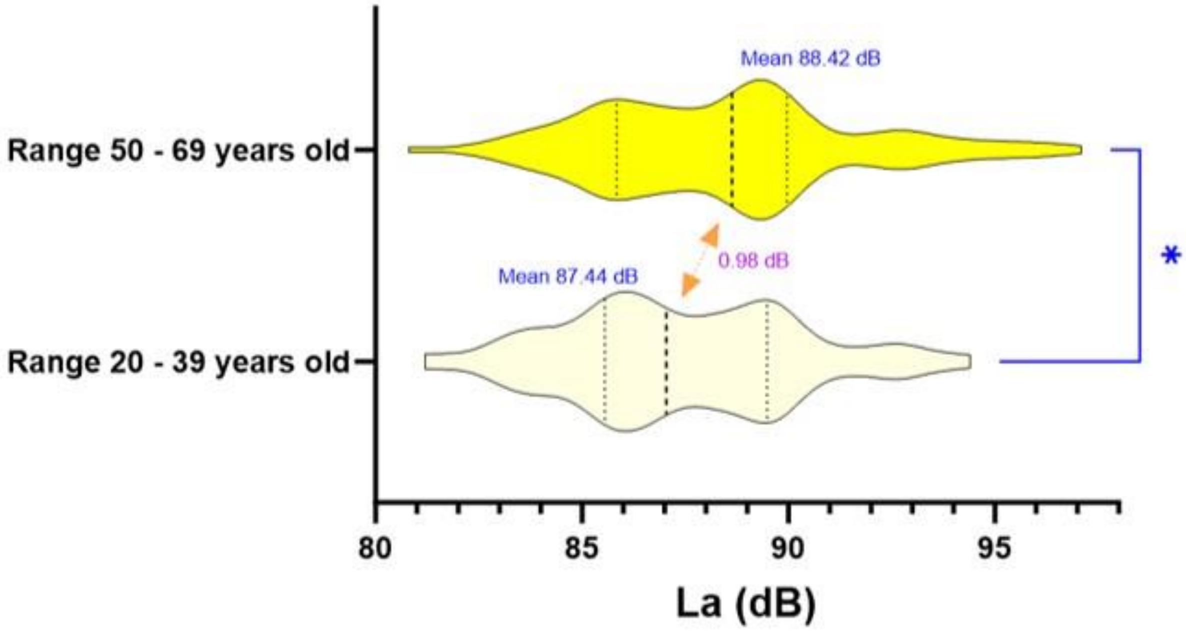

Figure 4. Comparison of vibration signals (dB) detected by the human fingertipdevice across two age groups: 25–39 years and 50–69 years. A statistically significant increase in vibration signal was observed in the older group, indicating higher perceived skin roughness. Notably, the average difference between the groups (~1 dB) corresponds to the level of improvement achieved after OSLC application, suggesting a rejuvenating effect equivalent to a shift from mature to younger skin in terms of tactile perception.

Our previous findings demonstrated that treatment with OSLC led to a 1 dB reduction in skin vibration signal. This magnitude of change corresponds to the natural difference in skin smoothness observed between younger (25–39 years) and older (50–69 years) individuals. Therefore, the improvement in skin texture following OSLC application can be interpreted as an enhancement equivalent to a shift from mature skin to a younger skin profile, suggesting a rejuvenating effect at the tactile level.

4. Discussion

This study provides compelling evidence that OSLC significantly enhances skin smoothness, as measured by a sophisticated tactile biomimetic system. The human fingertip device allowed for the quantification of vibrational signals that correlate with human tactile perception, especially those processed by Pacinian corpuscles, known for their sensitivity to high-frequency skin deformation.

The sustained smoothness observed even five days after stopping treatment suggests that OSLC promotes biological effects that persist beyond mere occlusion or short-term hydration. This long-lasting effect distinguishes OSLC from other moisturizing agents and underscores its potential as a high-performance active ingredient in cosmetic formulations.

These results are in line with earlier studies on skin biomechanics and tribology, particularly those highlighting the role of vibrational frequencies in sensory feedback [2,5]. Our data further expand on this by offering quantitative values specific to cosmetic application scenarios and by confirming the human perceptual relevance of changes in high-frequency vibration profiles.

5. Conclusion

OSLC demonstrated a clear, consistent, and statistically significant enhancement of skin smoothness as assessed by the human fingertiptactile metrology device. Vibrational signal reduction in the 1–500 Hz range, and particularly in the high-frequency band linked to Pacinian corpuscles, revealed that OSLC treatment led to skin texture changes perceptible to human touch. The efficacy was observed as early as one hour after application and persisted five days after cessation of product use, indicating both immediate and long-term benefits. Its ability to deliver perceivable softness highlights its potential to elevate both functional and sensory dimensions in skincare formulations.

6. References

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