International Journal of Pharmacognosy and Herbal Drug Technology (IJPHDT)
ISSN: 3049-1630 | Vol. 03, Issue 04, April-2026 | pp. 30-42

ORIGINAL ARTICLE https://www.aktpublication.com

Development and Physicochemical Characterization of a Polyherbal Lip Balm

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Abstract:

Cosmetics are widely used to enhance the appearance of the human body; however, many conventional lip products contain synthetic chemicals that may have adverse effects. The growing demand for herbal and natural cosmetics has led to the increased use of plant-based ingredients in lip care formulations. In this study, a herbal lip balm was prepared using papaya extract as the primary active ingredient, enriched with coconut oil, almond oil, beeswax, vitamin E, and rose oil to improve nourishment, texture, and stability. The lip balm exhibited a pH of 7.5 and a melting point of 60.2°C, indicating suitability for normal storage and application. Stability studies conducted at room temperature (27 ± 3°C) and refrigerated conditions (5 ± 2°C) demonstrated that the formulation remained uniform, stable, and free from deformation. The lip balm was further evaluated for color, appearance, odor, spreadability, pH, melting point, skin irritation (patch test), and overall stability. The results confirm that the formulated lip balm is safe, stable, and cosmetically acceptable, highlighting the potential of herbal ingredients in developing effective and skin-friendly lip care products.

Keywords: Herbal lip balm; Papaya extract; Coconut oil; Almond oil; Beeswax; Vitamin E; Rose oil.

Received: Jan. 27, 2026 **Revised: Feb. 23, 2026** **Accepted: March 18, 2026** **Published: April 20, 2026**

DOI: https://doi.org/10.64063/3049-1630.vol3.issue4.000235

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1. INTRODUCTION

Cosmetics have become an essential component of modern lifestyle, serving not only aesthetic purposes but also contributing to skin protection and overall personal care. In recent years, there has been a significant paradigm shift toward the use of natural, herbal, and sustainable cosmetic products, driven by increased consumer awareness regarding product safety, environmental impact, and long-term health benefits. This growing preference for plant-derived and organically

sourced ingredients has particularly influenced the lip care segment, where frequent application and direct contact raise concerns about ingredient safety and toxicity [1].

Herbal cosmetics, formulated using medicinal plants and naturally derived excipients, offer multiple advantages due to their biocompatibility, minimal side effects, and multifunctional properties. Historically, plants have been extensively utilized in cosmetic preparations such as scented ointments, balms, infusions, and poultices. Over the past century, scientific investigations have substantiated the safety, efficacy, and functional roles of plant-based constituents in cosmetic formulations. Herbal ingredients are rich sources of vitamins, essential fatty acids, flavonoids, phenolic compounds, and natural antioxidants, which collectively exhibit emollient, moisturizing, anti-inflammatory, antioxidant, and anti-aging activities, thereby improving skin health and appearance.[2]

Lips are soft, highly vascularized, and delicate structures that play a vital role in speech articulation, facial expression, and food intake. Unlike other areas of the skin, the lips lack sebaceous glands and have a thinner stratum corneum, making them more susceptible to dryness, cracking, pigmentation, and environmental damage. Consequently, lip care products such as lip balms are widely used to provide hydration, protection, and aesthetic enhancement. Traditionally, lip coloring and conditioning have been practiced across various cultures; however, the contemporary market is dominated by synthetic formulations. Although synthetic lip care products are often cost-effective and readily available, many contain artificial colorants, preservatives, and chemical additives that may cause adverse effects, including lip irritation, allergic reactions, and long-term toxicity, especially upon repeated use [3]. These concerns have intensified interest in the development of polyherbal lip balm formulations, which combine multiple herbal ingredients to achieve enhanced therapeutic and cosmetic benefits through synergistic effects.In this context, the present study focuses on the development and physicochemical characterization of a polyherbal lip balm, formulated using selected herbal components known for their moisturizing, protective, and antioxidant properties. The formulation aims to provide a safe, effective, and eco-friendly alternative to conventional synthetic lip balms while ensuring desirable physicochemical attributes, stability, and user acceptability.[4]

1.1 Anatomy of the Lips

The lips are complex anatomical structures composed of multiple specialized components that collectively contribute to their functional, sensory, and aesthetic roles (Figure 1).

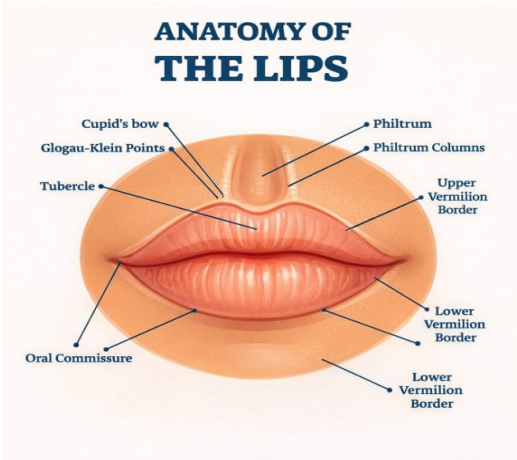

Figure 1. Anatomy of the lips

1. Skin: The outer layer of the lips consists of thinner and more sensitive skin compared to other body areas [5]

2. Vermilion Border: This is the margin that distinguishes the red-colored vermilion area of the lips from the adjacent skin [5].

3. Philtrum: The vertical groove or indentation in the center of the upper lip is known as the philtrum [6]

4. Cupid's Bow: The Cupid's bow commonly refers to the V-shaped area in the center of the upper lip's double curve [7].

5. Oral Mucosa: A thin, moist tissue layer covers the inner surface of the lips, helping to maintain moisture [8].

6. Muscles: The orbicularis oris muscle encircles the mouth and is involved in actions such as smiling and puckering [9].

7. Nerve Endings: The lips are highly sensitive due to a high density of nerve endings, which makes them responsive to touch, temperature, and pain [10].

1.2 PROBLEMS RELATED TO LIPS

Several conditions can affect the lips:

1. Cheilitis: Dry, cracked, swollen, and painful lips can result from inflammation, allergies, or irritants [11].

2. Dry Lips: Loss of moisture in lips can occur due to environmental factors such as cold temperatures, dry air, or frequent lip-licking, resulting in tightness, cracks, or peeling [12].

3. Chapped Lips: Severe dryness can lead to painful, bleeding, and uncomfortable lips, often caused by prolonged exposure to dryness, sun, wind, or harsh weather conditions [13].

4. Fever Blisters (Cold Sores): Herpes simplex virus causes painful, fluid-filled blisters that typically recur during periods of stress or illness [14].

5. Angular Cheilitis: Inflammation and cracking at the corners of the mouth can result from infections, poor nutrition, or prolonged moisture exposure [15].

6. Lip Infections: Bacterial, viral, or fungal infections can lead to symptoms such as swelling, redness, pain, and the formation of pus-filled blisters or sores [16].

7. Allergic Reactions: Allergic reactions to certain foods, cosmetics, or lip care products can cause swelling, itching, redness, and blistering [17].

8. Lip Discoloration: Changes in lip color can occur due to factors such as sun exposure, smoking, medications, or underlying health conditions [18].

Herbal cosmetic products, signifying safety, include diverse formulations and are preferable over synthetic products, which can have adverse effects on human health [19]. Coloring lips is an ancient practice that enhances beauty and adds glamour to makeup. The variety of shades, textures, and lusters has significantly expanded, evident in the wide range of lip products such as lip jelly, lip balm, and lipstick available in hundreds of colors to meet consumer demand. This work was intended for an extensive study of natural lip balm [20].

1.3 Types of Lip Balm

A. Tinted Lip Balm: Tinted lip balm moisturizes and adds color to the lips, serving as a lighter alternative to lipstick while providing hydration and a subtle, luminous finish.

B. Plumping Lip Balm: Plumping lip balm not only moisturizes but also enhances the volume of the lips while providing protection and hydration.

C. Medicated Lip Balm: Medicated lip balm is prescribed by doctors to treat chapped lips and other conditions. Despite being less soothing and potentially irritating, they are effective for medical use as advised by dermatologists.

D. Flavored Lip Balm: Flavored lip balm features various flavors like vanilla, mint, and mango, aimed at moisturizing lips while providing enjoyable scents and tastes to enhance user experience.

E. Organic Lip Balm: Organic lip balm is formulated from natural ingredients such as avocado oil, jojoba oil, beeswax, vitamin E, hemp, and cocoa butter, offering moisture and protection without harmful chemicals found in other lip balms [21].

1.4 Merits and demerits of lip balm

1.4.1 Merits lip balm

1. Natural lip balms are beneficial for both men and women, aiding in the maintenance of lip health and beauty while protecting against cold sores, chapping, and dryness [22].
2. Lip balms protect the natural health and beauty of the lips.
3. Sun block lip balms effectively prevent ultraviolet rays from damaging the lips.
4. It provides rejuvenation and relief, specifically targeting symptoms related to the lips that occur due to colds, flu, and allergies.
5. The use of natural lip cosmetics is intended to enhance facial appearance and improve skin condition [23].

1.4.2 Demerits lip balm

1. Lip balms composed of low-quality ingredients can cause significant harm to the lips.
2. Homemade lip balms typically have a shorter duration of effectiveness on the lips than commercially prepared varieties.
3. Natural oils in lip balms may make them greasier and more difficult to apply [22].
4. Lip balm addiction is a notable disadvantage associated with its usage [23].

1.5 Application of Natural Lip Balm

1. Natural lip balms help prevent dryness and protect environmental factors.
2. Various brands such as The Body Shop, Nivea, Himalaya, Blistex, and Babylip offer a range of chemical-based lip balms.
3. Natural lip balms are suitable for both men and women.
4. Formulating lip balms involves a balance of butters, oils, waxes, and various excipients.
5. Health regulators must closely scrutinize the ingredients of lip balms due to their potential ingestion [2, 6,24].

2. METHOD AND MATERIAL

2.1 Composition of the Formulation and Functional Role of Ingredients

This section describes the materials used in the formulation, including their botanical sources, chemical constituents, and functional roles in the development of the polyherbal lip balm.

2.1.1. Beeswax

Botanical Source:

Beeswax is a natural wax obtained from the honeycomb secreted by worker honey bees, *Apis mellifera*.

Family: Apidae

Chemical Constituents:

Beeswax is a complex natural substance composed primarily of long-chain fatty acids and esters. The major constituents include palmitic acid and cerotic acid, along with myricyl palmitate, hydrocarbons, and other minor components that contribute to its characteristic texture and stability.

Figure 2. Beeswax

Uses:

In pharmaceutical and cosmetic formulations, beeswax is widely employed as a stiffening agent, consistency enhancer, and ointment base. It imparts desirable hardness and structural integrity to semi-solid preparations such as lip balms, creams, and ointments. Beeswax also exhibits emollient and protective properties, forming a thin barrier on the skin that helps retain moisture and prevent dehydration. Due to its natural origin, biocompatibility, and pleasant texture, beeswax is particularly valued in herbal and natural cosmetic formulations for lip care products.[25]

2.1.2. Papaya Extract

Family: Caricaceae

Chemical Constituents:

Carica papaya contains a wide range of biologically active phytochemicals. The most significant constituents include papain and chymopapain, which are proteolytic enzymes responsible for the plant's therapeutic properties. Additionally, carpain, a bioactive alkaloid, is present along with flavonoids, phenolic compounds, vitamins (such as vitamin A and C), and natural antioxidants. These constituents collectively contribute to the pharmacological and cosmetic potential of papaya.

Figure 3. Papaya

Uses:

Carica papaya is extensively used in pharmaceutical and cosmetic preparations due to its wound debridement and wound healing properties, primarily attributed to the enzymatic activity of papain and chymopapain, which help in the removal of necrotic tissue and promote tissue regeneration. The plant also exhibits significant anti-inflammatory and antioxidant activities, making it beneficial in reducing skin irritation, inflammation, and oxidative stress. In cosmetic formulations, papaya extracts are valued for their ability to improve skin texture, support skin renewal, and enhance overall skin health, making them suitable for inclusion in herbal lip care and skin care products.[26]

2.1.3. Coconut oil

Botanical Name: *Cocos nucifera* Linn.

Family: Arecaceae

Chemical Constituents:

Coconut oil is a natural lipid obtained from the kernel of *Cocos nucifera* and is rich in medium- and long-chain fatty acids. The major fatty acids include oleic acid, a monounsaturated fatty acid that contributes to skin conditioning; myristic acid and palmitic acid, which are saturated fatty acids responsible for the oil's stability, consistency, and emollient properties. In addition to these, coconut oil contains small amounts of lauric acid, capric acid, vitamins, and natural antioxidants that enhance its therapeutic and cosmetic value.

Figure 4. Coconut oil

Uses:

Coconut oil is widely used in cosmetic and dermatological preparations as an effective emollient and moisturizing agent. It helps soften and smooth the skin by forming a protective barrier that reduces transepidermal water loss and maintains skin hydration. Due to its good spreadability, stability, and skin compatibility, coconut oil is commonly incorporated into lip balms, creams, lotions, and ointments. Its natural origin and nourishing properties make it particularly suitable for herbal and natural cosmetic formulations, where it contributes to improved texture, skin comfort [27]

2.1.4. Vitamin E

Chemical Name: Tocopherols and Tocotrienols

Chemical Constituents:

Vitamin E is a group of fat-soluble phenolic compounds, primarily comprising tocopherols and tocotrienols, which exhibit potent antioxidant activity. These compounds possess a chromanol ring with a hydroxyl group that enables effective scavenging of free radicals, thereby protecting lipids and cellular membranes from oxidative damage. Among the various forms, α-tocopherol is the most biologically active and widely used in pharmaceutical and cosmetic formulations.

Uses:

Vitamin E is extensively incorporated into skin care and cosmetic products due to its strong antioxidant, moisturizing, and anti-aging properties. It helps protect the skin from oxidative stress induced by environmental factors such as UV radiation and pollution. Vitamin E also supports skin barrier function, enhances moisture retention, and aids in the prevention of premature aging by reducing the appearance of fine lines and dryness. In lip care formulations, it contributes to lip nourishment, healing of chapped lips, and improvement of overall lip texture, while also enhancing the stability of formulations by preventing lipid oxidation.[28]

Figure 5. Vitamin E

2.1.5. Almond oil

Botanical Name: *Prunus amygdalus*

Family: Rosaceae

Chemical Constituents:

Almond oil is a fixed oil obtained from the kernels of *Prunus amygdalus* and is rich in unsaturated fatty acids, predominantly oleic acid and linoleic acid. Oleic acid contributes to excellent emollient and skin-penetrating properties, while linoleic acid plays an essential role in maintaining skin barrier function. In addition to fatty acids, almond oil contains minor constituents such as vitamins (especially vitamin E), phytosterols, and natural antioxidants, which enhance its stability and skin-beneficial effects.

Uses:

Almond oil is widely used in cosmetic and dermatological formulations due to its superior skin-softening, moisturizing, and nourishing properties. It helps improve skin hydration by forming a protective lipid layer that reduces moisture loss and enhances skin smoothness. Owing to its light texture, good spreadability, and high skin compatibility, almond oil is commonly incorporated into creams, lotions, massage oils, and lip care products. Its soothing and non-irritating nature makes it suitable for sensitive skin and herbal cosmetic formulations, contributing to improved texture, comfort, and overall skin health.[29]

Figure 6. Almond oil

2.1.6. Rose oil

Botanical Name: *Rosa centifolia* L.

Family: Rosaceae

Chemical Constituents:

Rose oil is an essential oil obtained from the petals of *Rosa centifolia* and contains a complex mixture of volatile aromatic compounds. The principal constituents include citronellol and geraniol, which are responsible for the characteristic fragrance and therapeutic properties of the oil. Other minor constituents, such as nerol, phenyl ethyl alcohol, and flavonoids, contribute to its stability and biological activity.

Uses:

Rose oil is widely used in cosmetic and personal care formulations primarily as a natural fragrance agent, imparting a pleasant and soothing aroma. In addition to its perfumery role, rose oil exhibits significant soothing, anti-inflammatory, and antioxidant properties, making it beneficial for sensitive and irritated skin. In lip care products, rose oil helps to calm inflammation, enhance sensory appeal, and protect the lips from oxidative stress. Its natural origin and therapeutic benefits make it a valuable ingredient in herbal and polyherbal cosmetic formulations.[30]

Figure 7. Rose water

2.2 Procedure for the Preparation of Herbal Lip Balm

The herbal lip balm was prepared using a combination of natural waxes, oils, and plant extracts, following a standardized hot-melt technique to ensure uniform blending and stability of the formulation (Table 1). The detailed procedure is as follows:

1. Melting of Beeswax:

Beeswax, serving as the primary stiffening agent and base material, was placed in a porcelain dish and gently melted over a water bath. This method ensured controlled and uniform heating, preventing degradation of the wax and preserving its emollient properties.

2. Heating of Oils:

A mixture of coconut oil, almond oil, and rose oil was weighed accurately and heated in a separate container over a water bath. The oils were warmed to a temperature comparable to the molten beeswax to facilitate homogeneous mixing and prevent phase separation.

3. Preparation of Active Ingredients:

Fresh papaya extract and vitamin E were prepared and maintained at a slightly elevated temperature immediately before addition, ensuring their stability and biological activity during incorporation into the formulation.

4. Mixing of Components:

All the components, including melted beeswax, warmed oils, papaya extract, and vitamin E, were combined at a precise temperature of approximately 150°C. Continuous stirring was performed throughout this process to achieve a uniform and consistent mixture, ensuring even distribution of active ingredients throughout the balm.

5. Initial Solidification:

The blended mixture was then carefully transferred into an ice bath to initiate rapid cooling and solidification. This step helped to retain the emollient and textural properties of the formulation while preventing separation of components.

6. Homogenization:

Once partially solidified, the mixture was further homogenized using a mortar and pestle, which ensured a smooth, fine-textured final product without lumps or inconsistencies.

7. Molding and Final Cooling:

The homogenized balm was poured into pre-labeled molds and refrigerated until completely solid. After complete cooling, the final herbal lip balm exhibited uniform texture, desirable hardness, and an appealing appearance, ready for evaluation and use.

Table 1. List of herbal ingredients for lip balm preparation.

S.N.	Ingredient	Taken quantity
1	Beeswax	3gm
2	Papaya extract	3ml
3	Coconut oil	3ml
4	Vitamin E	0.15ml
5	Almond oil	4.5ml
6	Rose oil	3-4 drops

2.3 Storage and precautions: Store in a cool, dry place away from direct heat.

2.4 Evaluation Parameter

The herbal lip balm was evaluated across different parameters to ensure a consistent standard.

1. Physical Appearance: Color, odor, and taste were evaluated in the study.
2. Melting Point: Melting the material to fill capillaries and then immersing it in a controlled-temperature vial of water is the determined method.
3. Spreadability: Product testing involved applying it to a glass slide to evaluate its uniformity and integrity.
4. Stability: Accelerated stability studies were conducted at room temperature (30°C) and at oven temperatures ranging from 40°C to 50°C.
5. Skin Irritation Test: Applied to the skin for a duration of 10 minutes to evaluate potential irritation.
6. pH Parameter: Determined using a calibrated pH meter, targeting a neutral pH near 7.

3. RESULTS AND DISCUSSION

The formulated lip balm was evaluated for various physicochemical and sensory parameters to assess its quality, safety, and user acceptability. The results of these evaluations are summarized in Table 2.

1. Color: The lip balm appeared light pink, indicating uniform incorporation of coloring agents. The color was appealing, which is an important factor for consumer acceptance. A consistent color also reflects proper mixing and stability of the formulation.
2. Odour: The lip balm exhibited a pleasant odor, suggesting successful addition of fragrance without any overpowering or unpleasant smell. A good odor is essential for enhancing user compliance and overall sensory experience.
3. Melting Point: The melting point of the lip balm was found to be 52°C. This indicates that the product is solid at room temperature but will melt upon application to the lips. The melting point is a critical parameter as it affects the ease of application and the product's stability under various environmental conditions.
4. Spreadability: The spreadability test showed better results, implying that the lip balm can be easily applied to the lips without requiring excessive rubbing. Optimal spreadability ensures a smooth and even layer on the lips, improving both comfort and effectiveness of the product.
5. Stability: The lip balm demonstrated good stability, showing no signs of phase separation, discoloration, or texture changes during the evaluation period. Stability is crucial for maintaining the product's shelf life and effectiveness over time.
6. Skin Irritancy: No irritation was observed during the skin irritancy test, confirming the safety of the formulation for topical use on sensitive areas such as the lips. This indicates that the chosen ingredients are compatible and non-irritating.
7. pH: The pH of the lip balm was measured at 7.2, which is within the neutral range and suitable for skin application. A pH close to the natural skin pH helps in preventing irritation and maintaining the skin barrier function.

Overall, the evaluation parameters suggest that the formulated lip balm is safe, stable, aesthetically pleasing, and user-friendly. The combination of acceptable color, odor, spreadability, and neutral pH makes this formulation suitable for regular topical use.

Table 2. Evaluation parameter of lip balm

S.N.	Evaluation parameters	Observed Value
1	Color	Light pink
2	Odour	Pleasant

3	Melting point	52°C
4	Spreadability test	Better
5	Stability	Good
6	Skin irritancy	No irritation
7	pH	7.2

4. CONCLUSION

The comprehensive evaluation of the formulated lip balm indicates that it meets the desired standards of physicochemical and sensory quality, making it suitable for cosmetic application. The product exhibited a pleasant odor and an appealing light pink color, which are important for consumer acceptability and indicate uniform incorporation of colorants and fragrance. The melting point was determined to be 52°C, suggesting that the formulation is thermally stable at normal storage conditions while still being able to melt comfortably upon application to the lips.

The spreadability of the lip balm was found to be good, ensuring that it can be applied smoothly and evenly, enhancing user comfort and the efficacy of the product. Stability studies demonstrated no observable changes in color, odor, or texture over the evaluation period, confirming the formulation's physical and chemical stability. Furthermore, the skin irritancy test revealed no adverse reactions, highlighting the safety of the lip balm for topical use on sensitive areas such as the lips. The pH of the formulation was measured at 7.2, which is close to the natural skin pH, indicating compatibility with the skin and reducing the risk of irritation. Overall, the formulated lip balm combines safety, stability, and aesthetic appeal with effective functional performance. These results suggest that the lip balm is a reliable, cosmetically acceptable product suitable for regular use, with a well-balanced formulation that ensures both user satisfaction and product durability.

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We sincerely acknowledge Kamla Institute of Pharmaceutical Sciences, Shri Shankaracharya Professional University, Bhilai, Chhattisgarh, India, for providing facilities and allowing us to perform the research work.

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