International Journal of Research in Dermatology
Madhavi MSL et al. Int J Res Dermatol. 2026 Nov;12(6):553-558
https://www.ijord.com

DOI: https://dx.doi.org/10.18203/issn.2455-4529.IntJResDermatol20263734

Original Research Article

Efficacy of hybrid sun protection gel in improving skin biophysical parameters: a short term clinical study

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Received: 07 July 2026
Revised: 04 August 2026
Accepted: 30 September 2026

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ABSTRACT

Background: Skin is the largest organ of the human body and protects the internal organs. Skin takes the impact of multiple environmental factors, especially ultraviolet radiation from sun and is subjected to damage, manifesting as pigmentation, dryness, wrinkles etc., compromising over all skin health. Personal care industry offers sunscreens with different levels of sun protection factors (SPF) in different formats. Sun care market is rapidly growing, however there are some unmet needs of consumers like sticky/ tacky or oily feel from sunscreens preventing the usage on skin for longer duration or usage in humid weathers. The present clinical study is designed to evaluate the efficacy of test product (sun protection gel) for sun protection, with consumer acceptable sensory and other skin benefits like hydration, brightness, glow and smoothness in Indian female volunteers suffering from dull skin.
Methods: SPF study was conducted in healthy humans as per Indian BIS guidelines to establish sun protection factor. Skin benefit studies were conducted in healthy female volunteers with dull skin to assess improvement in various skin biophysical parameters, visual assessments by dermatologist and feedback from study participants on efficacy and sensory.
Results: Test product demonstrated, SPF 50 and improvement in skin brightness, glow, hydration and smoothness immediately after application of product which lasted up to 24 hours above the baseline levels.
Conclusions: The present sun care leave-on test product demonstrated an SPF 50 along with improved visual and biophysical parameters of skin, with no undesirable sensory on skin and side effects.

Keywords: Sun protection, Hydration, Light sensory

INTRODUCTION

Sun protection is one of the fastest growing segments in the global beauty and skincare industry, driven by rising consumer awareness of photoaging, hyperpigmentation, and long-term UV induced skin damage. Despite this momentum, sensory drawbacks remain a major barrier to sunscreen usage and adherence. Traditional high SPF formulations typically rely on oil rich UV filters that can feel heavy, sticky, or greasy, sensory attributes that could be discomforting in hot and humid weather such as Indian climate.

Sensory attributes such as texture, dry touch, appearance post use, fragrance strongly influence sunscreen usage habits, and this has been validated by multiple consumer surveys. In a 300 subjects consumer study conducted by Vergilio et al, 56.7% reported the feel and appearance on skin as the least pleasing aspect of sunscreens due to greasy film, shine, residue and the reasons cited for consumers not using sunscreens are primarily due to

sensory which becomes a great purchase motivator.[1] Another global analysis of 73 commercial sunscreens conducted by Volhardt et al in 2021 found that only a few products achieved the coveted "dry touch" feel that a large segment of consumers desire, contributing to underuse or insufficient application of sunscreen among the public.[2]

These findings emphasize that an ideal sunscreen must be effective, light, non-greasy, non-oily, quick-absorbing and invisible on the skin, no white cast, to ensure people apply it in the correct amount and reapply as needed. This calls for increased research and development on improving sunscreen formulas that are climate adaptive which can satisfy the sensorial needs apart from sun protection benefits.

Formulating high efficacy broad spectrum sunscreen that delivers a sensorial delight is challenging. High UV protection typically requires addition of active organic sun filters, most of them being oil soluble or adding mineral ingredients, which would impart an oily sticky feel or leave a white cast reside post use. Formulation scientists are today leveraging new age actives, polymers, emulsifier systems which not only delivery sun protection but also provide delightful sensory / pleasant experience. Sensorial drawbacks during use can also act as a barrier, preventing consumers from applying the recommended dosage resulting in sub optimal sun protection. Portilho et al concluded that formulation vehicle and sensory are fundamentals to ensure consumer applies right amount of sunscreen for sun protection.[3]

Recent advances in formulation science are reshaping the sunscreen product design landscape, enabling hybrid products that deliver both high-performance UV defense and desirable skincare benefits like brightening, hydration etc. Globally, there is increasing demand for 'multifunctional' sunscreens that can effectively maintain sun protection efficacy while offering superior sensorial profiles.

For hot, humid and high sweat environments, innovations such as lightweight gels, gel crème's, fluids, sprays and other formats that avoid tackiness and deliver mattifying end feel are desirable. Conversely, in colder or drier climates, sunscreen creams with integration of barrier supportive ingredients like ceramides, humectants, waxes/emollients work well to give sun protection and barrier repair, and moisturization benefits.

The present test product was designed specifically to overcome traditional sensory barriers like sticky/oily feel with high SPF protection. Through thoughtful ingredient selection and optimized sensory design, the formula delivers high *in vivo* UV protection, brightening benefits, and pleasant sensorial experience (lightweight, smooth, and non-sticky feel). The present clinical study examines the sun protection efficacy and improvement in skin biophysical parameters in subjects with dull skin.

METHODS

Ethics and informed consent

Present clinical study was carried out as per GLP and ICH guidelines in compliance with the local government regulations. The study was reviewed and approved by independent ethics committee in India and an informed consent was obtained from all study subjects. SPF and UVA protection studies were executed between July-September, 2025 at MS Clinical research, Bangalore, India and clinical efficacy of test product on skin biophysical parameters was conducted in December 2025 at Mascot Spin control India Pvt Ltd, Mumbai, India.

SPF testing

The sun protection factor (SPF) of the test product (Sun protection gel) was determined by standardized method that evaluates human skin from erythema (skin redness) upon exposure to ultraviolet radiation from a solar simulator equipped with xenon arc lamp. SPF testing was performed on 10 healthy volunteers as per guidelines ISO 24444:2019/Amd.1:2022(E) and IS 17494: 2021. This is a single centre, double blinded, randomized and controlled study.

The study was conducted for a total of 4 visits for each trial participant at the study site. Sun protection gel application, UV exposures and MED assessment were carried out in stable conditions at the room temperature maintained at 23±3 °C. UVA protection was measured on basis delayed tanning response on human volunteer as per BIS method IS 17492:2021, basis ISO guidelines, ISO 24442:2022(E) for UVAPF testing on human participants.

Skin benefits clinical design

The study was a blinded, split face and monocentric. Once side of face served as untreated site with no application of the test product, whereas other side of the face served as treatment site with test product (Sun protection gel) applied twice with a gap of 4 hours (as SPF products are generally recommend applying at least twice during daytime. Subjects were recruited as per inclusion and exclusion criteria. Only female volunteers with dull skin were recruited in the age group of 20-45 years. Pregnant and lactating women were excluded from the study.

Volunteers with any skin related problems or allergies that can potentially interfere in the study results were also excluded from the study as per the dermatologist's discretion. Subjects have undergone wash-out period of 3 days and were provided with a neutral cleanser during that time. Volunteers were restricted from using any skincare products during the study period. Post wash out, only those subjects meeting the inclusion and exclusion criteria were proceeded into treatment phase. Total of 36

participants qualified for treatment phase all of them completed the study.

On the baseline visit, subjects were acclimatized for 15 minutes, followed by dermatologist's visual assessment for skin dullness/glow and instrumental assessments like brightness by Spectrophotometer CM-26d (Konica Minolta, Japan), hydration by Corneometer CM 825 (Courage and Khazaka, Germany), smoothness (Antera 3D image analysis). Visual, skin dullness scale was used to assess the reduction in dullness by dermatologist (i.e., improvement in skin glow) on a scale 0 to 9, higher the value, more the dullness).

Study duration was for 24 hours, improvement on various attributes were measured instantly after first application of the product, after 4 hours, 8 hours and 24 hours. Measurements were taken both on untreated and treated sites at all assessment time points. Consumer assessment on product efficacy and sensory was taken on attributes like overall satisfaction on product efficacy and sensory like smell, texture and consistency.

Demographics of the study volunteers

Total 36 subjects were enrolled and all completed the study. Efficacy of the test Sun protection gel was assessed by dermatological, instrumental and image analysis.

Statistical analysis

All statistical tests for clinical data were performed at two-sided 5% level of significance & 95% confidence interval and Statistical software PAST 4.03 and SigmaStat 3.5 were used for the analysis of the data. Paired t-test was used to evaluate the efficacy of the product.

RESULTS

SPF and UVA protection results

An average of 10 volunteers' data was used to assess the efficacy of the Sun protection gel and established value to be SPF 50 and UVA protection of PA++++ indicating broad range sun protection offered by the present Sun protection gel.

Table 1: Demographics and volunteers characteristics at baseline for biophysical assessments.

Age range	20-45 years (inclusive both the ages)
Gender category, number of participants	Female, 36
Race and ethnicity	Asian, Indian

Skin visual and biophysical parameters

Skin brightness

Skin brightness was assessed by L* (luminescence) using Spectrophotometer. There is significant improvement in skin L* instantly, with sustained higher levels at all assessment time points up to 8 hours. Skin remains above baseline till 24 hours on test Sun protection gel treated site (Figure 1) whereas no considerable change in the brightness on the untreated site.

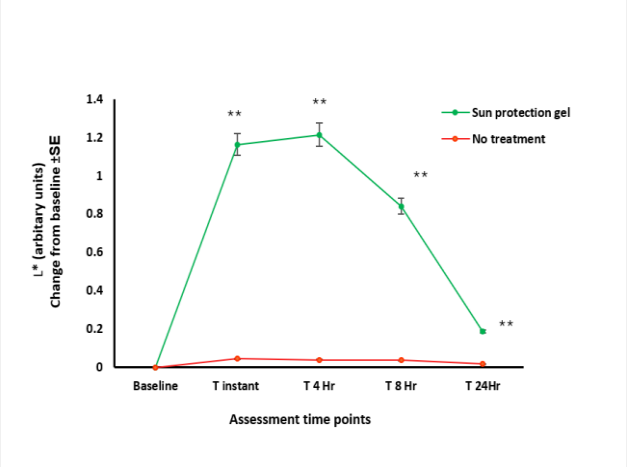


Figure 1: Skin brightness (measured by L*) - data expressed as change from baseline ± SE; ** p<0.05 vs baseline).

Skin dullness

Skin dullness was assessed based on dermatological visual assessment on a scale of 0-9 (0 is highest glowing skin and 9 is very dull skin). There is an instant reduction in dullness and remained below baseline line levels till 24 hours (Figure 2). There is no change in the dullness on the untreated site (no treatment site) at any studied time point.

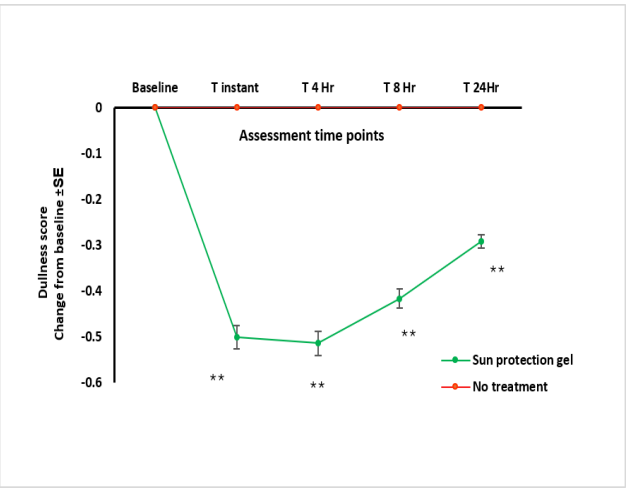


Figure 2: Dullness score (to measure glow); data expressed as Change from baseline ± SE; ** p<0.05 vs baseline).

Skin hydration

Hydration was measured using Corneometer. There is significant improvement in skin hydration instantly by 70% (vs baseline) on Sun protection gel treated site, which remained above baseline levels till 24 hours (Figure 3). There is no considerable change in skin hydration on the untreated site from baseline to 24 hours assessment time points.

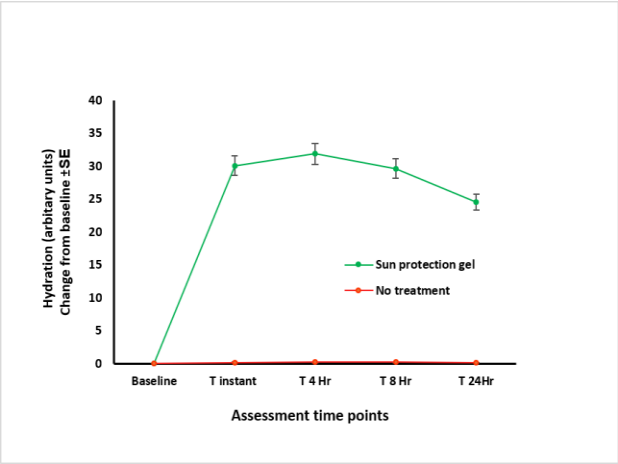


Figure 3: Skin Hydration; Data expressed as Change from baseline ± SE; ** p<0.05 vs baseline).

Skin roughness

Skin roughness was measured using Antera3D image analysis. There is an instant reduction in skin roughness (i.e., statistically significant improvement in smoothness) on Sun protection gel treated site, which remained above baseline line levels till 24 hours (Figure 4) and is significantly high compared to untreated site at all assessment time points. There is no considerable change on skin smoothness on the untreated site from baseline to 24 hours assessment time points.

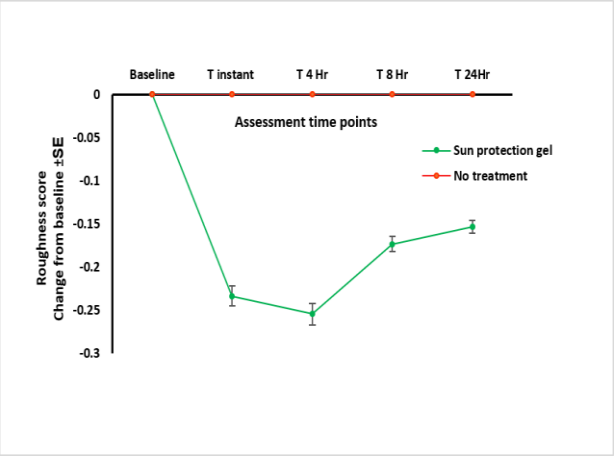


Figure 4: Skin Roughness; Data expressed as Change from baseline ± SE; ** p<0.05 vs baseline).

Study participant's feedback

Product sensory and efficacy was captured based on participant's feedback. 100% of the participant's felt product is non-sticky and non-greasy. None of the participants experienced white cast or white patches on the face after application of the product. More than 90% of the participants agreed that product provided hydration, made skin smoother and enhanced glow and product sensory (Figure 5).

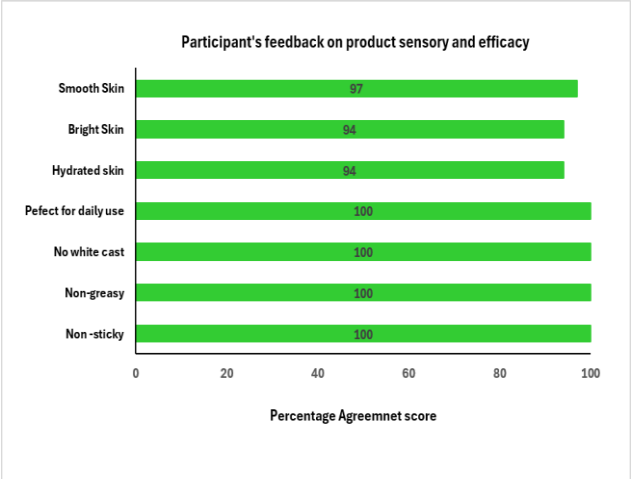


Figure 5: Participant's feedback (agreement) on product sensory and efficacy; Data expressed as mean percentage agreement.

DISCUSSION

Human skin is the first line of defense made up of two different layers dermis and epidermis. Epidermis and its sub layers protect the internal organs by acting as physical barrier to external environment, encountering biotic and abiotic stressors (UV radiation, extreme weather and pollution) on regular basis.[4] While macro molecules of skin like collagen, keratin, elastin and glycoproteins offer structural integrity,5 it is also endowed with an array of biochemical machinery in different layers of epidermis like photo-protective pigment eumelanin, enzymatic antioxidants (superoxide dismutase, glutathione peroxidase, and glutathione) along with non-enzymatic antioxidant (Vitamin E and Vitamin C), anti-microbial peptides, lipids, natural moisturizing factor(NMF) generating proteases and exfoliating enzymes that maintain optimum pH to balance the natural microbiome and to keep the skin healthy.[5-8]

Upper layers of human skin is endowed with special pigment (melanin) producing cells, the melanocytes to offer photoprotection.[9] Melanin is a highly stable polymeric pigment made with phenolic and indolic compounds, provides photoprotection to UV labile molecules like DNA, folates and other molecules in human skin.[10] While exposure to UV radiation is essential to synthesize vitamin D, which plays an

essential role in bone metabolism, immune response and differentiation, excess of exposure causes photo aging, immune suppression, and increases risk of skin cancers in susceptible skin types.[11,12] Acute exposure to UV radiation causes erythema and freckles in lighter skin tones population whereas moderate skin tones tend to tan leading to uneven skin tones.[13,14]

Human exposure to solar radiation is highly variable due to geographical location, seasonal changes, lifestyle and social-economic factors. However, the differential response to sun light specifically UV radiation determines the risk and degree of damaging effects on skin. Overall, in all skin types and across geographical locations chronic exposure to UV radiation is damaging, and leads to pigmentation disorders, immune suppression, photo aging and increases cancer risk which can cause considerable health burden.[15]

There is compelling scientific evidence of UV induced damage effects at cellular level in skin cells like accumulation of cyclobutene pyrimidine dimers (in keratinocytes), redox imbalance, upregulation of inflammation, collagen and elastin degradation,18 development of mutated cells increasing the risks of cancer/solar keratosis/premature aging/immune suppression/ photo damage in skin.[16-20] This prompted the scientific community to advocate and introduce photo protection into human skin care routine, which has become a part of personal care product category.

While market is flooded with well-established sun protection range of products with different levels of SPF from 15-70 in different formats, there is an increasing consumer demand for additional skin benefits like glow, brightness, hydration, soft and supple skin from the same product. The present test product/formula is designed to meet the aspirational sun protection with added glow and hydration benefits for the evolving consumers. Sun care products are designed for photoprotection to skin against UV B and UV A radiation from solar rays. The present Sun protection gel designed with optimum levels of organic and inorganic sun filters demonstrated the sun protection factor of 50 and PA++++, providing holistic sun protection as per standard methods.

Natural water content (moisture) of human stratum corneum is 15-20% and increases with the depth to reach to a maximum of 70% at the viable region of the epidermis.[21] Exposure to extreme weather conditions like dry and cold causes xerosis (dryness) making skin rough, itchy and hence need to be replenished with sufficient moisture. Humid and sultry weather makes consumers cleanse face multiple that can strip off natural skin moisture. Moreover, consumers with oily skin tend to wash their face multiple times to keep the skin oil-free, which can wash off of the natural moisture holding NMF in the skin, thus making hydration an expected consumer benefit from sun protection products. Glycerol is gold standard humectant to impart moisturization in skin.[22,23] The present sun protection gel is crafted with optimum level of glycerol and propylene glycol to deliver sustained hydration. In the present clinical study, test product the sun protection gel, improved skin hydration instantly by 70%, with sustained moisturized skin till 24 hours, with 100% of users showing improved hydration.

Skin texture as assessed by 3D imaging, showed improved smoothness instantly after application of the product with sustained smoothness till 24 hours and with 100% study participants agreeing that product makes skin smooth instantly. One of the traditional barriers of sunscreen has been oily and sticky sensory. To optimize the sensorial experience, the formula leverages silicone-based sensory modifiers and fine silica.[24] These sensory modifiers impart a smooth, dry-touch finish and help mitigate common consumer complaints associated with sunscreens, such as tackiness, heaviness, or pilling during application. The result is a high-efficacy sunscreen with a refined sensorial profile that supports daily wear, particularly in hot and humid climates.

Limitations

Present clinical study is a split face comparative (treatment vs untreated) design, however a longer duration study with higher sample size, including men can bring more scientific value in demonstrating the long-term benefits of such hybrid products.

CONCLUSION

The present sun protection gel addressed the sensory barrier and need of additional skin care benefits in combination with high UV protection of SPF50 making it holistic hybrid sun protection product. In concurrence with clinical assessments, more than 93% of the participants felt the test product provides hydration, glow and smoother skin without any stickiness or oily feel or white cast on the skin. None of the study participants experienced any undesirable skin feeling like itchiness or redness/irritation after using the test product indicting the product is safe to use.

ACKNOWLEDGEMENTS

The authors would like to acknowledge and thank MS Clinical Research, Bangalore, India and Mascot Spincontrol India Pvt Ltd., Mumbai, India for conducting Clinical Studies.

Funding: No funding sources
Conflict of interest: None declared
Ethical approval: The study was approved by the Institutional Ethics Committee

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Cite this article as: Madhavi MSL, Duggal C, Pawar A, Punyani S. Efficacy of hybrid sun protection gel in improving skin biophysical parameters: a short term clinical study. Int J Res Dermatol 2026;12:553-8.