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Formulation and Evaluation of Herbal Lip Balm with Sun Protection Factor (SPF 15)

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Abstract: *The present study was aimed at the formulation and evaluation of a herbal lip balm with sun protection factor (SPF 15) using natural ingredients. Lips are highly sensitive to environmental factors such as dryness, UV radiation, and pollution, which can lead to cracking and damage. The use of herbal ingredients in cosmetic formulations offers a safer and more biocompatible alternative to synthetic products.*

In this study, a lip balm was formulated using beeswax as a base, along with coconut oil, beetroot infused castor oil, vitamin E, and zinc oxide. Beetroot infused castor oil was prepared by heating beetroot powder with castor oil and filtering the mixture to obtain a natural coloring and emollient agent. Zinc oxide was incorporated as a physical sunscreen to provide UV protection.

Different trial formulations (F1–F4) were prepared by varying the proportions of oils, while keeping beeswax constant, and the optimized formulation (F2) was selected based on evaluation parameters. The prepared formulations were evaluated for organoleptic characteristics, spreadability, melting point, pH, washability, skin irritation, stability, and SPF value.

The optimized formulation exhibited smooth texture, uniform appearance, good spreadability, and stability under various storage conditions. The melting point was found to be within the acceptable range, and the pH was suitable for lip application. No signs of skin irritation were observed. The SPF value of the formulation was determined using UV spectrophotometric method and was found to be approximately 15.50, indicating moderate protection against UVB radiation.

The results of the study suggest that the developed herbal lip balm is safe, stable, and effective for daily use, providing both moisturizing and sun protective benefits. The formulation demonstrates the potential of herbal ingredients in the development of cosmetic products with enhanced functionality and consumer acceptability..

Keywords: *SPF 15*

INTRODUCTION

The lips are one of the most sensitive and delicate parts of the human body. Unlike other areas of the skin, the lips lack sebaceous glands and have a very thin stratum corneum, making them highly susceptible to dryness, cracking, and environmental damage. Exposure to external factors such as wind, low humidity, pollution, and especially ultraviolet (UV) radiation can lead to dehydration, chapping, hyperpigmentation, and even long-term damage like actinic cheilitis or lip cancer. Therefore, proper lip care is essential for maintaining both aesthetic appearance and physiological health [1,2].

Lip balms are semisolid cosmetic preparations designed to protect, moisturize, and nourish the lips. They form a protective barrier that prevents moisture loss and shields the lips from harmful environmental conditions. Traditional lip balms primarily contained petroleum-based ingredients; however, increasing concerns regarding synthetic chemicals and their potential side effects have led to a growing demand for herbal and natural alternatives. Herbal lip balms are formulated using plant-based ingredients that are safe, biodegradable, and compatible with human skin [3,4].

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The use of herbal cosmetics has gained significant importance in recent years due to their minimal toxicity, reduced side effects, and eco-friendly nature. Natural ingredients such as beeswax, plant oils, herbal extracts, and natural colorants are widely used in lip balm formulations. Beeswax acts as a natural base and provides structural integrity to the formulation. It also forms a protective layer on the lips, preventing moisture loss. Coconut oil and castor oil serve as excellent emollients, providing hydration, smoothness, and gloss. These oils are rich in fatty acids, which help in repairing damaged lip tissues and maintaining softness [5,6].

In addition to moisturization, protection against solar radiation is a critical aspect of lip care. The lips are particularly vulnerable to UV radiation because they contain less melanin compared to other skin areas. Ultraviolet radiation is classified into UVA (320– 400 nm) and UVB (290– 320 nm) rays, both of which contribute to lip damage. UVB radiation is primarily responsible for sunburn and DNA damage, while UVA penetrates deeper and causes premature aging.

Therefore, incorporating sun protection factor (SPF) into lip balm formulations is essential [7].

SPF is a measure of a product's stability to protect the skin from UVB radiation. An SPF of 15 blocks approximately 93% of UVB rays, providing moderate protection suitable for daily use. In herbal formulations, physical sunscreen agents such as zinc oxide are commonly used. Zinc oxide acts by reflecting and scattering UV radiation, making it a safe and effective ingredient for topical applications. It is non-irritating, non-comedogenic, and suitable for sensitive skin [3,8].

Natural colorants are another important component of herbal lip balms. Synthetic dyes may cause irritation or allergic reactions; hence, plant-based colorants like beetroot extract are preferred. Beetroot (Beta vulgaris) contains betalains, which impart a natural red color along with antioxidant properties. These antioxidants help in protecting the lips from oxidative stress and environmental damage [9].

Vitamin E (tocopherol) is often incorporated into lip balm formulations as an antioxidant and preservative. It protects the formulation from oxidation and enhances the shelf life of the product. Additionally, it provides nourishment to the lips and promotes healing of dry and cracked skin [10].

The formulation of a herbal lip balm involves careful selection of ingredients to achieve desirable properties such as smooth texture, good spreadability, stability, and aesthetic appeal. Evaluation of the formulation is equally important to ensure its quality, safety, and effectiveness. Various parameters such as melting point, pH, spreadability, stability, surface characteristics, and SPF value are assessed [11,12].

In the present study, an attempt is made to formulate a herbal lip balm with SPF 15 using natural ingredients like beeswax, coconut oil, castor oil, beetroot extract, vitamin E, and zinc oxide. The formulation aims to provide moisturization, protection against UV radiation, and aesthetic enhancement using safe and herbal components.

II. PLAN OF WORK

The present study entitled "Formulation and Evaluation of Herbal Lip Balm with SPF 15" was carried out in a systematic and stepwise manner to achieve the desired objectives. The entire work was planned and executed in the following stages:

1. Literature Survey

A comprehensive literature review was conducted using standard textbooks, research articles, and online databases to understand the formulation aspects of herbal lip balm, selection of suitable ingredients, and methods for evaluation. Special emphasis was given to the use of natural ingredients, SPF determination methods, and stability considerations.

2. Selection of Ingredients

Based on literature and availability, suitable herbal and excipient ingredients were selected. Beeswax was chosen as the base, coconut oil as an emollient, castor oil for gloss and moisturization, beetroot for natural colour, zinc oxide as a sunscreen agent, vitamin E as an antioxidant, and rose oil for fragrance.

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3. Preparation of Beetroot Infused Castor Oil

Beetroot infused oil was prepared by heating beetroot powder with castor oil followed by filtration. This step was carried out to obtain a uniform natural colouring agent and to improve the texture of the formulation by avoiding direct use of powder.

4. Formulation Development

Different trial formulations (F1–F4) were prepared by varying the proportions of oils while keeping beeswax concentration constant. This was done to study the effect of ingredient variation on the physical properties of the lip balm.

5. Optimization of Formulation

Based on preliminary evaluation results such as texture, spreadability, and stability, the best formulation (F2) was selected as the optimized formulation for further studies.

6. Preparation of Herbal Lip Balm

The lip balm was prepared using the fusion method. Beeswax was melted and mixed with oils, followed by incorporation of zinc oxide, vitamin E, and fragrance. The mixture was then poured into molds and allowed to solidify.

7. Evaluation of Formulation

The prepared formulations were evaluated for various parameters including:

- Organoleptic characteristics
- Spreadability
- Melting point
- pH
- Washability
- Skin irritation test
- Stability studies

SPF determination using UV spectrophotometry

8. Data Analysis and Interpretation

The results obtained from evaluation studies were analyzed to determine the performance of the formulation. The optimized formulation was compared with trial batches to justify its selection.

9. Documentation of Results

All observations, calculations, and results were systematically recorded and presented in tabular and descriptive formats. Graphs and tables were used where necessary to improve clarity.

10. Conclusion and Future Scope

Based on the findings, conclusions were drawn regarding the effectiveness and stability of the formulation. Suggestions for future improvements and scope for further research were also included.

AIM

To formulate and evaluate a herbal lip balm with SPF 15 using natural ingredients that provides effective moisturization, protection against environmental factors, and adequate sun protection while ensuring safety, stability, and consumer acceptability.

OBJECTIVES :

- To develop an innovative herbal lip balm formulation using natural ingredients that ensures superior lip care and safety.
- To enhance lip hydration and nourishment by incorporating emollient-rich natural oils that repair and protect dry, chapped lips.
- To utilize natural coloring agents like beetroot extract, promoting a chemical-free and aesthetically appealing formulation.

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- To achieve an ideal balance of texture, spreadability, and stability for smooth application and long-lasting performance.
- To scientifically evaluate the formulation through physicochemical parameters such as melting point, pH, spreadability, and uniformity.
- To validate the sun protection efficiency by determining SPF using UV spectrophotometric analysis.
- To develop an eco-friendly and cost-effective formulation that supports the growing demand for herbal cosmetics.
- To create a multifunctional lip care product combining moisturization, protection, and natural beauty enhancement in a single formulation.
- To integrate SPF 15 protection into the lip balm using a safe physical sunscreen agent, providing effective defense against harmful UV radiation.

III. LITERATURE REVIEW

The use of cosmetics has evolved significantly over time, with increasing emphasis on safety, efficacy, and natural origin. Herbal cosmetics have gained considerable attention due to their minimal side effects, biocompatibility, and eco-friendly nature. Lip balms, in particular, are widely used cosmetic products designed to protect, moisturize, and enhance the appearance of lips. The incorporation of herbal ingredients into lip balm formulations has been extensively studied and reported in various pharmaceutical and cosmetic research works.

Sharma et al. (2011) reported that lip balms are semisolid cosmetic preparations formulated to protect the lips against dryness, cracking, and environmental damage. The authors explained that lips are highly sensitive due to the absence of sebaceous glands and lower melanin content. According to the study, beeswax is commonly used in lip balm formulations because it provides hardness, structural stability, and forms a protective layer that prevents moisture loss from the lips.[2]

Kumar and Singh (2012) reviewed the role of herbal ingredients in cosmetic formulations and emphasized the increasing popularity of plant-derived oils and extracts in personal care products. Natural oils such as coconut oil and castor oil are extensively used in lip balm formulations due to their excellent emollient and moisturizing properties. Coconut oil contains medium-chain fatty acids that help in retaining moisture and repairing dry lip tissues, whereas castor oil improves gloss, smoothness, and spreadability of the formulation.[4]

Mishra et al. (2015) investigated the use of beetroot (Beta vulgaris) as a natural coloring agent in herbal cosmetic preparations. The authors reported that beetroot contains betalain pigments, especially betanin, which impart an attractive reddish color to formulations. The study also highlighted the antioxidant activity of beetroot, which helps protect the lips from oxidative stress and environmental damage while avoiding the side effects associated with synthetic dyes.[9]

Dwivedi et al. (2013) emphasized the importance of incorporating Sun Protection Factor (SPF) into topical formulations for protection against harmful ultraviolet radiation. According to the study, prolonged exposure to UV rays can cause dryness, hyperpigmentation, premature aging, and actinic cheilitis of the lips. The authors concluded that lip care formulations containing sunscreen agents are essential for daily protection against UVB radiation.[7]

Barel et al. (2009) described zinc oxide as a safe and effective physical sunscreen agent widely used in cosmetic and pharmaceutical formulations. The authors explained that zinc oxide provides broad-spectrum protection by reflecting and scattering both UVA and UVB rays. The study further reported that zinc oxide is non-toxic, photostable, non-irritating, and suitable for sensitive skin, making it highly appropriate for SPF-containing lip balm formulations.[3]

Chanchal and Swarnlata (2008) studied the application of herbal ingredients in cosmetic products and reported that Vitamin E (tocopherol) acts as a potent antioxidant in lip balm formulations. According to the authors, Vitamin E prevents oxidative degradation of oils, enhances stability, improves shelf life, and promotes healing of dry and cracked lips. The study also highlighted its nourishing and moisturizing effects on skin tissues.[6]

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Lavanya and Sravani (2013) formulated and evaluated herbal lip balm preparations using natural ingredients and evaluated parameters such as texture, melting point, spreadability, pH, and stability. The study reported that the ratio of waxes and oils significantly influences the consistency and application properties of lip balms. An optimized balance of oils and waxes was found to provide smooth texture, easy spreadability, and acceptable stability.[11]

WHO (2004) provided guidelines regarding the use of herbal ingredients in cosmetic products and highlighted the importance of safety, efficacy, and standardization of herbal formulations. According to the guidelines, herbal cosmetics should be evaluated for stability, irritation potential, and consumer safety before commercial application. The report also encouraged the use of natural and biodegradable ingredients in personal care products.[17]

PLANT AND INGREDIENT PROFILE

1. Plant Profile of Beetroot

Common Name: Beetroot

Scientific Name: Beta vulgaris

Taxonomy

Kingdom: Plantae

Division: Angiosperms

Class: Eudicots

Botanical Order: Caryophyllales

Family: Amaranthaceae

Genus: Beta

Species**:** ***Beta vulgaris***

Biological Source: Beetroot consists of the fresh or dried roots of Beta vulgaris belonging to **Family** Amaranthaceae.[13]

Chemical Constituents:

Betalains (Betanin)

Flavonoids

Phenolic compounds

Vitamins (Vitamin A, Vitamin C)

Minerals (Iron, Potassium, Magnesium)

Carbohydrates

Medical and Cosmetics Uses

Used as a natural coloring agent in cosmetics.

Provides antioxidant protection.[12]

Helps in healing dry lips.

Improves skin health and nourishment.[17]

Used in herbal remedies for detoxification.[13]

Fig no. 1- Beetroot Powder

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2. Ingredient (Drug) Profile

Beeswax

Source: Purified wax obtained from honeycomb of honeybees ***(Apis mellifera)*** belonging to **Family** Apidae [5]

Category: Natural wax

Description: Yellowish solid wax with characteristic odour**.**

Function in formulation:

Provides hardness and structure;

Acts as a base material ;

Forms a protective barrier on lips[3,5]

Fig no. 2- Beeswax

Coconut Oil

Biological Source: Fixed oil obtained from dried kernel of ***Cocos nucifera[14]***

Category: Fixed oil

Description: Clear, colorless oil with pleasant odor

Function in formulation:

Acts as emollient and moisturizer[4]

Prevents dryness of lips

Possesses mild antimicrobial properties[9]

Fig no. 3- Coconut Oil

Castor Oil

Biological Source: Fixed oil obtained from seeds of Ricinus communis

Category: Fixed oil

Description: Pale yellow, viscous liquid

Function in formulation:

Provides gloss and shine[4]

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Improves spreadability
Enhances smooth texture[11]

Vitamin E
Chemical Name: Tocopherol
Category: Antioxidant and Skin-conditioning agent
Description: Fat-soluble vitamin
Function in formulation:
Prevents oxidation of oils[10]
Enhances shelf life
Nourishes and repairs lips[6]

Fig no. 4 - Vitamin E

Zinc Oxide
Category: Physical sunscreen agent
Description: Fine white amorphous powder
Function in formulation:
Provides SPF protection[8]
Reflects and scatters UVA and UVB radiation[3,8]
Protects lips from sun damage[7]

Fig no. 5- Zn oxide powder

Rose Oil
Biological Source: Volatile oil obtained from fresh petals of ***Rosa damascena[14]***
Family: Rosaceae
Category: Natural fragrance agent
Description: Aromatic volatile oil with characteristic pleasant rose odor

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Function in Formulation:
Provides pleasant rose fragrance
Gives refreshing and soothing effect [2]

Fig no. 6- Rose Oil

IV. METHODOLOGY

1. Materials and Chemicals

Materials

- Beeswax
- Coconut oil
- Beetroot powder
- Castor oil
- Vitamin E
- Rose oil
- Glass rod
- Whatman filter paper

Chemicals

Zinc oxide (sunscreen agent, SPF contributor)

2. Equipment

- Analytical weighing balance
- Beakers (50 mL, 100 mL)
- Water bath (water bath setup)
- Thermometer
- Spatula
- Lip balm molds/containers

3. Experimental / Methodology

3.1 Preparation of Beetroot Infused Castor Oil

Principle: Oil infusion extracts natural pigments (betalains) from beetroot into castor oil, providing uniform color and avoiding grittiness.[9]

Procedure:

Weigh 3 g of beetroot powder and transfer to a clean beaker.

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Add 15 mL castor oil to the powder.
Heat the mixture on a water bath at 60–70 °C for 40-50 minutes with occasional stirring.
Allow to cool slightly.
Filter through muslin cloth or filter paper to remove solid residue.
Collect the clear red-colored beetroot infused castor oil in a clean container.
Store in an amber container until use.
Note: From this stock infusion, required quantity (≈3–3.5 g) is taken for each 10 g batch.

Fig no. 7- Beetroot Infused Castor Oil

3.2 Formulation Development

3.2.1 Trial Formulations (F1–F4)

(All batches = 10 g, beeswax kept constant at 2.5 g)

SR. NO.	INGREDIENTS	F1 (g)	F2 (g)	F3 (g)	F4(g)
1	BEESWAX	2.5	2.5	2.5	2.5
2	COCONUT OIL	3.8	3.5	3.2	3.7
3	BEETROOT INFUSED CASTOR OIL	3.0	3.3	3.6	3.8
4	ZINC OXIDE	0.8	0.8	0.8	0.8
5	VITAMIN E	0.2	0.2	0.2	0.2
6	ROSE OIL	q.s	q.s	q.s	q.s
7	TOTAL	10g	10g	10g	10g

3.2.2 Optimized Formulation (F2 – Main Formulation)

SR NO.	INGREDIENTS	QUANTITY
1	BEESWAX	2.5g
2	COCONUT OIL	3.5g (3.8 ml)
3	BEETROOT INFUSED CASTOR OIL	3.3g (3.4 ml)
4	ZINC OXIDE	0.8g
5	VITAMIN E	0.2g
6	ROSE OIL	q.s
7	TOTAL	10g

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Selection basis: F2 showed best texture, spreadability , non-stick feel,uniform color, and stability while maintaining SPF.3.3 Method of Preparation of Herbal Lip Balm

3.3 Method of Preparation of Herbal Lip Balm

Principle: Fusion method using wax base and oil phase with uniform dispersion of zinc oxide.[2,12]

Procedure:

Accurately weigh all ingredients as per formulation.

Place beeswax (2.5 g) in a beaker and melt on a water bath (≈70 °C).

Add coconut oil to the molten beeswax and mix gently.

Add beetroot infused castor oil and stir to obtain a uniform oil phase.

Levigate zinc oxide (0.8 g) with a small portion of the warm oil to form a smooth paste, then add to the bulk with continuous stirring to avoid lumps.

Remove from heat; allow to cool slightly (≈55–60 °C).

Add Vitamin E (0.2 g) and rose oil (q.s); mix thoroughly.

Pour the molten mixture into lip balm molds/containers.

Allow to cool and solidify at room temperature.

Label and store in a cool, dry place.

3.4 Experimental Setup Notes

Indirect heating (water bath) is used to prevent degradation of oils and loss of volatile components.

Temperature control (60–70 °C) ensures proper melting without burning beeswax.

Pre-dispersion of zinc oxide ensures uniform SPF distribution and smooth texture.[7]

Clean, dry apparatus is essential to avoid contamination and ensure stability.

3.5 Rationale of Formulation Components:

Beeswax (2.5 g): Provides structure, hardness, and occlusive barrier.[5]

Coconut oil: Emollient; improves softness and spreadability.[4]

Beetroot infused castor oil: Dual role—natural colorant + emollient/gloss.

Zinc oxide (0.8 g): Physical sunscreen; contributes to SPF ~15.[3]

Vitamin E: Antioxidant; enhances stability and lip nourishment.[10]

Rose oil: Improves fragrance and acceptability.

3.6 Methodology Basis

The formulation and preparation steps are adapted from standard cosmetic formulation practices (fusion method) and literature on herbal lip balm and SPF evaluation, with modification to include beetroot oil infusion for natural coloration.[2,7,11]

EVALUATION OF HERBAL LIP BALM WITH SPF 15:

1. Organoleptic Characteristics

Parameters: Colour, odour, texture, appearance

Theory: Organoleptic evaluation assesses the aesthetic acceptability of the formulation using sense organs.

Procedure: The prepared lip balm was visually inspected.

Result: light Reddish-Pink colour, smooth texture, uniform consistency, uniform appearance, pleasant odour, glossy appearance.

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Fig no. 8- Herbal Lipbalm

2. Skin Irritation Test

Theory: Ensures the formulation is safe and non-irritant for topical application.

Procedure: A small quantity was applied on the skin surface of the hand and observed for 24 hrs for any signs of redness, itching, irritation, or inflammation, indicating that the formulation is safe and non-irritating for topical use.

Result: No redness, itching, or irritation observed (non-irritant).

Fig no. 9- Skin Irritation Test

3. Spreadability Test

Theory: Indicates ease of application; higher value = better spreadability.

Procedure:

Take a small quantity of prepared herbal lip balm formulation.

Place the sample between two clean glass slides.

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Place a weight of 20 g over the upper glass slide.
Allow the weight to remain for a fixed period of time to facilitate spreading of the formulation.
Measure the distance spread by the upper slide.
Record the time taken for spreading of the formulation.

Formula: $S = M \times L/T$

Where:

S= Spreadability (g·cm/sec),
M= Weight applied (g)
L = Length moved (cm)
T= Time taken (sec)

Sample Calculation:

M = 20g
L=5cm
T=3sec

S = 20×5÷ 3= 33.3 g.cm/sec

Result:

Spreadability = **10cm/sec → Good** (easy to spread).

Fig no. 10- Spreadability Test

4. Melting Point Determination

Principle

The melting point of lip balm is determined to evaluate its thermal stability and suitability for topical application. An ideal lip balm should remain solid at room temperature and melt smoothly during application on lips. The melting point mainly depends on the concentration of waxes and oils present in the formulation.

Procedure

Take a small quantity of prepared herbal lip balm formulation.
Fill the lip balm sample into one end of a capillary tube.
Attach the capillary tube to a thermometer using a rubber band or thread.
Immerse the thermometer along with capillary tube into a beaker containing water.
Heat the water bath gradually with continuous stirring to ensure uniform heating.
Observe the temperature at which the lip balm sample starts melting inside the capillary tube.
Record the observed temperature as melting point.
Repeat the procedure three times and calculate the average melting point.

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Observation Table

Trial	Melting Point (°C)
1	63°C
2	65°C
3	64°C

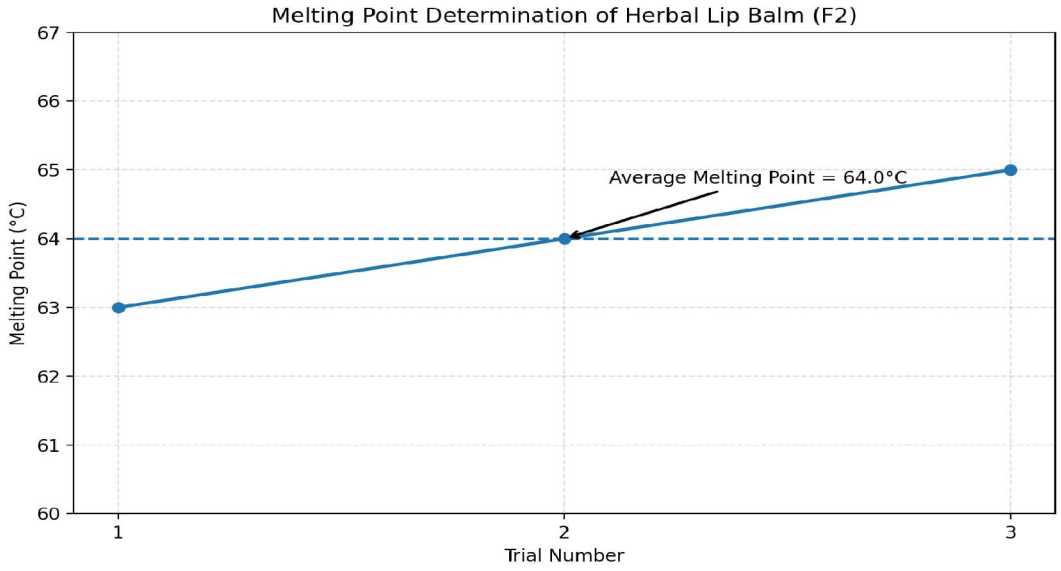
Calculation

Average Melting Point = (63 + 64 + 65) / 3 = 64°C

Result

The average melting point of the prepared herbal lip balm was found to be 64°C, indicating good thermal stability and suitable consistency for lip application.

Fig no. 11- Melting Point Determination



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5. pH Determination

Theory: pH should be compatible with lip skin to avoid irritation.

Procedure:

Accurately weigh 1 g of prepared herbal lip balm formulation.

Transfer the sample into a beaker containing 10 mL of distilled water.

Heat the mixture gently on a water bath with continuous stirring to facilitate uniform dispersion of lip balm components in water.

Allow the prepared dispersion to cool to room temperature.

Dip a pH paper strip into the dispersion for few seconds and compare the obtained color with the standard pH color chart.

Record the observed pH value.

Result:

pH = 6.5 (skin compatible).

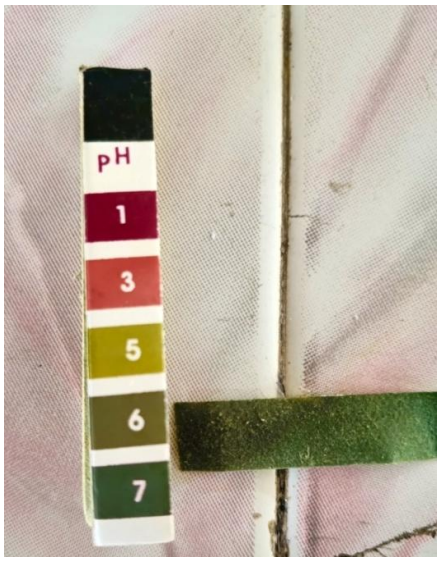

Fig no. 12- pH Determination

6. Washability Test

Principle

Washability test is performed to evaluate the ease of removal of the lip balm formulation from the skin surface. This test indicates user convenience and cleansing property of the formulation.

Procedure

Apply a small quantity of prepared herbal lip balm on the skin surface.

Allow the formulation to remain for few minutes.

Wash the applied area using water with gentle rubbing.

If required, use mild soap solution to facilitate removal of waxy and oily components.

Observe the ease of removal and presence of any oily or sticky residue on the skin.

Record the washability characteristics of the formulation.

Result

The prepared herbal lip balm was washable with water and mild soap, and no excessive oily or sticky residue remained on the skin surface after washing. The formulation showed satisfactory washability suitable for topical application.

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Fig no. 13- Washability Test

7. Stability Study

Principle

Performed to evaluate stability of herbal lip balm under different storage conditions.
Observed for changes in colour, odour, texture, consistency, and appearance.

Procedure

Prepared lip balm was stored under:
Room temperature
4°C (Refrigeration temperature)
40°C (Elevated temperature)
Samples were observed for "Short term stability study for 3 days."
Physical changes were recorded daily.

Observations

Storage Condition	Observation
Room Temperature	No significant change
Refrigeration Temperature	No significant change
Elevated Temperature	Slight softening observed

Result

Formulation remained stable during study period.
No significant changes in colour, odour, texture, or phase separation were observed.
Lip balm showed good stability under different storage conditions.

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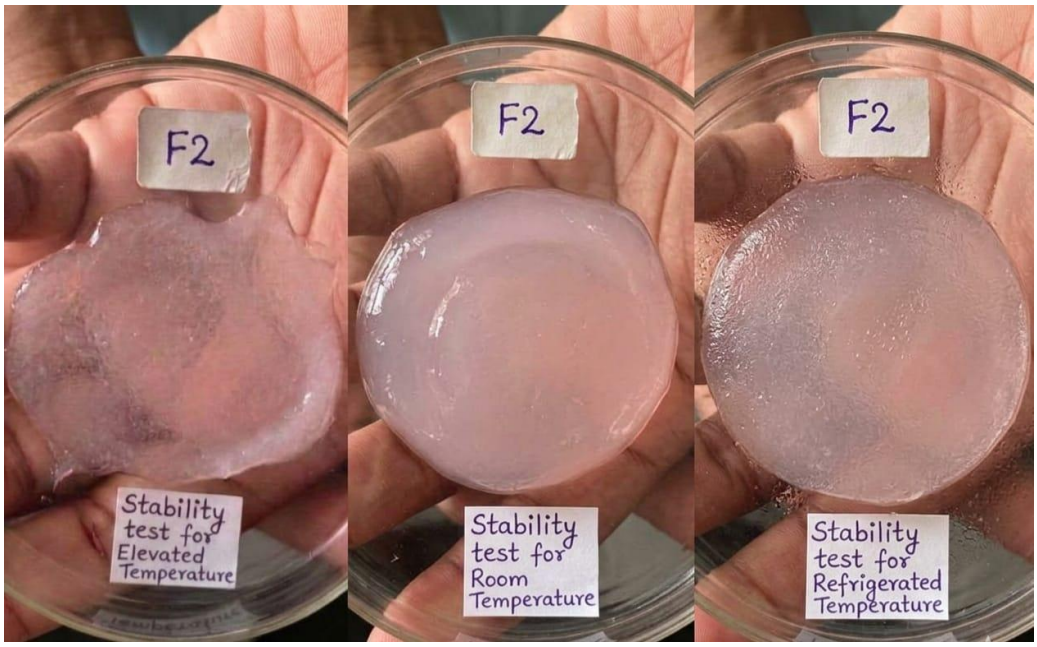

Fig no. 14- Stability Study

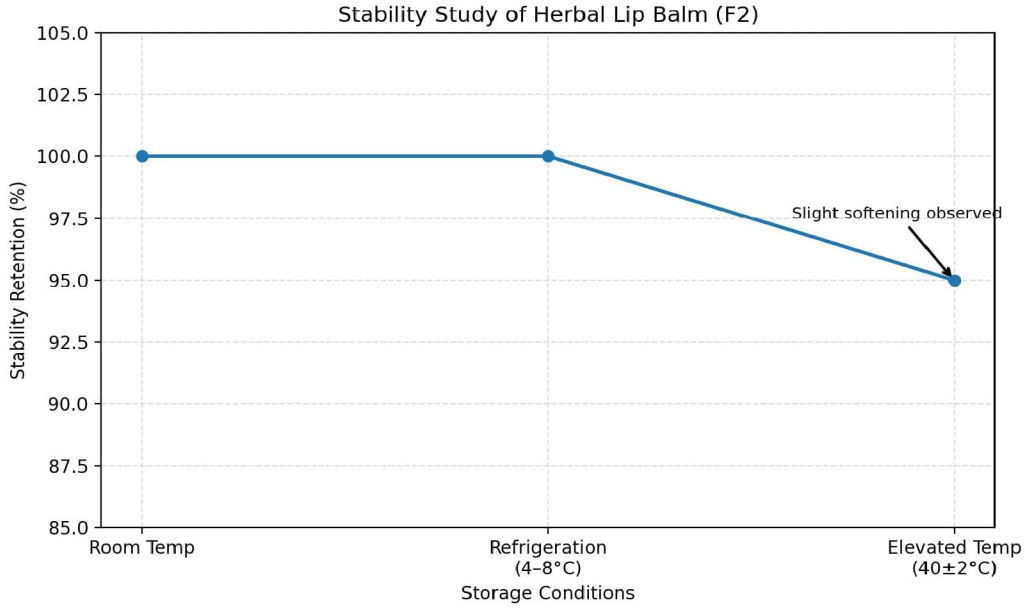

Fig no. 15- Stability Study Graph

8. SPF (Sun Protection Factor) Evaluation

Principle

The SPF of the prepared herbal lip balm was determined by UV spectrophotometric method using ethanol as solvent. The absorbance of the sample solution was measured in the UVB region (290–320 nm), and SPF value was calculated using Mansur equation.[7]

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Method: Single Dilution Method

Procedure

Accurately weigh 1 g of prepared herbal lip balm formulation.

Transfer the sample into a 100 mL volumetric flask containing ethanol.

Disperse the sample in ethanol by gentle heating with continuous stirring to facilitate partial extraction of UV-active constituents and uniform dispersion of zinc oxide for UV spectrophotometric SPF analysis.

Make up the volume to 100 mL using ethanol to obtain stock solution.

Filter the prepared solution to remove undissolved wax particles and other insoluble materials.

Pipette 1 mL of filtrate and dilute up to 10 mL with ethanol.

Measure the absorbance of the diluted solution at 290, 295, 300, 305, 310, 315, and 320 nm using UV-visible spectrophotometer, using ethanol as blank.

Calculate SPF value using Mansur equation.

Formula:– $SPF=CF \times \sum EE(\lambda) \times I(\lambda) \times Abs(\lambda)$

Where:

CF = Correction factor (10)

EE(λ) = Erythemal effect

I(λ) = Solar intensity

Abs(λ) = Absorbance at wavelength(λ)

Standard EE × I Values

Wavelength(nm)	EE×I
290	0.0150
295	0.0817
300	0.2874
305	0.3278
310	0.1864
315	0.0839
320	0.0180

Calculation Tables: Absorbance Readings for SPF Evaluation

λ (nm)	Abs 1	Abs 2	Abs 3	Mean Abs	SD
290	0.84	0.86	0.85	0.85	0.010
295	1.08	1.12	1.10	1.10	0.020
300	1.53	1.57	1.55	1.55	0.020
305	1.63	1.67	1.65	1.65	0.020
310	1.38	1.42	1.40	1.40	0.020

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315	1.03	1.07	1.05	1.05	0.020
320	0.68	0.72	0.70	0.70	0.020

"Standard deviation is calculated using (n−1) in denominator for triplicate readings, and it indicates precision. Lower SD means better Accuracy.

λ (nm)	Mean Abs	EE×I	Product
290	0.85	0.015	0.01275
295	1.10	0.0817	0.08987
300	1.55	0.2874	0.44547
305	1.65	0.3278	0.54087
310	1.40	0.1864	0.26096
315	1.05	0.0839	0.08810
320	0.70	0.018	0.01260

Total: ∑(EE×I×Abs) = 1.5506

Final Calculation : SPF = 10× 1.5506 = 15.50

Result: The SPF value of the prepared herbal lip balm was found to be 15.50, indicating moderate and effective protection against UVB radiation.

"The SPF value obtained confirms that the formulation provides adequate sun protection suitable for daily use."

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Fig no. 16- UV Spectrophotometre

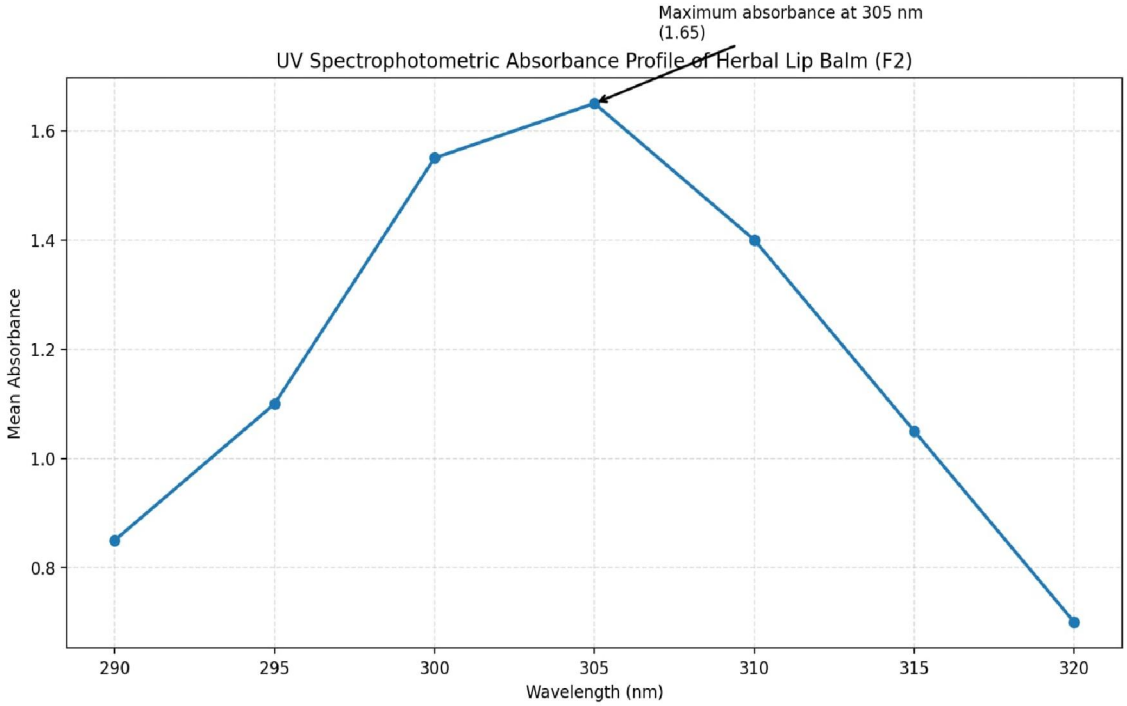

Fig no. 17- UV Spectrophotometric Absorbance Profile

V. RESULTS

The present study was undertaken to formulate and evaluate a herbal lip balm with SPF 15 using natural ingredients. The formulation was developed successfully by preparing different trial batches and optimizing them to obtain the final

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formulation (F2). The prepared lip balm was evaluated for various physicochemical parameters to assess its quality, stability, and performance.

The organoleptic evaluation of the formulated lip balm indicated that the product possessed a smooth and uniform texture with a pleasant rose odour. The colour of the formulation was observed to be reddish pink, imparted by the beetroot infused castor oil. The appearance was glossy and homogeneous, indicating proper mixing and absence of phase separation.

The skin irritation test revealed that the formulation was safe for topical application, as no signs of redness, itching, or irritation were observed after application on the skin. This confirms the compatibility of the formulation with sensitive lip tissues.

The spreadability of the lip balm was found to be satisfactory, indicating that the formulation can be easily applied on the lips without excessive force. The calculated spreadability value demonstrated that the lip balm spreads uniformly and provides a smooth application, which is an essential characteristic for user acceptability.

The melting point of the formulation was found to be within the acceptable range, indicating good thermal stability. The lip balm remained solid at room temperature and melted appropriately upon application, ensuring ease of use under normal environmental conditions.

The pH of the formulation was found to be within the range suitable for skin application, indicating that the formulation is non-irritant and compatible with lip skin. This ensures that prolonged use of the product will not cause any adverse effects.

The washability test indicated that the prepared herbal lip balm formulation could be removed satisfactorily from the skin surface using water with mild soap. No excessive oily or sticky residue remained after washing, indicating good washability and user-friendly application characteristics suitable for daily use.

The stability studies carried out under different storage conditions, including room temperature, refrigeration, and elevated temperature, showed no significant changes in colour, texture, or consistency. This indicates that the formulation is physically and chemically stable and suitable for storage under various conditions.

The SPF evaluation of the optimized formulation was carried out using UV spectrophotometric method. The calculated SPF value was found to be approximately 15.50, which indicates that the formulation provides moderate protection against UVB radiation. This confirms the effectiveness of zinc oxide as a sunscreen agent in the formulation.

Overall, the optimized formulation (F2) exhibited satisfactory physicochemical properties, good stability, and effective sun protection, demonstrating its suitability as a herbal lip balm for daily use.

"The results clearly indicate that the developed (F2) formulation meets the desired criteria for a stable, safe, and effective herbal lip balm with SPF 15."

VI. DISCUSSION

The present study focused on the formulation and evaluation of a herbal lip balm with SPF 15 using natural ingredients such as beeswax, coconut oil, beetroot infused castor oil, vitamin E, and zinc oxide. The objective was to develop a stable, safe, and effective lip care product with sun protection properties. The formulation was optimized by preparing trial batches (F1–F4) and selecting the best-performing formulation (F2) based on evaluation parameters.

The organoleptic characteristics of the optimized formulation (F2) indicated a smooth texture, uniform consistency, and pleasant odour, which are essential for consumer acceptability. The reddish colour obtained from beetroot infusion was uniform and aesthetically appealing, confirming that natural colorants can effectively replace synthetic dyes. This finding is in agreement with previous studies that highlight the use of plant-based pigments as safe and effective cosmetic colorants [7,12].

The spreadability of the formulation was found to be satisfactory, indicating ease of application. This can be attributed to the balanced ratio of beeswax and oils, where beeswax provided structural integrity and oils contributed to smoothness and lubrication. Similar observations have been reported in studies where the proportion of wax and oil significantly influences the application properties of lip balms [3,11].

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The melting point of the formulation was within the acceptable range (60–65°C), demonstrating adequate thermal stability. This ensures that the lip balm remains solid under normal storage conditions while melting appropriately upon application. The result confirms that the selected concentration of beeswax (2.5 g) was optimal for achieving the desired consistency without making the formulation too hard or too soft [3].

The pH of the formulation was found to be within the skin-compatible range, indicating that the product is safe for use on lips and does not cause irritation. This is supported by the skin irritation test, which showed no signs of redness or discomfort, confirming the non-toxic and biocompatible nature of the herbal ingredients used [2].

The stability studies conducted under different environmental conditions revealed no significant changes in colour, texture, or consistency, indicating that the formulation is stable. The presence of vitamin E as an antioxidant contributed to the prevention of oxidative degradation of oils, thereby enhancing the shelf life of the product. These findings are consistent with earlier reports emphasizing the role of antioxidants in improving the stability of cosmetic formulations [8,17].

The SPF evaluation of the optimized formulation yielded a value of approximately 15.50, which indicates moderate protection against UVB radiation. This confirms the effectiveness of zinc oxide as a physical sunscreen agent. Zinc oxide is known to reflect and scatter UV radiation, making it suitable for use in topical formulations [6]. The obtained SPF value aligns with standard guidelines, where SPF 15 is considered adequate for daily protection [16].

The use of beetroot infused castor oil in the formulation served a dual purpose by providing both colour and emollient properties. This approach improved the uniformity of colour distribution and eliminated issues such as grittiness associated with direct use of powder. This highlights the importance of selecting appropriate extraction techniques in herbal formulations [12].

Overall, the study demonstrates that it is possible to develop an effective herbal lip balm with sun protection properties using natural ingredients. The formulation exhibited desirable physicochemical characteristics, stability, safety, and adequate SPF value. The results support the growing trend toward herbal cosmetics as safer alternatives to synthetic products.

VII. CONCLUSION

The present study was successfully carried out to formulate and evaluate a herbal lip balm with SPF 15 using natural ingredients. The formulation was developed using beeswax as a base, along with coconut oil, beetroot infused castor oil, vitamin E, and zinc oxide. The use of herbal components ensured safety, biocompatibility, and improved consumer acceptability.

The prepared lip balm exhibited satisfactory organoleptic properties, including smooth texture, uniform consistency, pleasant odour, and attractive natural colour. The formulation showed good spreadability, appropriate melting point, and skin-compatible pH, indicating its suitability for topical application on lips. The absence of any irritation confirmed the safety of the product.

The stability studies demonstrated that the formulation remained stable under different storage conditions without any significant changes in physical characteristics. The SPF evaluation revealed that the formulation provided effective sun protection with an SPF value of approximately 15.50, confirming the suitability of zinc oxide as a sunscreen agent.

The use of beetroot infused castor oil proved to be effective in providing uniform colour and improved texture, highlighting the advantage of herbal extraction techniques over direct addition of plant powders.

Overall, the study confirms that a stable, safe, and effective herbal lip balm with sun protection properties can be successfully formulated using natural ingredients, offering a suitable alternative to synthetic cosmetic products.

Scope for Future Work

The present work can be further extended in the following ways:

Development of formulations with higher SPF values for enhanced sun protection

Incorporation of additional herbal extracts with therapeutic benefits such as anti-aging and healing properties

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Conducting in vivo SPF studies for more precise evaluation
Performing long-term stability studies to determine shelf life
Exploration of natural preservatives to improve product stability
Scaling up the formulation for commercial production and market evaluation.

"Thus, the developed herbal lip balm formulation demonstrates promising potential as a safe, effective, and economical lip care product for daily use."

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