

Development and Assessment of Herbal Sun Protective Lip Balm Incorporating with Chia Seed Oil and Virgin Coconut Oil

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ABSTRACT

Background: The lips are highly vulnerable to ultraviolet radiation because of their thin epithelium, low melanin and continuous environmental exposure. Conventional lip balms often contain synthetic UV filters and petrochemical excipients which may cause irritation and long-term safety concerns, leading to increasing the natural alternatives. **Objectives:** The aim of this study was to formulate and evaluate an herbal sun protective lip balm using chia seed oil and virgin coconut oil as natural functional ingredients. **Materials and Methods:** Lip balm formulations were prepared by different concentrations of chia seed oil and virgin coconut oil while maintaining the total lipid base constant. The formulations were evaluated for organoleptic characteristics, pH, melting point, spreadability and *in vitro* Sun Protection Factor (SPF). SPF was determined by using UV-visible spectrophotometry based on the Mansur method in the wavelength range of 290-320 nm. **Results:** All formulations exhibit acceptable physical characteristics, smooth texture, uniform appearance, acceptable pH, and good spreadability. *In vitro* SPF values ranged from 28.8±1.0 to 34.2±1.1, indicating moderate to high UV protection. Formulation F5 showed the highest SPF value (34.2±1.1), which may be attributed to the antioxidants and rich omega-3 fatty acid composition of chia seed oil and the moisturizing properties of virgin coconut oil. **Conclusion:** The study demonstrates that chia seed oil and virgin coconut oil can be effectively used in herbal lip balm formulations to provide photoprotective and moisturizing effects, offering a safer natural alternative to synthetic lip care products.

Keywords: Chia Seed Oil, Herbal Lip Balm, Sun Protective Factor, UV-visible Spectroscopy, Virgin Coconut Oil.

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INTRODUCTION

Ultraviolet (UV) radiation is one of the main environmental factors that profoundly influences skin health and integrity. Prolonged exposure to UV radiation causes erythema, inflammation, oxidative stress, premature aging, DNA damage, and an increased the chances of skin cancer (Tang *et al.*, 2024). UV radiation stimulates the production of Reactive Oxygen Species (ROS), which disturb cellular homeostasis by harming lipids, proteins, and nucleic acids, thereby expediting photoaging and inflammatory responses in dermal tissues (Hussen *et al.*,

2025). Thus, efficient photoprotection is deemed a crucial element of dermatological and cosmetic treatment. The lips are especially susceptible to UV-induced damage due to their anatomical characteristics including a thin stratified epithelium, low melanin levels, minimal keratinization, and limited sebaceous gland activity, which compromise their natural protective barrier. Consequently, the lips are more vulnerable to dehydration, fissuring, pigmentation, inflammation, and disorders such as actinic cheilitis and lip photoaging (Dureja *et al.*, 2005). Regardless of such increased susceptibility, special lip protection is often overlooked in regular skin care routines.

Synthetic UV filters (oxybenzone, octinoxate and avobenzone,) and inorganic compounds (titanium dioxide and zinc oxide) are common in commercial lip balms and sunscreen lip-care products. These chemicals are effective blockers or absorbers of UV radiation; however, there are increasing doubts about their safety in the long term. Many studies have revealed



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possible adverse effects, such as skin irritation, allergy, systemic absorption, endocrine disruption, and ecological toxicity of synthetic sunscreen ingredients (Santander Ballestín and Luesma Bartolomé, 2023). All the above safety concerns, combined with increased consumer awareness, have driven the call to natural and plant-based cosmetic alternatives (Michalak, 2023).

Formulations made of plant extracts have received much interest owing to their diverse qualities like photoprotection, antioxidation, moisturization, and potential to restore the skin barrier (Michalak, 2023). The mentioned properties can be mostly attributed to the existence of bioactive phytochemicals, including flavonoids, phenolic compounds, Polyunsaturated Fatty Acids (PUFAs), vitamins, and carotenoids that are present in plant extracts (Segura-Campos *et al.*, 2014). Unlike synthetic agents, herbal ingredients often have a synergistic effect, which can provide protective and nourishing effects and reduce the risks of an adverse reaction. Antioxidants are important in preventing oxidative destruction of skin by UV. They have a significant role in preserving the integrity of cells and slowing photo-ageing by removing free radicals and decelerating lipid peroxidation (Hussen *et al.*, 2025). Oils rich in unsaturated fatty acids and natural antioxidants have been shown to possess moderate UV-blocking properties and enhance the natural defense systems of the skin (Saraf and Kaur, 2010). Therefore, lip-care products were that contained antioxidant-rich oils, which might provide protective and restorative benefits.

As a bioactive oil, chia seed oil, which is a product of *Salvia hispanica* L., has received ample interest in both cosmetics and pharmaceuticals due to its unique bioactive profile. About 28-32% of oil in chia seed contains a high concentration of omega-3 polyunsaturated fatty acid, specifically α -linolenic acid. Besides the fatty acids that are considered essential, chia seed oil also includes tocopherols, polyphenols, phytosterols, carotenoids, and phospholipids, which contribute to the antioxidant, anti-inflammatory, and emollient properties of the product (Segura-Campos *et al.*, 2014). Topical application of chia seed oil has been linked to greater skin hydration conditions, more effective protection by the skin barrier, and decreased levels of oxidative stress, which causes it to be an effective factor in photoprotective skin care products (Figure 2) (Saraf and Kaur, 2010).

Virgin coconut oil is a byproduct of *Cocos nucifera* L., which is widely used in dermatological and lip-care products because of its excellence moisturizing and emollient effects. The oil is produced by cold pressing or light processing of fresh coconuts kernels hence maintaining its bioactive compounds (Nareswari *et al.*, 2022). Virgin coconut oil is characterized by high levels of medium-chain fatty acids, especially lauric acid, which plays a crucial role in the enhancement of the skin barrier, as well as

in decreasing water loss. Additionally, the oil has antioxidants like Vitamin E, Vitamin C, and polyphenolic compounds which are known to help in repairing and hydrating the skin. The past studies have revealed that virgin coconut oil used topically may increase skin elasticity, reduce trans epidermal water loss, and expedite wound healing (Nevin and Rajamohan, 2010).

Chia seed oil and virgin coconut oil used together can improve both the functionality of lip care preparations as well as their stability and cosmetic appeal, and meet the recent trends towards natural and sustainable cosmetic compositions.

Despite the current increase in interest in herbal lip care products, there is a lack of scientific research evaluating the sun safety of natural oil-based lip balms. *In vitro* Sun-Protective Factor (SPF) measured by UV-visual spectrophotometry is a simple, dependable, and cost-effective way to assess the photoprotective efficacy of cosmetic preparations. The Mansur spectrophotometer is known to be a useful method of mainly SPF assessment (Bhatt *et al.*, 2025).

The objective of this study is to formulate and evaluate an herbal sun protective lip balm, utilizing with chia seed oil and virgin coconut oil as primary active components. The findings may aid in the creation of environmentally acceptable, plant-derived sun protection preparations that provide supplementary skin advantages, and present a sustainable substitute for synthetic sunscreen agents. This research substantiates the increasing desire for safer and more plant-based skincare alternatives within the cosmetic field (Figure 1).

MATERIALS AND METHODS

Materials

Chia seed oil (*Salvia hispanica* L., cold pressed, cosmetic grade) was purchased from Bargi Naturals, India. Virgin coconut oil (*Cocos nucifera* L., cold pressed) was procured from Organic India. Cocoa butter, shea butter, vitamin E, and glycerin were obtained from S.D Fine Chemical, India. Beetroot powder and cherry essence were used as natural coloring and flavoring agents. All chemicals were of analytical grade and used without further purification.

Methods

Preparation of Herbal Lip Balm

Lip balm formulations (F1-F5) were prepared by using the fusion method, widely employed for lip based cosmetics (Reddy, 2024). Cocoa butter and shea butter were melted at 70-75°C in a water bath. Preheated chia seed oil and virgin coconut oil (40-45°C) were added gradually with continuous stirring at 300 rpm. Vitamin E, glycerin, color, and flavor were incorporated, and the homogeneous blend was poured in sterile molds and allowed to solidify at room temperature.

Formulation Design

Five formulations were developed by varying chia seed oil and virgin coconut oil proportions while keeping the total lipid base constant (Table 1). The optimized formulations were identified based on physicochemical performance and SPF values.

Organoleptic and Physical Characteristics

Color, appearance, texture, and homogeneity were visually assessed; sensory acceptability was evaluated by 10 semi trained volunteers following standard cosmetic procedures.

pH

1 g of lip balm was melted and dissolved in 10 mL of distilled water. pH was calculated at 25°C using a calibrated digital pH meter. Experiments were performed in triplicate, and results were expressed as Mean±SD.

Melting Point

Estimated by using the capillary tube method in a melting point apparatus. Performed in triplicate.

Spreadability

Evaluated by using the slip and drag method by placing 1 g of formulation between two glass slides under standard weight for 60 sec and assessing ease of movement.

In vitro SPF

SPF was determined via the spectrophotometric Mansur equation method. 1 g sample was diluted in ethanol to get a final

concentration of 0.2 mg/mL. Absorbance was measured within the range of 290-320 nm in UV-visible spectrophotometer. Mansur's equation to calculate the SPF value of lip balm preparations *in vitro* can be seen in the following equation.

$$SPF = CF \times EE(\lambda) \times I(\lambda) \times abs(\lambda)$$

The Mansur's equation was then calculated, where CF (correction factor/10), EE (Erythema spectrum of effect), I (sun intensity spectrum), and Abs (Absorbance Value) were scanned in the wavelength range of 290-320 nm. The absorbance value (λ) obtained then was multiplied by EE (λ) and I (λ). SPF values were calculated as mean±SD from triplicate measurements (Thabaj *et al.*, 2025).

Stability Study

Developed formulations were stored at room temperature and in refrigerator for 4 weeks and monitored for physical characteristics.

Statistical Analysis

All experiments were conducted in triplicate. The results were expressed as mean±standard deviation.

RESULTS

Organoleptic Characteristics

All formulation batches showed smooth, uniform consistency without phase separation. Pink coloration from beetroot and present odor from cherry essences provided acceptable aesthetic attributes. Volunteers chosen F3 and F5 due to enhanced smoothness a pay-off.

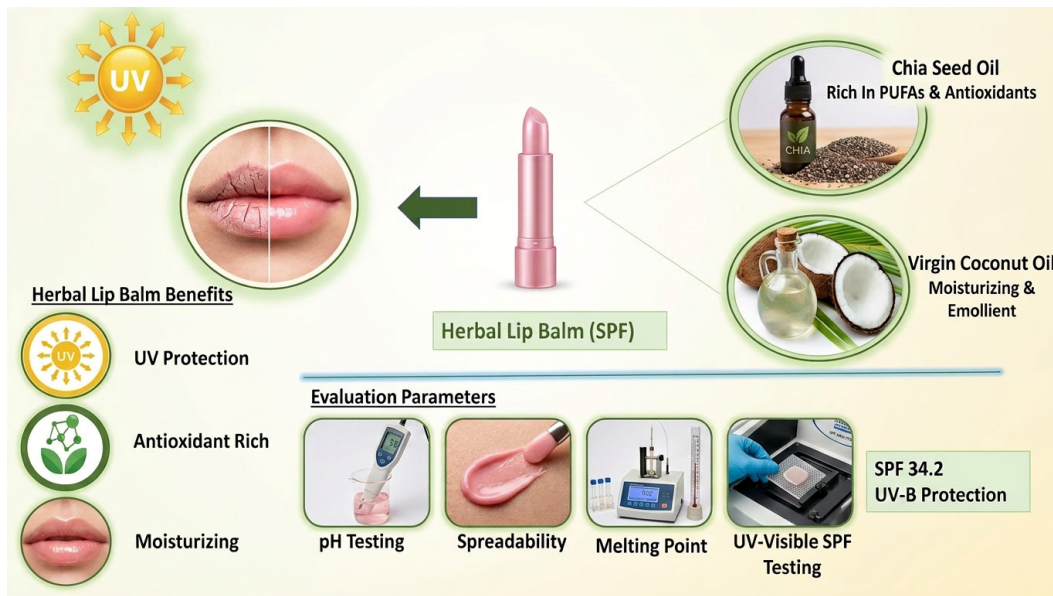


Figure 1: Development and evaluation of sun-protective herbal lip balm incorporating chia seed oil and virgin coconut oil. Chia seed oil contributes antioxidant activity and UV absorption, while virgin coconut oil provides moisturizing and emollient effects, collectively enhancing UV-B protection and lip hydration.

pH Evaluation

pH values ranged from 5.8 ± 0.12 to 6.2 ± 0.10 within acceptable limits for application. Maintenance of near neutral pH indicates good compatibility with lip tissue and minimized irritation risk.

Melting Point

Melting points were obtained between $62.0 \pm 0.8^\circ\text{C}$ and $65.0 \pm 0.6^\circ\text{C}$ confirming suitable thermal stability for ambient storage while allowing melting on lip contact.

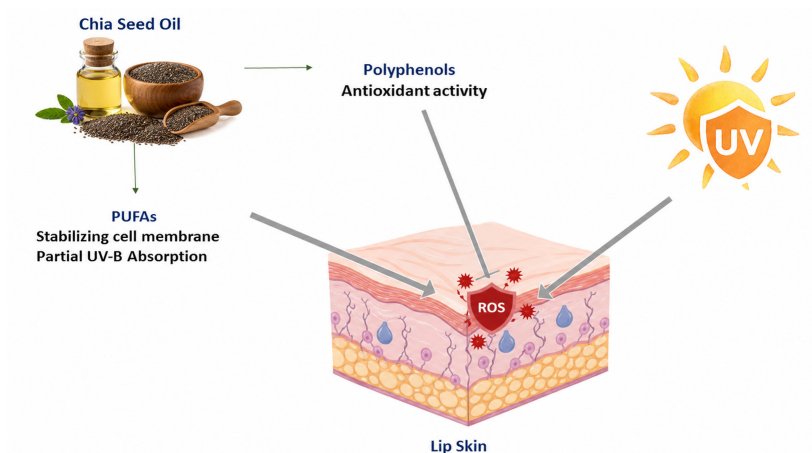


Figure 2: Possible mechanism of UV-Protection by chia seed oil.

Table 1: Composition of Herbal Lip Balm Formulations (W/W %).

Ingredients	F1	F2	F3	F4	F5 (Optimized)
Chia Seed Oil	5	10	15	20	18
Virgin Coconut Oil	25	20	15	10	12
Cocoa Butter	30	30	30	30	28
Shea Butter	15	15	15	15	18
Vitamin E	1	1	1	1	2
Glycerin	1	1	1	1	2
Cherry Essence	1	1	1	1	1
Beet Root	Q.S	Q.S	Q.S	Q.S	Q.S

Table 2: Evaluation Parameters of Herbal Lip Balm.

Formulation	Parameters							
	Color	Odor	Texture	Homogeneity	pH	Melting Point	Spreadability	Stability
F 1	Light Pink	Acceptable	Soft	Good	6.1 ± 0.10	63.2 ± 0.7	Good	Stable
F 2	Light Pink	Acceptable	Soft	Good	6.0 ± 0.12	62.8 ± 0.6	Good	Stable
F 3	Medium Pink	Pleasant	Very Smooth	Very Good	5.9 ± 0.11	64.0 ± 0.7	Very Good	Stable
F 4	Medium Dark Pink	Acceptable	Smooth	Good	6.0 ± 0.09	64.5 ± 0.8	Good	Stable
F 5	Dark Pink	Pleasant	Very Smooth	Very Good	5.8 ± 0.12	65.0 ± 0.6	Very Good	Stable

Table 3: *In vitro* Sun Protective Factor (SPF) Values of Herbal Lip Balm Formulations.

Formulation	SPF (Sun Protective Factor)
F 2	28.8±1.0
F 3	30.7±1.0
F 5	34.2±1.1

Spreadability

All formulations demonstrated good spreadability, with F3 and F5 exhibiting very good spreading due to optimal viscosity. Enhanced spreadability supports uniform formation and improved user experience.

F2 and F4 did not meet the expected values and properties, as shown in Table 2. So F1, F3 and F5 were considered for further evaluation.

In vitro SPF

The *in vitro* SPF values determined for the herbal lip balm formulations are shown in Table 3. The SPF values of the formulated products varied from 28.8±1.0 to 34.2±1.1, reflecting different levels of UV-B protection based on their composition. In the analysis of the three batches, F3 and F5 demonstrated the highest SPF values of 30.7±1.0 and 34.2±1.1, respectively. The enhanced SPF observed can be lined to the formulation of fatty acids, tocopherols and polyphenols, all of which contribute to increased UV absorption and a reduction in oxidative stress. Virgin coconut oil has an occlusive effect. The interaction between the two was synergistic which was crucial in enhancing photoprotection.

Stability Test

The prepared formulations were changed nothing in the appearance, odor, or texture of all formulations even after a four-week stability evaluation, resulting in satisfactory physical stability.

DISCUSSION

The present study was aimed to develop a sun-protective herbal lip balm using chia seed oil and virgin coconut oil as functional ingredients. The results indicated that all prepared formulations possessed the acceptable physicochemical characters, uniform texture, smooth appearance and adequate spreadability indicating good consumer acceptability.

The pH of all formulations was found to be within in the acceptable range for topical preparations, suggesting minimal risk of irritation. The melting point values indicated adequate thermal stability, ensuring product integrity under normal storage conditions.

The *in vitro* values were ranged from 28.8±1.0 to 34.2±1.1, indicating moderate to high sun protection. The higher SPF observed in formulation F5 may be attributed to the presence of bioactive compounds such as poly unsaturated fatty acids and antioxidants in chia seed oil which are known to absorbs UV radiation and mitigate the reactive oxygen species. Virgin coconut oil additionally offers moisturizing benefits and improves the barrier protection.

The overall findings support the potential use of natural oils as effective alternatives to synthetic UV filters in lip care products, offering improved safety and biocompatibility.

CONCLUSION

The current study revealed that an herbal lip balm containing a blend of chia seed oil and virgin coconut oil has acceptably good physicochemical characteristics and offers substantial *in vitro* protection against UV-B. The batches that were prepared showed promising nature, with F3 and F5 having the desirable features such as, the correct pH, favorable spreadability, and the maximum recorded SPF values (34.2±1.1) in that order. These observations indicate the potential success of the use of plant-derived ingredients as effective ingredients of the lip care products to be used as sun protection. More *in vivo* experiments and longer stability tests should be undertaken to prove therapeutic relevance and long-term efficacy.

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ABBREVIATIONS

UV: Ultraviolet; **SPF:** Sun-Protective Factor; **ROS:** Reactive Oxygen Species; **DNA:** Deoxyribonucleic Acid; **PUFAs:** Polyunsaturated Fatty Acids; **Q.S:** Quantity sufficient; **SD:** Standard Deviation; **CF:** Correction Factor; **EE:** Erythema Effect Spectrum; **I:** Solar Intensity Spectrum; **Abs:** Absorbance.

CONFLICT OF INTEREST

The authors declare that there is no conflict of interest.

FUNDING

There was no particular grant of funding agencies to this research.

ETHICAL STATEMENT

A sensory test was conducted under the informed consent of the subjects. No invasive procedures were involved in the study and the study followed ethical practices in the institutions.

AUTHOR CONTRIBUTIONS

Conceptualization and study design were carried out by Ramadevi Pemmerredy and Budime Priyanka. The experimental work formulation and developmental studies were performed by Kusume Sireesha and Rentala Glory Therissa. Data analysis and interpretation were conducted by Pulla Prudvi Raj and Gowrishankar Jayabalan. The manuscript drafting, critical revision and correspondence were handled by Palati Divya Jyothi. All authors reviewed and endorsed the final manuscript.

SUMMARY

This study successfully developed and evaluated herbal sun-protecting lip balm incorporating chia seed oil and virgin coconut oil. The formulations demonstrated acceptable physicochemical properties and effective *in vitro* sun protection, highlighting their potential as safe and natural alternatives to conventional lip care products containing synthetic UV filters.

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