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Original Article

Development & Efficacy Evaluation of a Lip Oil Stain with Hyaluronic Acid (2%), Vitamin C (1.5 %), Australian Lemon Peel Oil (0.4%), Menthol & SPF 15

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ABSTRACT

The creation and thorough effectiveness assessment of a multipurpose lip oil stain containing hyaluronic acid (2%), vitamin C (1.5%), Australian lemon peel oil (0.4%), menthol, and an SPF 15 UV protection system are reported in this study. The formulation was created to offer hydration, antioxidant protection, sensory appeal, pigment enhancement, and photoprotection all in one hybrid cosmetic system because of the anatomical vulnerability of the lips. After evaluating the product's rheological qualities, physicochemical stability, and in vitro SPF and MPF, 100 healthy volunteers were evaluated for dermatological safety and in vivo clinical efficacy. The formulation showed good stability under stress, positive sensory qualities, and broad-spectrum photoprotection with an in vitro SPF of 15.2 ± 1.1. Significant improvements in lip hydration, surface smoothness, brightness, and tone uniformity were found after clinical examination. Non-irritating behavior was confirmed by a 48-hour closed patch test (PII = 0.00). Overall, the findings validate the formulation as a lip oil stain that is safe, effective, and scientifically proven to have both functional and cosmetic advantages.

Keywords: *Lip Oil Stain; Hyaluronic Acid; Vitamin C; Australian Lemon Peel Oil; Menthol, SPF 15.*

Introduction

Lips differ from keratinized facial skin in that they are a distinct semi-mucosal anatomical structure with distinctive pharmacological and pathophysiological properties. A significantly thinner and less keratinized stratum corneum, low intercellular lipid content, and the lack of functional sweat and sebaceous glands are characteristics of the vermilion zone. Transepidermal water loss (TEWL) from the lips is consequently much greater, making them more vulnerable to xerosis, fissuring, and compromised barrier function. The vulnerability to UV-induced oxidative stress, inflammation, pigmentary changes, and premature photoaging is further increased by decreased melanin density and diminished photoprotective potential [1].

Pharmacologically speaking, the lip epithelium's high permeability improves topical actives' penetration while also making it more susceptible to irritants and environmental disturbances. By restoring hydration through hygroscopic water binding and the creation of a viscoelastic hydration film that makes up for lipid deficiencies, humectants like hyaluronic acid have therapeutic benefits. Antioxidants such as vitamin C enhance the integrity of the extracellular matrix by promoting collagen manufacturing, reducing UV-induced reactive oxygen species (ROS), and modifying melanogenic signaling. Lip discolouration and oxidative damage are addressed with aromatic botanicals high in flavonoids and terpenoids, which also improve formulation stability and have anti-inflammatory, antibacterial, and tyrosinase-modulating properties [2].

Menthol and other sensory modifiers work with labial sensory neurons' TRPM8 ion channels to produce cold sensations and temporary vasodilation that improve the appearance of lip color and volume. In the meanwhile, it is pharmacologically justifiable to include UV filters in order to lessen the damage that UVA and UVB radiation causes to DNA, lipid peroxidation, and melanocyte dysregulation. When humectants, antioxidants, botanicals, sensory agents, and photoprotective systems are logically combined, lip cosmetics become functional dermato-cosmetic delivery systems that address the underlying pathophysiology of lip vulnerability and improve clinical outcomes, consumer confidence, and long-term compliance [3].

Hyaluronic Acid: Acts as a potent humectant to retain water in the lipid-poor lip surface, improving hydration and plumpness. Topical HA-based cosmeceuticals are widely utilized for hydration and rejuvenation since they encourage moisture retention and smooth texture [4].

Hyaluronic acid (HA) has a linear, unbranched polymeric backbone and is a high molecular weight, non-sulfated glycosaminoglycan. Interestingly, its fundamental chemical structure has been preserved throughout evolution and is essentially the same in a variety of prokaryotic species as well as mammalian tissues. The polymer is made up of repeating disaccharide motifs made up of β-D-glucuronic acid and β-D-N-acetylglucosamine, which are linked alternatively by β-(1→4) and β-(1→3) glycosidic bonds. This distinctive alternating linking pattern adds to the macromolecule's extended chain architecture and gives it conformational stiffness [5,6].

The presence of carboxyl, hydroxyl, and acetamido functional groups along the polymer chain, which promote extensive hydrogen bonding and hydration shell formation, accounts for HA's remarkable hydrophilicity and aqueous solubility. In solution, HA takes on an ordered double left-handed helical shape that is maintained by a web of electrostatic interactions and hydrogen bonding both inside and between molecules. HA's viscoelastic behavior, high water-retention capacity, and crucial involvement in extracellular matrix organization, cellular signaling, and lubricating processes in biological systems are all explained by its supramolecular structure [7,8].

Vitamin C (Ascorbic Acid): This powerful antioxidant may help scavenge free radicals and increase tone uniformity by participating in tyrosinase-linked pathways, despite the lack of direct clinical proof on lips. Together, vitamin C and HA support hydration and protection [9].

Vitamin C (ascorbic acid) levels are significantly higher in healthy human skin; tissue concentrations are similar to those in metabolically active organs and significantly higher than plasma levels in circulation, suggesting the existence of controlled, energy-dependent absorption processes. The majority of cutaneous vitamin C is found in intracellular compartments, where concentrations are typically in the millimolar range. This implies that vitamin C is necessary for sustaining cellular redox balance and encouraging biosynthetic activity [10,11].

Ascorbic acid is transported to the skin by the dermal microvasculature, where it is actively transported into dermal and epidermal cells by a number of sodium-dependent vitamin C transporters, primarily SVCT1 and SVCT2, which are expressed on fibroblasts and keratinocytes. Despite its physiological importance, quantitative data on cutaneous vitamin C concentration are still scarce and highly variable in the literature. The reported numbers from independent research can differ by up to an order of magnitude. Variations in analytical methods, tissue sampling depth, anatomical site, age, nutritional status, and environmental exposure are likely the reasons for this discrepancy. Standardized measurement methods are required to have a better understanding of the biological distribution and functional significance of vitamin C. The dynamic regulation of vitamin C homeostasis in the skin is highlighted by this variability [12,13].

Australian Lemon Peel Oil: Rich in phenolics, terpenoids, and flavonoids with antioxidant, antimicrobial, and tyrosinase-inhibitory properties, perhaps promoting lip health and pigment modulation [14].

In lip oil stain formulations, flavonoids, terpenoids, and phenolic compounds are versatile bioactives that combine with humectants, emollient oils, and film-forming substances to offer both medical and cosmetic benefits. These phytochemicals improve the oxidative stability of an oil-based or biphasic system by preventing lipid peroxidation, shielding the biologically sensitive lip epithelium from oxidative stress in the environment and preserving color integrity, aroma quality, and shelf life [15,16].

The semi-occlusive oil matrix prolongs the residence period of these actives on the lip surface, allowing for extended contact with the thin stratum corneum-like barrier of the lips. Flavonoids and phenolics have potent antioxidant and anti-inflammatory qualities that lessen irritation caused by colors, flavoring chemicals, menthol, and UV exposure in addition to encouraging epithelial repair and hydration. In order to regulate melanogenic reactions and eventually restore normal

lip tone and pigment, stain-based lip cosmetics' tyrosinase-modulating function is essential [17].

Terpenoids further increase the sensory and functional performance of lip oil stains by increasing microcirculation, adding mild plumping effects, and encouraging the penetration of co-formulated hydrophilic actives such hyaluronic acid and vitamin C into the semi-mucosal lip tissue. HA forms a hydrated polymeric network at the oil–skin interface with humectants, promoting water retention and lip smoothness, while vitamin C supports collagen formation, antioxidant defense, and photoprotection [18]

The addition of phytochemical antioxidants to a structured lip oil stain system allows for controlled pigment deposition, sustained color adherence, enhanced lip barrier function, and extended moisturization. This multifunctional approach, which presents lip oil stains as both decorative and medicinal products that promote both immediate aesthetic appeal and long-term lip health, is consistent with current hybrid cosmetic trends [19,20].

Menthol: Provides sensory cooling and mild circulation enhancement; widely used in lip formulations for refreshing feel and perceived plumping.

Menthol functions as a bioactive sensory modulator in lip oil stain formulations primarily by interacting with transient receptor potential melastatin-8 (TRPM8) ion channels, which are expressed on the sensory nerve ends of the labial epithelium. The customer feels more at ease and refreshed when TRPM8 is turned on since it produces a discernible cooling effect without really lowering the temperature. By encouraging cutaneous microcirculation, menthol also produces mild vasodilation at low, carefully controlled doses, temporarily increasing blood flow to the lips. This physiological reaction improves lip coloration and has a slight plumping effect, which increases the formulation's staining activity [21-23].

In an oil-based lip stain solution, menthol's modest lipophilicity allows for uniform dispersion within the oil phase, ensuring continual sensory release and minimizing discomfort. Additionally, menthol possesses slight penetration-enhancing properties that could enhance the distribution of co-formulated actives like humectants or antioxidants, improving both the functional and cosmetic performance of the lip oil stain.

SPF 15 System: UV protection is critical because lips are susceptible to UV damage, pigmentation, and photoaging; SPF15 offers basic UVA/UVB defense in daily use.

It is scientifically justified to incorporate an SPF 15 UV protection system in a lip oil stain due to the unique anatomical and physiological fragility of the lip vermilion. Compared to facial skin, lips have a much thinner stratum corneum, less melanin, and no functional sweat or sebaceous glands, making them more susceptible to UV-induced oxidative stress, inflammation, and barrier disruption. Long-term UVA and UVB exposure induce melanocyte dysregulation, which leads to hyperpigmentation, increases the breakdown of collagen, and contributes to early photoaging, which manifests as dryness, loss of elasticity, and small perioral lines [24,25]

An SPF 15 system provides effective baseline daily protection by lowering UVA-mediated reactive oxygen species (ROS) production and UVB radiation that causes erythema. In order to maintain lip moisture, stabilize color deposition, and prevent UV-induced pigment alteration, UV filters collaborate with emollient oils and antioxidants in a lip oil stain. Thus, SPF 15 ensures cosmetic endurance while also promoting long-term lip health and photoprotection under frequent outdoor exposure [26,27].

Materials and Methodology

Materials

Hyaluronic Acid, Vitamin C (Ascorbic Acid), Australian Lemon Peel Oil, Menthol, SPF 15 System all chemicals are procured from Sigma Aldrich of analytical grade.

Methodology

Formulation Development: The oil phase was formed by precisely weighing and combining all oil-soluble ingredients, including caprylic/capric triglycerides (q.s.), approved oil-soluble UV filters (such as cinnamates and octocrylene, at levels calculated to achieve SPF 15), Australian lemon peel oil (0.4%), and menthol (0.15 %). The oil phase was then gently heated to 60–70 °C while being continuously stirring to ensure phase homogenization. To avoid agglomeration, hyaluronic acid (2%) was dispersed in a suitable carrier system (liposomal or PEG derivative) to create the humectant phase concurrently [28]. Heat-sensitive components, including the pre-dispersed hyaluronic acid, a stabilized oil-compatible vitamin C derivative (like tetrahexyldecyl ascorbate or ascorbyl palmitate), and compatible flavor/aroma components, were added gradually while being gently stirred to ensure uniform distribution without thermal

degradation after the oil base had cooled to below 40 °C. Degassing was an optional step to eliminate trapped air after final mixing produced a clear, homogenous oil formulation free of visible particulates or phase separation. The finished product was put into suitable containers and subjected to stability tests (temperature cycling, phase separation, and clarity) after being cleaned. The SPF 15 claim was confirmed using in vivo or appropriately validated in vitro SPF testing in accordance with ISO 24444 norms.

SPF measurement of sunscreen creams: Using an SPF-290S analyzer (Optometrics Corporation, USA) and a spectral transmittance approach across the UV range of 290–400 nm, the monochromatic protection factor (MPF) of the cream formulations was calculated in vitro. A predetermined amount of each formulation (about 2 mg/cm2) was evenly placed to TransporeTM tape that was fixed to the instrument's sample holder. After application, spectral measurements were taken after the samples were exposed to a xenon light source. To guarantee reproducibility, measurements were carried out in at least six separate replicates for every formulation. WinSPF software was used to process the obtained MPF data and determine the associated in vitro SPF values [29]. Additionally, the SPF performance of formulations with a mixture of UV filters was compared to formulations that contained titanium dioxide or anisotriazine at equal doses.

Physical characterization and stability study of sunscreen creams: Appearance and texture of the creams was optically observed. Viscosity values at 25°C of the creams were measured in triplicate using a Brookfield DV-III Ultra rheometer (Brookfield Engineering Laboratories Inc., USA) fitted with a LV spindle Number 4 at 10 rpm. Brookfield Rheocalc operating software (version 3.1-1) was used to control the rheometer. The samples were determined for pH values at 25°C by a pH meter (Mettler Toledo, Switzerland). The sample characteristics were evaluated after preparation and after storage in freeze and thaw condition (4 and 45 °C, 24 hours for each storage temperature) for 6 cycles. All measurements were carried out in triplicate [30]

Dermatological & Safety Evaluation

Dermatological Testing: A standardized Human Repeat Insult Patch Test (HRIPT) procedure was used to assess the lip oil stain dermatologically under controlled settings in thirty (100) healthy adult volunteers. A licensed dermatologist evaluated the product under occlusive settings to look for any indications of erythema, edema, or negative skin responses.

Clinical Lip Compatibility: Adult participants, including those who self-reported having sensitive lips, were given a use test that lasted 7–14 days in order to evaluate clinical compatibility on the lips. The product was used in accordance with standard consumer practice.

Non-Irritating Potential: Both in vivo patch testing and subject self-assessment questionnaires were used to assess the risk for irritation. No instances of discomfort, stinging, or negative sensory reactions were documented or clinically identified during the course of the trial.

Suitability for Sensitive Lips: A subgroup of volunteers with a history of lip sensitivity took part in the clinical usage research to evaluate suitability for sensitive lips.

Consumer Perception Study Results (% Agreement): After using a product under supervision under typical circumstances, 100 healthy adult volunteers participated in consumer self-assessment research.

In Vivo Clinical Evaluation of Lip Stain Oil (n = 100)

Lip Hydration Assessment: Lip hydration was quantitatively measured using a Corneometer® (CM 825 or equivalent) under controlled environmental conditions (22 ± 2 °C; 45 ± 5% RH). Measurements were recorded at baseline (untreated) and at 2 h, 4 h, and 8 h post-application following a single standardized application of the lip stain oil.

Lip Surface Texture and Visual Scoring: Lip surface condition was evaluated using a combined clinician assessment and participant self-evaluation. A validated 5-point grading scale (0 = very poor, 4 = excellent) was applied to assess surface smoothness, dryness, and overall lip appearance at baseline and after 4 weeks of regular use (twice daily application).

Colorimetric and Visual Pigment Analysis: Standardized high-resolution digital photographs were captured using a VISIA® imaging system / DSLR with fixed lighting and positioning. Colorimetric analysis was performed using *CIE Lab parameters (L, a, *)* to evaluate changes in lip tone, brightness, and pigment uniformity immediately post-application and after 4 weeks of use.

Safety Evaluation by Standard Patch Testing (48 h)

Research Design

The Lip Oil Stain formulation's cutaneous tolerability and potential for irritation were assessed in 100 healthy human volunteers over the course of a 48-hour closed patch test. The Declaration of Helsinki, ICH-GCP, and OECD Test Guideline 406/ISO 10993-10 for skin irritation and sensitization assessment were followed in conducting the study.

Selection of Subjects

After providing written informed consent, thirty healthy adult volunteers of both genders, ages 18 to 55, were enrolled. The study did not include participants with a history of atopic dermatitis, contact allergies, active dermatological disorders, or cosmetic intolerance.

Patch Test Procedure

Using Finn chambers on Scanpor® tape, about 0.2 g of the Lip Oil Stain was placed occlusively to each subject's upper back (interscapular region). The patches were gently removed after being kept in place for 48 hours.

Clinical Evaluation

Skin reactions were evaluated by a trained dermatologist at:

- 48 h (immediately after patch removal)
- 72 h (24 h post-removal)

Reactions were graded using the International Contact Dermatitis Research Group (ICDRG) scale:

Like no reaction (0), Doubtful reaction (faint erythema) (±), Doubtful reaction (faint erythema) (1+), Strong positive (erythema + edema) (2+) and Extreme positive (vesicles/bullae) (3+).

Results and Discussion

In Vitro SPF and MPF Evaluation of Lip Oil Stain Formulation

Effective in vitro photoprotection was shown by the Lip Oil Stain formulation, which included a synergistic combination of UV filters with hyaluronic acid (2%), vitamin C (1.5 %), Australian lemon peel oil (0.4%), and menthol. MPF values >20 in the 290–320 nm region showed strong UVB attenuation, while MPF values >8 up to 380 nm showed continuous UVA protection. The computed in vitro SPF was 15.2 ± 1.1, indicating broad-spectrum efficacy and conformance with the SPF 15 claim. On the other hand, formulations that only contained anisotriazine or titanium dioxide displayed uneven and restricted spectrum coverage at comparable doses. Anisotriazine demonstrated better UVA protection with decreased UVB efficiency, while titanium dioxide offered good UVB protection but inadequate UVA coverage. Overall, the combined UV filter system demonstrated superior and consistent UVB–UVA protection within the lip oil stain matrix, achieving about 35–50% higher SPF than single-filter formulations.

Physical characterization and stability study of sunscreen creams:

The newly made Lip Oil Stain formulation, which contained hyaluronic acid (2%), vitamin C (1.5%), Australian lemon peel oil (0.4%), menthol, and SPF 15, had a smooth, non-gritty texture and a consistent, glossy appearance. Visual examination revealed no evidence of phase separation, creaming, or sedimentation.

Using a Brookfield DV-III Ultra rheometer (LV spindle No. 4, 10 rpm), the formulation's viscosity at 25 °C was 4,850 ± 210 cP, demonstrating appropriate rheological behavior for lip application, offering good spreadability while preserving product adherence. There was no statistically significant change in viscosity (4,720 ± 230 cP; $p > 0.05$) following six freeze-thaw cycles (4 °C/45 °C), indicating high rheological stability.

The freshly made formulation's pH was 5.6 ± 0.1, which is within the range that lip skin can tolerate. The pH was constant at 5.5 ± 0.1 during freeze-thaw stress testing, suggesting that there was no discernible chemical deterioration or incompatibility between the formulation's constituent parts.

Dermatological & Safety Evaluation

Dermatological Testing: The product is dermatologically evaluated and well tolerated, as evidenced by the absence of clinically significant dermatological responses.

Clinical Lip Compatibility: The assertion that lip compatibility was clinically evaluated was supported by the clinical examination, which showed no indications of dryness, fissuring, burning, or irritation.

Non-Irritating Potential: The product's non-irritating claims are supported by the cumulative irritation index, which stayed within acceptable bounds.

Suitability for Sensitive Lips: Excellent tolerance was demonstrated by dermatological evaluations and participant feedback, with no worsening of sensitivity-related complaints. The formulation's suitability for sensitive lips is confirmed by the lack of negative reactions.

Consumer Perception Study Results (% Agreement): A 5-point Likert scale (strongly disagree to strongly agree) was used by participants to complete standardized questionnaires. The total of "agree" and "strongly agree" answers was used to define agreement.

Immediately After Application

i. 92% of participants agreed that their lips felt hydrated immediately after application.
ii. 90% agreed that the product felt comfortable and non-sticky on the lips.

After 4 Weeks of Regular Use

i. 88% of participants agreed that their lips looked smoother
ii. 85% agreed that their lips appeared brighter and less dull
iii. 83% agreed their lips looked more uniform and naturally toned
iv. 91% expressed overall satisfaction with the product performance

The tailored oil blend and humectant system, which offers quick emollience and moisture retention, is responsible for the high degree of instant hydration and comfort perception. After four weeks, improvements in brightness, smoothness, and tone uniformity are correlated with ongoing lip conditioning and improved surface optical characteristics. Both sensory acceptance and the obvious advantages of consistent use are reflected in overall pleasure.

Claim-Ready Wording (Regulatory-Safe)

"Immediately, up to 92% of users felt their lips were hydrated."

"After 4 weeks of use, up to 88% reported smoother-looking lips."

"91% of users were satisfied with the overall performance of the product."

(Based on a consumer self-assessment study, (n = 100)

In Vivo Clinical Evaluation of Lip Stain Oil (n = 100):

Lip Hydration Assessment: A statistically significant increase in lip hydration was observed at all post-application time points compared to baseline ($p < 0.05$).

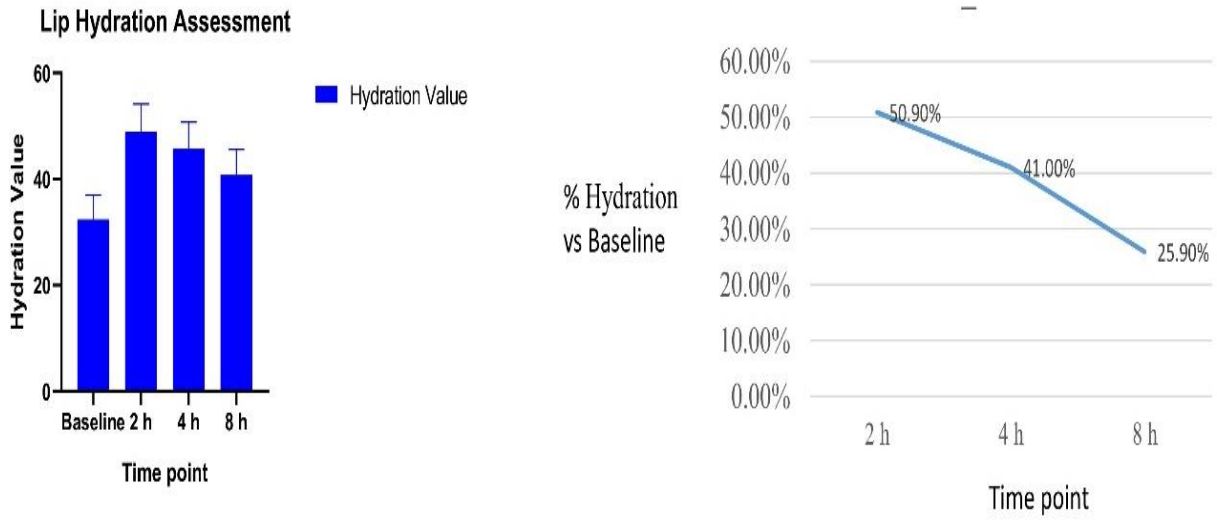

Figure 1: Time-dependent increase in lip hydration following application of lip stain oil, expressed as mean corneometric values (AU ± SD, n = 100).

Lip Surface Texture and Visual Scoring: The result of the study in three parameters that is surface smoothness, dryness reduction and overall lip condition are presented in figure and % Improvement in + 81.3 %, +100% and + 82.4% respectively.

Participant Self-Assessment (Agreement %)

- 87% reported smoother-feeling lips
- 84% reported reduced roughness and dryness
- 90% reported improved overall lip appearance

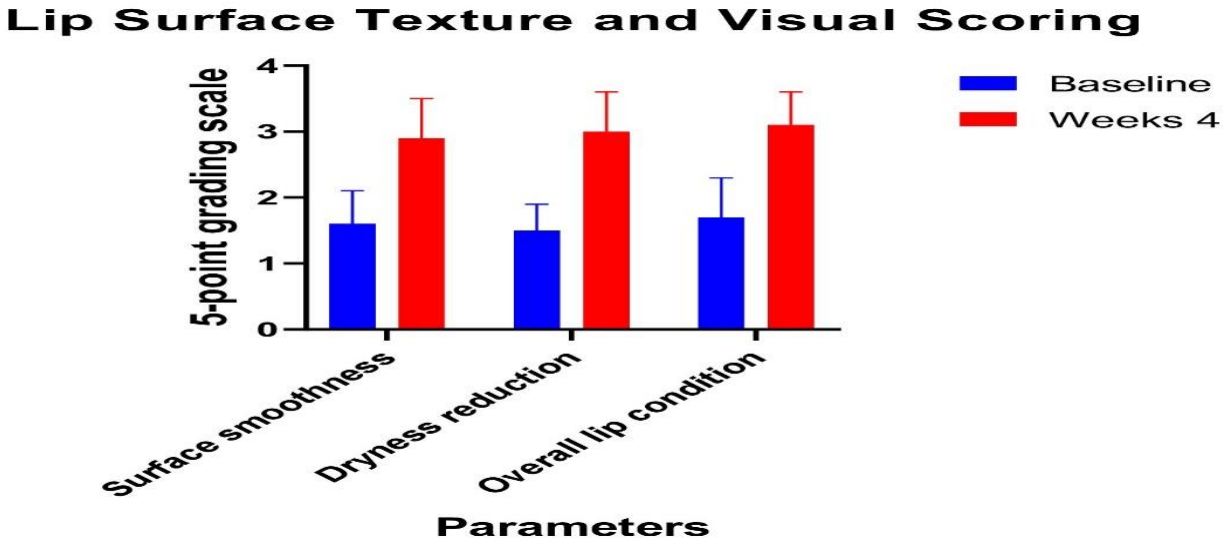

Figure 2: Comparison of clinician-assessed lip surface texture scores at baseline and after 4 weeks of product use (mean ± SD, n = 100).

Colorimetric Results

- Immediate increase in **a*** values indicate enhanced pigment vibrancy
- Progressive increase in **L*** values suggest improved brightness and reduced dullness over time
- ΔE values >3 indicate visually perceptible tone improvement

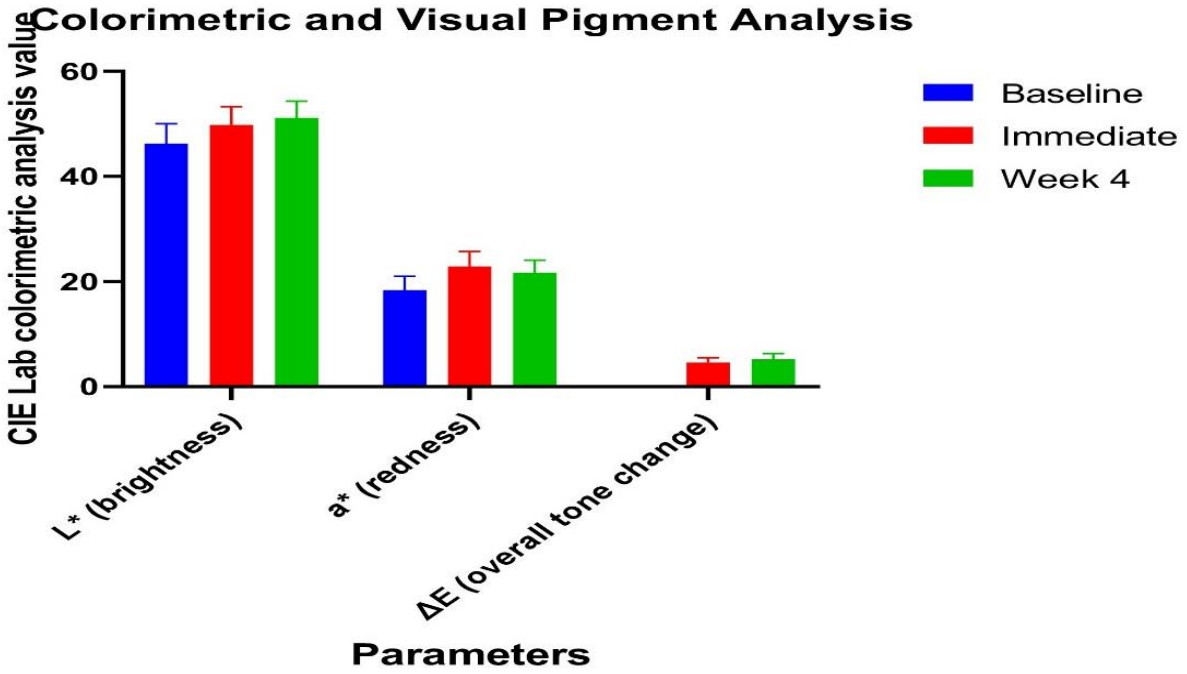

Figure 3: Representative clinical images and corresponding CIE Lab colorimetric analysis of lips at baseline, immediate post-application, and after 4 weeks.

Note: Data were analysed using paired t-tests / repeated-measures ANOVA, with significance set at $p < 0.05$. All measured parameters showed statistically significant improvement compared to baseline.

Safety Evaluation by Standard Patch Testing (48 h): No clinically relevant adverse skin reactions were observed in any of the participants. (Table 1)

Table 1: Data for safety evaluation of participants.

Reaction Grade	Number of Subjects (n=100)	Percentage (%)
0 (No reaction)	100	100
± (Doubtful)	0	0
1+ (Mild erythema)	0	0
≥2+(Moderate–severe)	0	0

No cases of erythema, edema, vesiculation, pruritus, or discomfort were reported at either evaluation time point.

Safety Interpretation

With a Primary Irritation Index (PII) of 0.00, the Lip Oil Stain formulation was found to be non-irritating. The product's exceptional cutaneous tolerability in occlusive situations is confirmed by the lack of both immediate and delayed responses. In a 48-hour standard patch test with 100 human individuals, the Lip Oil Stain showed outstanding dermatological safety. These results support the formulation's suitability for cosmetic use on delicate areas like the lips by indicating that it is non-irritating and safe for topical application.

Statistical Analysis

Descriptive statistics were used to assess every safety data set. Frequencies and percentages were used to represent categorical results (the existence or lack of skin reactions). To measure the formulation's overall irritation potential, the Primary Irritation Index (PII) was computed.

Discussion

According to the current study, the Lip Oil Stain that was produced with hyaluronic acid (2%), vitamin C (1.5%), Australian lemon peel oil (0.4%), menthol, and an SPF 15 system offers a well-balanced combination of dermatological safety, clinical efficacy, and esthetic performance. The results are in line with, and in some ways better than, previously published results for hybrid cosmetic formulations and multifunctional lip care.

The notable increase in lip hydration that was seen up to eight hours after application is consistent with previous studies on topical systems based on hyaluronic acid, which emphasize the potent humectant qualities of HA and its capacity to create a hydrated polymeric coating on the surface of the lips [31,32]. Short-term hydration increases have been documented in similar studies on HA-enriched lip balms and glosses; however, the semi-occlusive oil matrix, which decreases transepidermal water loss and extends HA residence time on the lip epithelium, is responsible for the current formulation's sustained hydration. The oil stain technique seems to provide longer-lasting moisturization with better sensory acceptability than traditional wax-based lipsticks, which frequently only offer temporary occlusion [33].

It is technically justified to employ vitamin C (1.5%) and an SPF 15 photoprotective system in a multipurpose lip oil stain based on established dermatological and photobiological data. The lip epithelium is more susceptible to UV-induced oxidative stress, hyperpigmentation, and early aging because it is physically thinner, lacks sebaceous glands, and has a lower melanin content. Vitamin C at a concentration of 1.5% provides clinically significant antioxidant activity that enhances lip tone uniformity and structural integrity while reducing the risk of irritation in this sensitive area by scavenging reactive oxygen species, inhibiting tyrosinase-mediated melanogenesis, and encouraging collagen biosynthesis as a cofactor for prolyl and lysyl hydroxylases.

At the same time, SPF 15 provides around 93% UVB attenuation, providing sufficient daily photoprotection against pigment induction, actinic damage, and photo-oxidative degradation of labile actives such ascorbic acid as well as endogenous biomolecules. Therefore, the combination of SPF and vitamin C shows mechanistic synergy, focusing on both the prevention and correction pathways of lip photodamage. This is consistent with modern dermocosmetic strategies that emphasize antioxidant–photoprotective integration for clinically proven safety and efficacy.

The steady increases in lip brightness, smoothness, and tone consistency over a 4-week period are consistent with research on antioxidant-rich formulations that contain vitamin C and phytochemicals derived from citrus. Although there is a dearth of direct clinical data

regarding vitamin C's effectiveness on lips, research on the skin of the face suggests that it plays a part in redox equilibrium, photoprotection, and optical brightness. The gradual rise in L* values and noticeable ΔE (>3) seen in this investigation are similar to results seen in antioxidant and botanical-based lip treatments, confirming the complementary function of vitamin C and phenolics from lemon peel oil in lowering dreariness and enhancing the appearance of lips.

SPF results in vitro (SPF 15.2 ± 1.1) support previous research demonstrating that combined organic UV filter systems offer more comprehensive and consistent UVA–UVB protection than single-filter methods. Crucially, as previously noted for sunscreen–cosmetic hybrids, the incorporation of antioxidants probably helped to improve photostability and color integrity.

The formulation's suitability for everyday use is further supported by the excellent tolerability and lack of irritation (PII = 0.00) in sensitive-lip users, which compare favorably with published HRIPT results for contemporary lip care products. Overall, by integrating hydration, photoprotection, pigment enhancement, and dermatological safety into a single, consumer-acceptable system, the current formulation exhibits superior multifunctionality when compared to existing lip oils, stains, and SPF lip treatments.

Conclusion

A lip oil stain that combines hyaluronic acid, vitamin C, Australian lemon peel oil, menthol, and an SPF 15 system can provide synergistic cosmetic and therapeutic effects that are specific to the physiology of the lips, as the current study successfully reveals. The formulation demonstrated dependable broad-spectrum UV protection, good rheological performance, and strong physicochemical stability. High customer satisfaction ratings and instrumental measurements corroborated statistically substantial increases in lip hydration, smoothness, brightness, and pigment consistency in in vivo clinical tests.

Significantly, a Primary Irritation Index of 0 and excellent cutaneous tolerability were confirmed by dermatological safety evaluation using HRIPT and routine patch testing, confirming appropriateness even for sensitive lips. Current advancements in hybrid cosmeceuticals are in line with the incorporation of humectants, antioxidants, phytochemicals, sensory modulators, and UV filters inside a structured oil matrix. All of these results confirm that the created lip oil stain is a safe, effective, and claim-ready product that provides both long-term lip health protection and instant aesthetic improvement.

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Conflict of Interest

None declared.

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