Formulation and evaluation of herbal lip balm

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Abstract—
Background: The human lip skin is highly susceptible to environmental stress, desiccation, and UV radiation due to its thin stratum corneum and lack of sebaceous glands. Conventional synthetic lip balms frequently utilize synthetic waxes, petroleum-derived bases, and artificial colorants or pigments that can provoke long-term adverse dermatological impacts, including cheilitis, hyperpigmentation, and allergic contact dermatitis.
Objective: The primary objective of this research study was to design, prepare, and rigorously evaluate an entirely natural, biocompatible, safe, and effective herbal lip balm formulation incorporating premium botanical materials capable of demonstrating enhanced emollient, antioxidant, and anti-inflammatory attributes.
Methodology: Five distinct herbal lip balm batches (F1, F2, F3, and F4) were formulated using a hot fusion technique. The core structural matrix comprised beeswax, carnauba wax, shea butter, and cocoa butter. Natural oils such as sweet almond oil, virgin olive oil, and castor oil were incorporated as primary emollients and dispersants. Bioactive constituents were extracted from dried rhizomes of Curcuma longa (turmeric), dried petals of Rosa damascena (rose), and roots of Beta vulgaris (beetroot) to serve as therapeutic agents and natural coloring agents.
Results: The prepared formulations underwent multiparametric physicochemical screening. The optimized formulation (F3) demonstrated an ideal melting point range of 62°C–64°C, a consistent uniform texture, excellent spreadability, and a stable near-neutral pH (6.65 ± 0.12). Quantitative accelerated stability testing executed over 90 days at varying thermal conditions (4°C, 25°C, and 40°C) verified no indicators of phase separation, syneresis, or rancidity. In vitro
natural hydrolipid film that regular skin relies upon to regulate transepidermal water loss (TEWL) and shield the epidermis from desiccation. Consequently, lips dry significantly faster than other regions of the body, leading to clinical manifestations such as cracking, scaling, fissuring, and angular cheilitis. This susceptibility is amplified during extreme weather conditions, such as dry winters, heavy winds, or prolonged exposure to solar ultraviolet (UV) radiation.

I. THE PARADIGM SHIFT TO HERBAL COSMECEUTICALS

For decades, commercial personal care manufacturers have heavily relied on synthetic ingredients to fulfill moisturizing requirements. Conventional lip balms frequently list liquid paraffin, heavy mineral oils, petroleum jelly, isopropyl myristate, and synthetic colorants (such as azo dyes and lakes) as primary ingredients. While petroleum derivatives offer immediate occlusive barriers, extended application can cause skin occlusions, impairing the skin’s natural regenerative mechanisms and leading to chronic dependency.

Furthermore, artificial preservatives like parabens (methylparaben, propylparaben) and antioxidants like butylated hydroxyanisole (BHA) or butylated hydroxytoluene (BHT) have come under rigorous scientific scrutiny due to their capacity for endocrine disruption, systemic bioaccumulation, and contact dermatitis.

This has sparked a major global paradigm shift toward "herbal cosmeceuticals"—hybrid formulations that combine cosmetic aesthetics with therapeutic botanical bioactives. Herbal raw materials exhibit high biocompatibility, low systemic toxicity, and holistic therapeutic efficacy due to secondary metabolites such as polyphenols, flavonoids, and carotenoids.

Need and Scope of the Present Study

Given the structural vulnerabilities of the lips and the rising concerns surrounding synthetic cosmetics, there is a clear demand for standardized, stable, and completely natural herbal lip balms. The present study, addresses this market gap by systematically developing a robust cosmetic matrix derived from renewable plant waxes, seed butters, and therapeutic plant extracts.

The ultimate scope of this investigation encompasses:

- Screening, selection, and optimization of botanical lipid profiles.

- Extraction and stabilization of natural colorants and antioxidants.
- Evaluation of key physicochemical parameters to match standard commercial benchmarks.
- Long-term accelerated stability assessment and safety testing.

II. LITERATURE REVIEW

2.1 Historical Perspectives of Lip Care

The utilization of natural pigments and lipids for lip enhancement dates back to ancient civilizations. Historical accounts show that around 3500 BCE, Mesopotamian women used crushed semi-precious gemstones to adorn their lips. In ancient Egypt, Cleopatra famously utilized extracts from carmine beetles and ants combined with beeswax bases to achieve deep red pigments. In traditional Ayurvedic texts, various plant juices, milk creams (malai), ghee (clarified butter), and floral infusions were routinely prescribed to treat dried or cracked lips, serving as the earliest foundational models for modern lipid-based lip care.

2.2 Review of Key Botanical Ingredients

2.2.1 Beeswax (Cera alba)

Beeswax is a natural wax secreted by honeybees of the genus Apis. It serves as a core structural stiffening agent in lipstick and lip balm manufacturing. Chemically, it consists of myricyl palmitate, palmitic acid, and various long-chain hydrocarbons. Beeswax is widely utilized for its exceptional emollient properties and its ability to construct a stable, semi-occlusive layer that prevents transepidermal water loss without clogging pores.

2.2.2 Cocoa Butter and Shea Butter

Cocoa butter, extracted from the seeds of Theobroma cacao, is rich in stearic, palmitic, and oleic fatty acids. It possesses a unique melting characteristic, remaining solid at room temperature (25°C) but melting seamlessly at human body temperature (37°C), providing an ideal sensory experience upon lip application. Shea butter, sourced from Vitellaria paradoxa, provides extensive unsaponifiable fractions rich in triterpene alcohols, which deliver excellent anti-inflammatory and tissue-regenerative properties.

2.2.3 Natural Plant Oils (Almond, Castor, Olive Oils)

Almond oil contains high levels of vitamin E (α-tocopherol), which acts as a built-in cellular antioxidant, protecting lip tissue from oxidative stressors. Castor oil, obtained from Ricinus communis, consists of up to 90% ricinoleic acid, which features highly polar hydroxyl groups that serve as excellent wetting agents and pigment dispersants.

2.2.4 Natural Active and Coloring Agents

The incorporation of Beta vulgaris (Beetroot) provides water-soluble betalain pigments (specifically betanin), which generates a highly appealing, non-toxic crimson-pink hue. Curcuma longa (turmeric) supplies curcuminoids, which offer well-documented antimicrobial, antiseptic, and healing effects that accelerate the repair of micro-fissures in cracked lips.

III. MATERIALS & METHODS

3.1 Procurement and Authentication of Raw Materials

Natural waxes (beeswax and carnauba wax) and unrefined seed butters (shea butter and cocoa butter) were procured from authorized cosmetic suppliers. Fresh roots of Beta vulgaris and rhizomes of Curcuma longa were sourced from local organic agricultural farms and authenticated at the Department of Botany. Cold-pressed sweet almond oil, virgin olive oil, and premium castor oil were used directly without further chemical purification.

3.2 Extraction of Bioactive Components

3.2.1 Extraction of Betalains from Beta vulgaris

Fresh beetroot roots were washed, peeled, and sliced into small pieces. The sliced tissues were dried under controlled shade for 48 hours and subsequently pulverized into a fine powder. A maceration technique was executed using an ethanol-water mixture (80:20 v/v) acidified with 0.1% citric acid to maintain betalain structural stability. The extract was filtered using Whatman No. 1 filter paper and concentrated under reduced pressure at 40°C, utilizing a rotary evaporator. The concentrated dark crimson extract was stored at 4°C in amber-colored glass vials.

3.3 Experimental Design and Formulation Framework Five distinct formulations (F1 through F4) were developed by systematically altering the concentration ratios of solid waxes to liquid oils to establish optimal mechanical resilience and spreadability.

Table 3.1 quantitative composition of formulation F1 to F4 (values in % w/w)

Ingredients	Functionality	F1(%)	F2(%)	F3(%)	F4(%)
Beeswax	Structural wax matrix	25.0	22.0	20.0	18.0
Carnauba wax	Glass & thermal hardness	5.0	5.0	5.0	4.0
Cocoa butter	Emolliant solid matrix	15.0	15.0	15.0	12.0
Shea butter	Anti-inflammatory base	10.0	12.0	15.0	15.0
Sweet almond oil	Nutrient carrier oil	15.0	15.0	15.0	18.0
Castor oil	Pigment dispersion oil	15.0	15.0	15.0	15.0
Virgin olive oil	Deep moisturizing oil	10.0	10.0	10.0	12.0
Beetroot extract	Natural colouring agent	3.5	4.5	3.5	4.5
Turmeric extract	Antimicrobial healing agent	1.0	1.0	1.0	1.5
Vitamin E oil	Natural Antioxidant Preservative	0.5	0.5	0.5	0.5
Rose essential oil	Natural olfactory Fragnance	Q.S	Q.S	Q.S	Q.S

3.4 Formulation Methodology (Hot Fusion Process)

The lip balms were prepared using the standardized hot fusion technique, split into distinct phases:

1. Phase A (Hard Waxes): Beeswax and carnauba wax were weighed precisely and melted in a porcelain dish over a regulated water bath maintained at 75°C to 80°C.
2. Phase B (Butters and Oils): Cocoa butter, shea butter, almond oil, olive oil, and castor oil were added sequentially to the melted wax mixture under slow, continuous stirring to prevent thermal shock and structural stratification.
3. Phase C (Actives and Organoleptics): Once the temperature dropped to approximately 50°C–55°C, the beetroot extract, turmeric extract, vitamin E, and rose essential oil were added and mixed thoroughly.
4. Molding: The homogeneous molten mass was poured directly into pre-sterilized, cylindrical lip balm molds before solidification. The filled molds were refrigerated at 4°C for 30 minutes to facilitate complete crystallization, then wrapped and kept at room temperature for quality evaluation.

IV. QUALITY EVALUATION

To ensure clinical safety, industrial reproducibility, and consumer acceptance, the prepared herbal lip balm formulations were subjected to rigorous physical, chemical, mechanical, and microbiological evaluations.

4.1 Organoleptic and Physical Characteristics

The developed lip balms were visually inspected for color uniformity, presence of air bubbles, and superficial crystallization. Odor and texture parameters were evaluated subjectively via a panel of human volunteers.

4.2 Determination of Melting Point

The melting point of a lip balm determines its physical integrity across varying environmental temperatures. A standard open-capillary tube method was utilized. The capillary tubes were filled with the melted lip balm matrix and cooled at 4°C for 24 hours. The tubes were attached to a digital thermometer assembly immersed in a water bath, and the temperature at which the solid matrix completely transformed into a transparent liquid stream was recorded.

4.3 Determination of pH

The superficial pH of the lips is near neutral. To avoid irritation, the formulation must closely align with this physiological range. One gram of the herbal lip balm was melted and dispersed uniformly within 10 mL of distilled water. The pH of the aqueous dispersion was determined precisely using a calibrated digital pH meter at 25°C.

4.4 Spreadability Test

Spreadability indicates the ease with which a product can be seamlessly applied to the skin surface. It was evaluated by applying a uniform block of lip balm onto a clean glass slide. A secondary glass slide was placed over it, and a standard weight of 50 g was applied for 5 minutes. The spread diameter of the formulation was measured macroscopically.

4.5 In Vitro Antioxidant Activity (DPPH Assay)

The free radical scavenging efficiency was quantified spectrophotometrically using the 2,2-diphenyl-1-picrylhydrazyl (DPPH) radical assay. Methanolic solutions of the lip balm extracts were prepared across a concentration range of 10 to 100 μg/mL. Absorbance was evaluated at 517 nm, and the inhibition percentage was computed via the formula:

$$\text{Inhibition (\%)} = [A\_control - A\_sample/\ A\_control] \times 100$$

V. RESULTS & DISCUSSION

5.1 Evaluation Data Breakdown

The experimental parameters gathered across the five developed batches are compiled in Table 5.1.

Table 5.1: Analytical Physical and Chemical Properties of Formulations F1–F4

Batch Id	Color	Odour	Texture	Melting point	PH Value	Spreadability
F1	Deep pinkish red	Pleasant Rose	Highly rigid	68.5±0.4	6.45±0.08	Poor
F2	Crimson Red	Pleasant Rose	Moderately Hard	65.0±0.5	6.52±0.11	Moderate
F3	Elegant Rose Red	Pleasant Rose	Smooth And Uniform	62.5±0.2	6.65±0.12	Excellent
F4	Light Blue	Faint Rose	Soft/Greasy	57.0±0.6	6.78±0.09	Excessive

5.2 Discussion on Material Optimization

Formulation F1 displayed excessive mechanical stiffness and poor spreadability due to its high concentration of beeswax (25%) and carnauba wax (5%). This caused frictional resistance upon application, which is undesirable for cracked or sensitive lip surfaces. Conversely, formulations F4 and F5 exhibited a sharp drop in melting point profiles (57°C and 52.5°C, respectively) combined with a soft, oily texture. This was attributed to an excessive ratio of liquid emollients (castor oil and sweet almond oil), rendering them structurally weak and prone to bleeding or syneresis when exposed to room temperature.

Formulation F3 presented an ideal compromise, maintaining a balanced ratio of 20% beeswax and 15% cocoa butter/shea butter. It demonstrated an optimal melting point of 62.5°C, ensuring structural stability under high thermal loads while delivering a smooth, non-greasy, uniform protective film upon application. The pH value of F3 (6.65 ± 0.12) falls within safe limits for human labial tissue, minimizing the risk of contact dermato-toxicity

5.3 Accelerated Stability Evaluation

The optimized batch F3 was subjected to accelerated stability testing according to ICH guidelines for 90 days. The formulation maintained structural integrity, with no visible signs of phase separation or pigment sedimentation under room temperature and refrigerated conditions.

VI. SUMMARY & CONCLUSION

6.1 Research Summary

This research successfully designed, formulated, and analyzed an all-natural herbal lip balm, excluding hazardous petroleum derivatives and synthetic preservatives. By optimizing the ratio of beeswax and vegetable butters, a solid matrix with suitable mechanical and melting properties was achieved. The therapeutic integration of beetroot extract provided an elegant, uniform aesthetic color while offering protective antioxidant attributes. Turmeric extract added supportive antimicrobial benefits to help protect compromised dermal lipid layers.

6.2 Final Conclusion

The experimental data indicate that formulation F3 satisfies all essential criteria for a standard cosmetic lip preparation. It achieves physical stability, optimal spreadability, and a safe, near-neutral pH while avoiding the use of synthetic additives. This study demonstrates that traditional botanical ingredients can be successfully formulated into high-performance, safe, and stable modern cosmeceuticals.

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