

Formulation and Evaluation of Thermosensitive Ghee-based Lipbalm

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Abstract: *The present study focused on the development and evaluation of a thermosensitive ghee-based dual-compartment lip balm designed for synchronized day and night lip care. The formulation aimed to protect lips from dryness, cracking, pigmentation, and irritation caused by environmental factors such as sunlight, pollution, dehydration, and temperature changes. Natural ingredients including ghee, beeswax, shea butter, squalane, sweet almond oil, castor oil, vitamin E, beetroot extract, rosehip oil, licorice extract, chamomile oil, zinc oxide, titanium dioxide, silica, and vanilla oil were used to prepare the formulation. The thermosensitive property allowed the balm to soften at lip temperature, improving spreadability, comfort, and moisturization. The daytime formulation provided protection and hydration, while the nighttime formulation offered deep nourishment and repair. Various physicochemical and performance evaluations such as appearance, pH, spreadability, viscosity, stability, moisturizing efficiency, irritation test, and microbial safety confirmed that the lip balm was stable, safe, non-irritating, and effective. The study concluded that the developed dual-compartment lip balm successfully combined natural ingredients with modern cosmetic technology to enhance lip protection, nourishment, and overall lip health.*

Keywords: Thermosensitive lip balm, Dual-compartment formulation, Ghee-based lip care, Natural ingredients, Lip nourishment, Moisturizing effect

I. INTRODUCTION

Lip care products are specially designed cosmetic and therapeutic formulations that help protect, moisturize, and maintain the health of lips. Unlike normal skin, lips are more delicate because they are thinner and do not have sebaceous glands, which makes them more prone to dryness, cracking, dehydration, and environmental damage. Factors such as sunlight exposure, pollution, cold weather, dehydration, and frequent use of cosmetic products can further worsen lip conditions. Because of this, regular lip care has become an important part of daily personal care routines.

Lip balms are one of the most commonly used lip care products because they provide effective hydration, nourishment, and protection. They are generally made using a combination of emollients, waxes, natural oils, humectants, antioxidants, and herbal extracts that help lock in moisture and keep lips soft and smooth. In recent years, there has been a growing preference for herbal and natural formulations due to their safety, skin-friendly nature, and minimal side effects. Ingredients like ghee, beeswax, and plant-based oils are widely used as they offer strong moisturizing, healing, and protective properties, making them highly suitable for lip care formulations [1].

With advancements in cosmetic science, more innovative lip care products are being developed, such as thermosensitive and dual-purpose lip balms. These modern formulations are designed to respond to temperature changes and provide better texture and application comfort [7]. At the same time, dual-layer or day and night lip balms are gaining popularity, where daytime formulations focus on protection and hydration, while nighttime formulations support deep repair and regeneration. The present study focuses on developing a thermosensitive ghee-based dual-layer



lip balm that combines natural ingredients with advanced formulation techniques to improve lip health, stability, and overall effectiveness [2][12].

1.2: Causes of Chapped and dry lips:

- Dry lips happen mainly because lips lose moisture easily as they do not have oil or sweat glands. Cold weather, heat, wind, and sun exposure quickly dry them out.
- Not drinking enough water, lip licking, mouth breathing, smoking, and use of harsh cosmetic products can make the condition worse.
- Sometimes, vitamin deficiencies or health problems also contribute to persistent dryness.
- Overall, dry lips are caused by moisture loss, bad habits, and environmental stress [10].

1.3: Need of lip protection and advanced lip care formulation:

The need for this work arises from the increasing demand for safe, effective, and multifunctional lip care products due to the high prevalence of dry, chapped, and damaged lips in today's population. Lips are highly sensitive structures with a thin epithelial layer, rich nerve supply, and absence of sweat and sebaceous glands, which makes them extremely vulnerable to moisture loss and environmental damage. Factors such as cold weather, heat, wind, pollution, UV radiation, dehydration, and poor lifestyle habits further worsen lip conditions, making continuous lip care essential.

At the same time, modern cosmetic use has increased exposure to chemical-based lip products that often provide only temporary relief without repairing the lip barrier. Many available formulations lack long-term hydration, healing properties, and adequate protection against environmental stress. This creates a clear need for advanced lip care systems that not only moisturize but also support repair, nourishment, and protection of lips in a more effective and sustained manner [3].

In addition, there is a growing preference for herbal and natural cosmetic products due to increased awareness of safety and side effects of synthetic ingredients. Traditional ingredients like ghee, beeswax, plant oils, and herbal extracts have shown excellent moisturizing, antioxidant, and healing properties, but there is a need to incorporate them into modern, stable, and more efficient delivery systems. Innovations such as thermosensitive and dual-layer technology can further enhance product performance by improving texture, spreadability, and functional separation of day and night care benefits [4].

Therefore, this project is needed to develop a thermosensitive ghee-based dual-layer lip balm that provides both day and night care in a single advanced formulation. The aim is to combine natural ingredients with modern formulation techniques to ensure hydration, barrier repair, UV protection, and overnight nourishment. This work ultimately addresses the need for a safer, more effective, and scientifically designed lip care product that improves overall lip health and meets current consumer expectations.

1.4: Introduction to Thermosensitive Ghee-Based Lip Balm with Dual Technology

A thermosensitive ghee-based lip balm with dual technology is an advanced lip care formulation designed to provide complete protection and nourishment to the lips using natural ingredients and smart formulation behavior. This type of lip balm uses ghee as a key base ingredient due to its excellent moisturizing, healing, and skin-repairing properties. Ghee helps to deeply nourish dry and damaged lips while forming a soft protective layer that prevents moisture loss and keeps lips smooth and healthy [3].

The thermosensitive property of this formulation means that the lip balm responds to body temperature. When applied on the lips, it gently softens or changes its texture, allowing smooth and even spreading. This improves user comfort and helps the active ingredients get absorbed more effectively, enhancing overall performance of the product.

The dual technology aspect refers to the combination of two functional benefits in a single formulation—daytime protection and nighttime repair. During the day, the lip balm helps protect lips from environmental factors like sun



exposure, pollution, and dryness, while maintaining hydration and softness. At night, it supports deeper nourishment and healing, helping to repair damaged lip tissue and restore natural lip health during rest.

Overall, this formulation represents a modern and innovative approach to lip care by combining traditional natural ingredients like ghee with advanced cosmetic technologies. It provides long-lasting hydration, protection, and repair in a single product, making it highly effective for maintaining healthy, soft, and well-nourished lips [4].

II. DRUG PROFILE

The detailed drug profile of all ingredients used in the formulation is presented in Table 1. The selected ingredients were chosen based on their moisturizing, protective, healing, antioxidant, UV-protective, soothing, and thermosensitive properties. These ingredients collectively contribute to the stability, efficacy, safety, and overall performance of the developed thermosensitive dual-compartment herbal lip balm[4][5].

Ingredient	Name Synonym	Biological Source	Family	Chemical Constituents	Uses
Ghee	Clarified butter	Milk of cow/buffalo (<i>Bos indicus</i> , <i>Bos bubalis</i>)	Bovidae	Saturated fats, fatty acids, vitamins A, D, E, K	Deepmoisturizer, emollient, thermosensitive base, improves lip softness and hydration [2].
Beeswax	Cera alba	Honeycomb of <i>Apis mellifera</i>	Apidae	Esters, long-chain alcohols, hydrocarbons	Provides structure, protective barrier, prevents moisture loss
Shea Butter	Butyrospermum butter	Seeds of <i>Vitellaria paradoxa</i>	Sapotaceae	Oleic acid, stearic acid, vitamins A & E	Moisturizing, healing, anti-inflammatory, improves lip softness
Squalane	Hydrogenated squalene	Oliveoil/ sugarcane	Lipid derivative	C ₃₀ H ₆₂ hydrocarbon	Lightweight hydration, non-greasy skin barrier support
Sweet Almond Oil	Oleum amygdalae	Seeds of <i>Prunus amygdalus</i>	Rosaceae	Oleic acid, linoleic acid, vitamin E	Softens lips, nourishes, improves elasticity
Castor Oil	Ricinus oil	Seeds of <i>Ricinus communis</i>	Euphorbiaceae	Ricinoleic acid	Humectant, gloss, moisture retention
Zinc Oxide	Zinc white	Mineral source	Inorganic	ZnO	UV protection, prevents pigmentation
Titanium Dioxide	Titania	Mineral ores	Inorganic	TiO ₂	UV filter, improves stability
Silica	Silicon dioxide	Quartz / sand	Inorganic mineral	SiO ₂	Improves texture, absorbs oil



Vitamin E	Tocopherol	Vegetable oils	Vitamin	Tocopherols	Antioxidant, healing
Vanilla Oil	Vanillin oil	<i>Vanilla planifolia</i> pods	Orchidaceae	Vanillin	Fragrance, sensory enhancement
Beetroot Extract	<i>Beta vulgaris</i>	Roots of <i>Beta vulgaris</i>	Amaranthaceae	Betalains	Natural colorant
Rosehip Oil	<i>Rosa canina</i> oil	Seeds of <i>Rosa canina</i>	Rosaceae	Fatty acids, vitamins A & C	Regeneration, pigmentation reduction
Licorice Extract	<i>Glycyrrhiza</i> extract	Roots of <i>Glycyrrhiza glabra</i>	Fabaceae	Glycyrrhizin	Skin lightening, anti-inflammatory
Chamomile Oil	Matricaria oil	Flowers of <i>Matricaria chamomilla</i>	Asteraceae	Bisabolol, chamazulene	Soothing, healing

Table 1: drug profile of ingredients

III. FORMULATION DESIGN DAY AND NIGHT LIP BALM

The present formulation was designed as a dual-compartment thermosensitive ghee-based lip balm system containing separate day and night formulations for targeted lip care. Both formulations were prepared using a lipid-based semisolid matrix composed of ghee, beeswax, shea butter, squalane, sweet almond oil, castor oil, and Vitamin E to provide moisturization, barrier protection, and smooth application.

The day lip balm was specially formulated to protect lips from environmental damage such as sunlight, pollution, and moisture loss during daytime exposure. Zinc oxide and titanium dioxide were incorporated as physical UV-protective agents, while silica was added to improve texture and reduce greasiness. Beetroot extract was used to provide a natural tint and antioxidant effect, whereas vanilla oil enhanced fragrance and user acceptability. The day formulation was designed to provide a lightweight, smooth, and protective finish on the lips.

The night lip balm was developed for intensive nourishment and overnight repair of damaged lips. Rosehip oil was incorporated for its regenerative and moisturizing properties, while licorice extract was added to help reduce lip pigmentation. Chamomile oil was included for its soothing and anti-inflammatory effects. The night formulation was designed to provide deep hydration, barrier restoration, and repair of dry or chapped lips during sleep.

Both formulations were prepared using the melt-and-mix method and optimized to exhibit thermosensitive behavior, where the balm remains stable at room temperature but softens gently upon application to lips for easy spreading and effective delivery of active ingredients

3.1: Preformulation Optimization Study

Different trial formulations (F1, F2, and F3) were prepared by varying the concentrations of beeswax, ghee, oils, and stabilizing agents to obtain the most suitable thermosensitive ghee-based lip balm formulation.

a. F1 – High Beeswax Formula (More Hardness)

Ingredient	Quantity (g)
Ghee	4
Beeswax	8
Shea Butter	4



Squalane	2
Sweet Almond Oil	2.5
Castor Oil	1
Zinc Oxide	0.5
Titanium Dioxide	0.5
Silica	1
Vitamin E	0.25
Vanilla Oil	0.25
Total	25

Table 1: Composition of F1 – High Beeswax Thermosensitive Lip Balm Formula

b. F2 – High Oil/Ghee Formula (Very Soft Formula)

Ingredient	Quantity (g)
Ghee	8
Beeswax	4
Shea Butter	5
Squalane	3
Sweet Almond Oil	3
Castor Oil	1
Zinc Oxide	0.25
Titanium Dioxide	0.25
Silica	0.25
Vitamin E	0.5
Vanilla Oil	0.75
Total	25

Table 2: Formulation Composition of F2 (High Oil/Ghee Formula for Enhanced Softness)

c. F3 – Final Optimized Formula

Ingredient	Quantity (g)
Ghee	5
Beeswax	6
Shea Butter	5
Squalane	3
Sweet Almond Oil	3
Castor Oil	1.5
Zinc Oxide	0.5
Titanium Dioxide	0.5

Table 3: Formulation Composition of Optimized Day Lip Balm (F3)

3.2: Finalized Formulation Table:

This infographic presents two customized herbal lip balm formulations designed for different times of the day — a Day Lip Balm and a Night Lip Balm.

The Day Version is enriched with ingredients like zinc oxide, titanium dioxide, and silica to provide UV protection, lightweight hydration, and protection against dryness and pigmentation during daytime exposure. Ingredients such as ghee, shea butter, and almond oil help maintain soft, moisturized lips throughout the day.



The Night Version is specially formulated for deep nourishment, repair, and lip regeneration while sleeping. It contains restorative ingredients like rosehip oil, licorice extract, chamomile oil, and vitamin E, which help in reducing pigmentation, soothing damaged lips, and improving lip texture overnight.

Both formulations combine natural oils, waxes, and botanical extracts to provide hydration, protection, healing, and enhanced lip softness in a balanced 25 g preparation.

DAY VERSION – Day Lip Balm

No.	Ingredients	Quantity	Main Base / Function
1	Ghee	5 g	Main base
2	Beeswax	6 g	Strong film
3	Shea Butter	5 g	Moisturizing
4	Squalane	3 g	Light feel
5	Sweet Almond Oil	3 g	Condition
6	Castor Oil	1.5 g	Dispersion / UV protect
7	Zinc Oxide	0.5 g	UV protect
8	Titanium Dioxide	0.5 g	UV booster
9	Silica	0.5 g	Control greasing
10	Vitamin E	0.25 g	Antioxidant
11	Vanilla Oil	0.25 g	Fragrance

Total Weight: 25 g

NIGHT VERSION – Night Lip Balm

No.	Ingredients	Quantity	Main Base / Function
1	Ghee	10 g	Main base (deep nourishment)
2	Beeswax	5 g	Strong film
3	Shea Butter	4 g	Moisturizing
4	Squalane	2 g	Light feel
5	Sweet Almond Oil	1.5 g	Condition
6	Rosehip Oil	1 g	Regeneration
7	Licorice Extract	0.5 g	Depigmenting
8	Vitamin E (Tocopherol)	0.5 g	Cell charger
9	Chamomile Oil	0.5 g	Brightening
10	Vanilla Oil	0.5 g	Aroma / Smell

Total Weight: 25 g

Table 5: Finalized Formulation of Thermosensitive Ghee-Based Dual-Compartment Day and Night Lip Balm



IV. PROCEDURE

a. Procedure for preparation of day version lip balm (25g)

Step 1: Cleaning of Apparatus

All glassware, beakers, spatulas, mortar-pestle, and lip balm containers were washed thoroughly with distilled water and rinsed with ethanol. The apparatus was dried completely before use.

Step 2: Weighing of Ingredients

All ingredients were accurately weighed using a digital analytical balance.

Ingredients:

- Ghee – 5 g
- Beeswax – 6 g
- Shea butter – 5 g
- Squalane – 3 g
- Sweet almond oil – 3 g
- Castor oil – 1.5 g
- Zinc oxide – 0.5 g
- Titanium dioxide – 0.5 g
- Silica – 0.5 g
- Vitamin E – 0.25 g
- Vanilla oil – 0.25 g

Step 3: Preparation of Powder Dispersion

Zinc oxide and titanium dioxide were transferred into a mortar and triturated with castor oil to form a smooth slurry. Silica was added gradually and mixed properly to obtain a uniform dispersion free from lumps.

Step 4: Melting of Wax Phase

Beeswax was taken in a clean beaker and melted using a water bath at a temperature of about 65–70°C with continuous gentle stirring.

Step 5: Addition of Ghee and Shea Butter

After complete melting of beeswax, ghee was added slowly with continuous stirring. Shea butter was then incorporated and heated until a clear and uniform molten mixture was obtained.

Step 6: Addition of Liquid Oils

Squalane and sweet almond oil were added gradually into the molten base and mixed thoroughly to obtain a smooth homogeneous mixture.

Step 7: Incorporation of Powder Dispersion

The prepared zinc oxide–titanium dioxide dispersion was added slowly into the molten base with continuous stirring to ensure uniform distribution of powders and prevent clumping.

Step 8: Cooling of Formulation

The formulation was allowed to cool gradually with continuous stirring until the temperature reached approximately 45–50°C.

Step 9: Addition of Cooling Phase Ingredients

Vitamin E and vanilla oil were added into the warm mixture and stirred properly to ensure uniform mixing.

Step 10: Homogenization

The formulation was mixed continuously for several minutes to obtain a smooth, lump-free, and uniform consistency.

Step 11: Filling of Containers

The semi-molten lip balm was poured carefully into sterilized lip balm containers before solidification.

Step 12: Cooling and Solidification

The filled containers were allowed to cool slowly at room temperature for proper solidification and smooth texture formation.



Step 13: Final Inspection and Storage

The prepared lip balm was inspected for smoothness, uniformity, and absence of oil separation. The containers were closed tightly and stored in a cool and dry place at 20–25°C.

b. Procedure for preparation of night version lip balm (25g)

Step 1: Cleaning of Apparatus

All glassware, beakers, spatulas, glass rods, mortar-pestle, and lip balm containers were cleaned properly using distilled water and ethanol. The apparatus was dried completely before use, and the containers were sterilized to maintain cleanliness and prevent contamination.

Step 2: Weighing of Ingredients

All ingredients were accurately weighed using a digital analytical balance.

Ingredients:

- Ghee – 10 g
- Beeswax – 5 g
- Shea butter – 4 g
- Squalane – 2 g
- Sweet almond oil – 1.5 g
- Rosehip oil – 1 g
- Liquorice extract – 0.5 g
- Vitamin E – 0.5 g
- Chamomile oil – 0.5 g
- Vanilla oil – 0.5 g

Step 3: Melting of Beeswax

Beeswax was transferred into a clean beaker and melted using a water bath at a controlled temperature of 65–70°C with continuous gentle stirring.

Step 4: Addition of Ghee

After complete melting of beeswax, ghee was added slowly into the molten wax phase with continuous stirring until a uniform mixture was obtained.

Step 5: Addition of Shea Butter

Shea butter was added gradually into the molten mixture and heated with continuous stirring until a smooth, creamy, and homogeneous base was formed.

Step 6: Addition of Liquid Oils

Squalane, sweet almond oil, and rosehip oil were added slowly into the molten base while stirring continuously to ensure uniform mixing and proper incorporation of nourishing oils.

Step 7: Incorporation of Licorice Extract

Liquorice extract was added gradually into the warm oil phase and mixed thoroughly to achieve uniform dispersion without clumping.

Step 8: Cooling of Formulation

The formulation was removed from heating and allowed to cool gradually with continuous gentle stirring until the temperature reached approximately 45–50°C.

Step 9: Addition of Cooling Phase Ingredients

Vitamin E, chamomile oil, and vanilla oil were added into the warm formulation and mixed properly to ensure uniform distribution of heat-sensitive ingredients.

Step 10: Homogenization

The formulation was stirred continuously for several minutes to obtain a smooth, uniform, and lump-free consistency without air bubbles or oil separation.



Step 11: Filling of Containers

The semi-molten lip balm was poured carefully into sterilized lip balm containers before complete solidification.

Step 12: Cooling and Solidification

The filled containers were allowed to cool slowly at room temperature to achieve proper solidification and smooth texture formation.

Step 13: Final Inspection and Storage

The prepared lip balm was inspected for smooth appearance, uniform consistency, and absence of oil separation or graininess. The containers were tightly closed and stored in a cool and dry place at 20–25°C.

V. MAINTAINING THERMO-SENSITIVITY IN LIP BALM FORMULATION

Thermosensitivity of the lip balm was maintained by carefully balancing the proportions of waxes, oils, butters, and active ingredients so that the formulation remained stable at room temperature while melting smoothly upon application to the lips. A proper wax-to-oil ratio was optimized to achieve desirable hardness, spreadability, and consistency without making the balm excessively hard or greasy[3].

Beeswax was used as the primary structural wax because of its high melting point and ability to provide thermal stability, shape retention, and resistance to oil leakage. The day formulation contained a comparatively higher amount of beeswax to improve firmness and reduce greasiness during daytime exposure, whereas the night formulation contained a lower wax concentration to obtain a softer and more nourishing texture.

Ghee concentration was also adjusted carefully in both formulations. Lower ghee content was maintained in the day balm to improve stability and reduce excessive softness, while higher ghee concentration was incorporated in the night balm to provide deep moisturization and enhanced overnight repair.

Shea butter was added to improve creaminess, smooth melting behavior, and flexibility of the lipid matrix. To avoid grain formation and instability, controlled heating below 75°C and gradual cooling were maintained throughout the preparation process.

Silica was incorporated to reduce oily feel and improve heat stability, especially in the day formulation. Zinc oxide and titanium dioxide were properly dispersed in castor oil before incorporation to ensure uniform texture and prevent clumping or uneven melting.

Controlled heating and slow cooling were important in maintaining the thermosensitive nature of the lip balm. Rapid cooling was avoided because it may lead to crystal formation, cracking, and texture instability. Vitamin E was added as an antioxidant to protect oils from oxidation and improve shelf life.

The prepared formulations were stored at controlled room temperature (20–25°C) away from direct sunlight and excessive heat. Stability studies such as heating–cooling cycle tests and melting point evaluation were performed to assess thermal stability, texture retention, and overall product performance [6].

Overall, proper ingredient selection, optimized wax-to-oil balance, controlled processing conditions, and suitable storage helped in maintaining the desired thermosensitive behavior of the lip balm formulation[1].

5.1: Storage Conditions:

The prepared thermosensitive ghee-based dual-compartment lip balm should be stored at a controlled room temperature of **18–25°C** to maintain its stability, consistency, and thermosensitive properties. Appropriate storage conditions help preserve the structural integrity of the formulation and ensure optimum performance during application.

The product should be protected from **direct sunlight, excessive heat, and high humidity**, as these conditions may cause softening, oil separation, oxidation of natural ingredients, and loss of fragrance. Conversely, exposure to very low temperatures may increase the hardness of the formulation and reduce its spreadability.

The lip balm should be stored in **airtight and light-resistant containers** to minimize moisture absorption, oxidation, and environmental contamination. Proper packaging also helps maintain the integrity of the dual-compartment system



and prolongs product quality. Under recommended storage conditions, the formulation is expected to remain **stable, safe, and effective for approximately 12–18 months.**

5.2: Packaging:

- ❖ Pink Side – Day Lip Balm
 - Used for daytime protection and hydration
 - Provides UV protection and smooth lip texture
 - Gives soft glow and moisture throughout the day
- ❖ Yellow Side – Night Lip Balm
 - Used for overnight nourishment and repair
 - Helps reduce dryness and pigmentation
 - Deeply moisturizes and heals lips while sleeping
 - Dual-compartment packaging for easy differentiation
 - Attractive pastel cosmetic design
 - Compact, lightweight, and travel-friendly container
 - Hygienic applicator included for safe application
 - Air-tight packaging maintains freshness and stability
 - Transparent container allows visibility of both formulation
 - Prevents mixing or contamination between day and night balms
 - Convenient two-in-one herbal lip care packaging



Figure 1: Optimized Thermosensitive Ghee-Based Dual-Compartment Lip Balm Formulation



5.3: How to use it:



Figure 2: Illustration showing the method of application of the developed thermosensitive ghee-based dual-compartment lip balm. The user unscrews the applicator cap, applies the formulation evenly on the lips, and securely closes the container after use.

VI. EVALUATION TEST

Various evaluation parameters such as pH, spreadability, homogeneity, and stability studies are commonly employed to assess the quality of lip balm formulations [1][2][8].

6.1: Physical Appearance Evaluation

The physical appearance of the prepared thermosensitive ghee-based lip balm was evaluated to assess its color, odour, texture, smoothness, and overall aesthetic acceptability. The formulation was visually inspected to ensure uniformity, elegance, and suitability for cosmetic application [1].



Figure 3: Physical Appearance of Optimized Thermosensitive Ghee-Based Dual-Compartment Lip Balm

Sr. No.	Observation Parameter	Practical Observation	Result
1	Colour	Light yellow creamy colour observed	Acceptable
2	Odour	Pleasant herbal aroma observed	Good
3	Texture	Smooth and non-greasy	Satisfactory

Table 4: Physical Appearance Characteristics of Thermosensitive Ghee-Based Lip Balm



Observation: The formulation exhibited an attractive appearance, pleasant odour, smooth texture, and acceptable physical characteristics. The lip balm showed good aesthetic acceptability and was found suitable for lip care application.

6.2: pH Determination

The pH of the prepared thermosensitive ghee-based lip balm was determined to evaluate its compatibility with the lips and skin and to ensure that the formulation would not cause irritation during regular use [9].

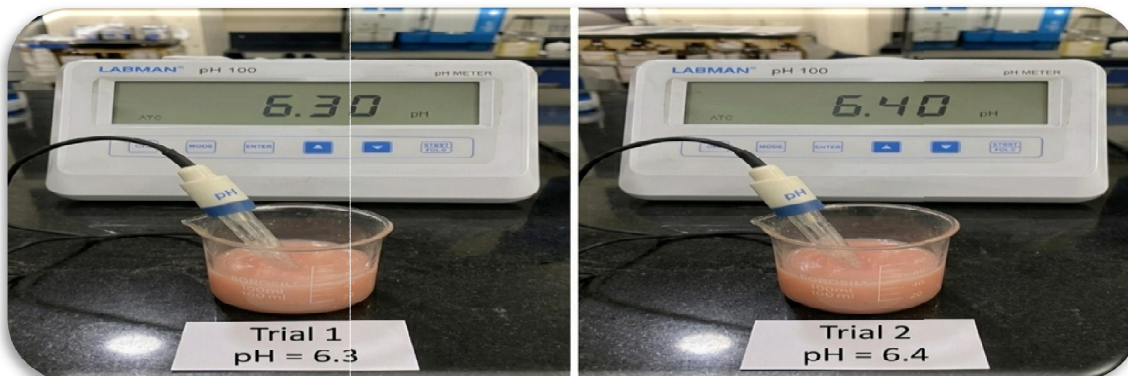


Figure 1: Digital pH meter showing the pH measurement of the prepared lip balm formulation (pH 6.3–6.4).

Sr. No. Trial Observed pH Result

1	Trial 1 6.3	Suitable
2	Trial 2 6.4	Acceptable

Table 5: The softening behavior of the lip balm was evaluated at 35°C and 37°C to determine its temperature responsiveness and application characteristics.

Observation: The lip balm exhibited a pH range of 6.3–6.4, which is close to the physiological pH of the lips and skin. The formulation was found to be mild, skin-friendly, and suitable for topical application without causing irritation.

6.3: Spreadability Test

The spreadability test was performed to evaluate the ease and uniformity of application of the prepared thermosensitive lip balm. Good spreadability is essential to ensure smooth application, adequate coverage, and user acceptability [5].

$$S = (m \times L) / t$$

Where:

- S = Spreadability (g·cm/s or N·cm/s depending on units)
- m = Mass or weight applied to the sample (g or N)
- L = Distance the sample spreads under the applied weight (cm)
- t = Time taken for the sample to spread (s)



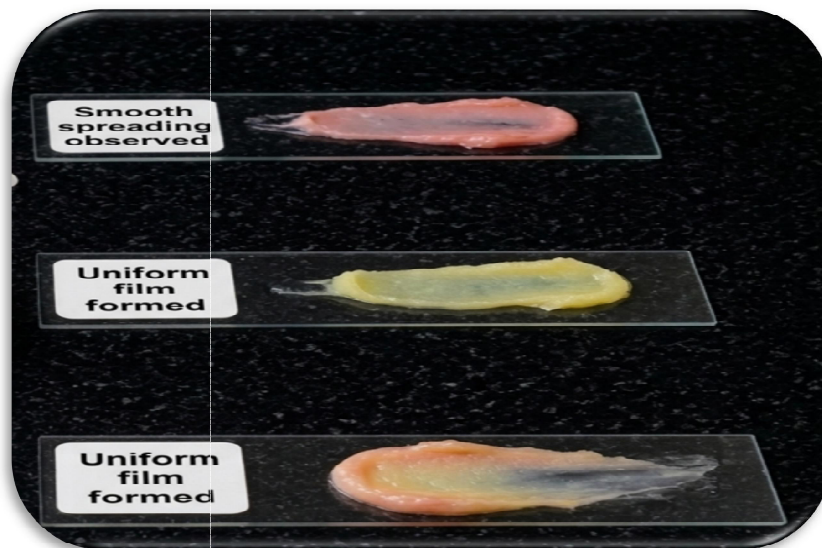


Figure 2: evaluation of the spreading behavior of the prepared lip balm demonstrating smooth application and uniform film formation.

Sr. No.	Observation	Result
1	Smooth spreading observed	Good
2	Uniform film formed	Excellent

Table 6: Spreadability Evaluation of Optimized Thermosensitive Ghee-Based Lip Balm

Observation: The prepared lip balm exhibited excellent spreadability and formed a uniform film upon application. The formulation spread smoothly over the lips without dragging, breakage, or excessive greasiness. These results indicate that the lip balm possesses desirable application properties and can provide effective moisturization with improved consumer acceptability.

6.4: Softening Time Test

The softening time test was carried out to evaluate the thermosensitive behavior of the prepared lip balm and to determine the time required for the formulation to soften at temperatures close to body temperature. This test helps assess the ease of application and temperature responsiveness of the formulation [8].

Sr. No.	Temperature	Time Observed	Result
1	35°C	4 min 20 sec	Acceptable
2	37°C	3 min 50 sec	Good

Table 8: The softening behavior of the lip balm was evaluated at 35°C and 37°C to determine its temperature responsiveness and application characteristics.

Observation: The formulation exhibited a softening time of 4 minutes 20 seconds at 35°C and 3 minutes 50 seconds at 37°C. The reduction in softening time with increasing temperature confirmed the thermosensitive nature of the lip balm. The formulation remained stable at room temperature while softening appropriately near body temperature, thereby facilitating smooth application and improved spreadability on the lips.



6.5: Skin Irritation Test

The skin irritation test was performed to evaluate the safety and compatibility of the prepared thermosensitive lip balm formulation. The formulation was applied to the skin and observed for any signs of redness, itching, swelling, or irritation [9].



Figure 7: Irritation Test Results of Optimized Thermosensitive Ghee-Based Lip Balm

Sr. No. Parameter Observation Result

1	Redness	Absent	Safe
2	Itching	Absent	Non-irritant

Table 9: Skin Irritation Test Results of Optimized Thermosensitive Ghee-Based Lip Balm

Observation: No redness, itching, swelling, or any other signs of irritation were observed during the study period. The formulation was found to be non-irritant and safe for topical application. The presence of natural and skin-friendly ingredients contributed to its good compatibility with the skin, making it suitable for regular lip care use.

6.6: Stability Study

The stability study was carried out to evaluate the physical stability of the prepared thermosensitive lip balm formulation under different storage conditions. The formulation was stored at various temperatures and monitored for changes in appearance, texture, consistency, and overall performance over the study period [8].

Storage Condition	Observation	Result
4°C	No change observed	Stable
25°C	Stable texture maintained	Good
40°C	Slight softening observed	Acceptable

Table 10: Stability Evaluation Under Different Storage Conditions

Observation: The formulation remained stable under all tested storage conditions. No significant changes in appearance, texture, or consistency were observed at 4°C and 25°C throughout the study period. At 40°C, slight softening of the formulation was observed; however, the product remained acceptable and retained its overall integrity. These findings indicate that the lip balm possesses satisfactory stability, with optimum performance under refrigerated and room temperature conditions.

6.7: Homogeneity Test

The homogeneity test was performed to evaluate the uniform distribution of ingredients in the prepared thermosensitive lip balm formulation and to ensure the absence of lumps, coarse particles, crystal formation, or phase separation. A homogeneous formulation is essential for maintaining product stability, consistency, and uniform application [12].



Sr. No.	Observation	Result
1	Uniform consistency observed	Good
2	No lumps present	Passed

Table 11: Evaluation of Homogeneity of Formulation Based on Physical Observation

Observation: The prepared formulation exhibited excellent homogeneity and a uniform appearance throughout the sample. No lumps, crystal formation, or phase separation were observed. The ingredients were well dispersed within the formulation, resulting in a stable and homogeneous texture suitable for smooth and effective lip care application.

6.8: Perfume/Flavor Retention Test

The fragrance and flavor retention test was performed to evaluate the stability of the aromatic components present in the formulation during storage and to assess consumer acceptability over time [2].

Sr. No.	Observation Day	Observation	Result
1	Day 1	Strong and pleasant fragrance retained	Excellent
2	Day 15	Fragrance retained with slight reduction in intensity	Good
3	Day 30	Pleasant aroma still present without off-odor	Acceptable

Table 12: Evaluation of Perfume/Fragrance Stability of the Formulation During Storage Period

Observation: The prepared lip balm exhibited satisfactory perfume and flavor retention throughout the storage period. Although a slight reduction in fragrance intensity was observed over time, the formulation maintained a pleasant aroma without developing any undesirable odor. These results indicate good stability of the fragrance components and enhanced consumer acceptability of the product.

• Interpretation of Results

The evaluation results demonstrated that the prepared thermosensitive ghee-based lip balm possessed desirable physicochemical and cosmetic properties. The formulation exhibited an attractive appearance, pleasant aroma, smooth texture, acceptable pH, and good homogeneity, indicating proper formulation and uniform distribution of ingredients. The melting point and softening time studies confirmed its thermosensitive nature, as the lip balm remained stable at room temperature while softening near body temperature for smooth application.

The formulation showed excellent spreadability, allowing uniform application without excessive greasiness. No signs of redness, itching, or irritation were observed during the skin irritation study, confirming its safety and compatibility for topical use. Stability studies revealed that the lip balm remained physically stable under different storage conditions, while the perfume and flavor retention test indicated satisfactory fragrance stability throughout the storage period.

Overall, the developed thermosensitive ghee-based lip balm was found to be stable, safe, aesthetically acceptable, and suitable for effective lip care application.

VII. DISCUSSION

The present study successfully developed a thermosensitive ghee-based dual-compartment lip balm for synchronized day and night lip care. Ghee acted as the main nourishing base and provided excellent moisturizing, healing, and softening effects due to its rich fatty acid and antioxidant content. Beeswax contributed to the firmness, stability, and protective barrier-forming property of the formulation, helping to reduce moisture loss from the lips [2].

The thermosensitive nature of the formulation allowed the lip balm to remain stable at room temperature while softening near body temperature, resulting in smooth application and better spreadability [3][4]. The dual-compartment technology helped in separating the day and night formulations according to their specific functions. The day compartment mainly provided hydration and environmental protection, while the night compartment focused on repair, soothing, and nourishment of dry or damaged lips[1].



Other ingredients such as shea butter, squalane, almond oil, castor oil, rosehip oil, licorice extract, chamomile oil, vitamin E, zinc oxide, and beetroot extract further enhanced the moisturizing, protective, antioxidant, and soothing properties of the formulation [6].

Evaluation studies confirmed that the formulation possessed good stability, smooth texture, satisfactory spreadability, prolonged moisturizing effect, safe skin compatibility, and good consumer acceptability. Overall, the formulated thermosensitive dual-care lip balm showed promising potential as an effective and innovative lip care product [7][8].

• **Future scope of the developed product:**

- Further clinical studies can be carried out to evaluate long-term safety and effectiveness of the formulation.
- The formulation can be modified with additional herbal or medicated ingredients for enhanced therapeutic benefits.
- Advanced packaging systems may be developed to improve stability and convenience of the dual-compartment technology.
- Large-scale production and commercial development of the product can be explored.
- Further studies can be conducted to improve fragrance retention and high-temperature stability.
- The thermosensitive technology can also be applied in other cosmetic and topical formulations such as creams, balms, and ointments.

VIII. CONCLUSION

The present study successfully formulated and evaluated a thermosensitive ghee-based dual-compartment lip balm designed for synchronized day and night lip care. The formulation demonstrated satisfactory physicochemical properties, good stability, smooth texture, excellent spreadability, and effective moisturizing ability.

The incorporation of natural ingredients such as ghee, beeswax, shea butter, natural oils, herbal extracts, and antioxidants contributed significantly to the nourishing, protective, soothing, and repairing properties of the formulation. The thermosensitive behavior of the lip balm allowed it to remain stable at room temperature while softening near body temperature, ensuring smooth application and better user comfort.

The dual-compartment technology proved beneficial in providing separate functional benefits for daytime protection and nighttime repair within a single product system. Evaluation studies confirmed that the formulation was non-irritant, microbiologically safe, and cosmetically acceptable.

Overall, the developed thermosensitive ghee-based dual-care lip balm can be considered a promising, innovative, stable, and effective lip care formulation with potential for future cosmetic and therapeutic applications.

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