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Original Article

Development, Stability and Safety Evaluation of Lipstick Formulated with *Butea monosperma*

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ABSTRACT

Background: Increasing safety concerns regarding synthetic colorants have promoted the development of herbal cosmetic formulations. *Butea monosperma* flowers are rich in natural pigments and bioactive compounds suitable for cosmetic use. **Objectives:** The present study aimed to formulate and evaluate a herbal lipstick using the aqueous extract of *Butea monosperma* flowers as a natural colorant. **Materials and Methods:** The extract was prepared by maceration and reflux extraction and incorporated into a wax-oil base. The formulation was evaluated for organoleptic properties, melting point, spreadability, stability, pH, skin irritation, and FTIR compatibility. **Results:** The formulation exhibited desirable organoleptic properties, a melting point of 69.0±0.05°C, good mechanical strength, excellent spreadability, and a smooth application profile. Stability studies conducted over 60 days at room and elevated temperatures indicated no changes in colour, odour, appearance, or textural attributes. The pH of the formulation was 6.8±0.01, which remained within the acceptable dermal range. Skin irritation studies revealed no signs of erythema or swelling, confirming its dermatological safety. FTIR analysis demonstrated the retention of major functional groups of the plant extract, indicating chemical compatibility and absence of degradation within the formulation. **Conclusion:** Overall, the herbal lipstick showed promising aesthetic and functional characteristics, supporting the potential of *Butea monosperma* as a safe and effective natural colorant in cosmetic applications.

Keywords: *Butea monosperma*, Herbal cosmetics, Lipstick formulation, Natural colorant, Phytocosmetic.

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INTRODUCTION

The cosmetic industry has grown rapidly due to increasing consumer interest in beauty and personal care products. Lipsticks are among the most widely used cosmetics; however, conventional formulations often contain synthetic dyes and additives associated with adverse effects such as irritation, allergic reactions, and possible carcinogenicity (Mawazi *et al*., 2022). These concerns have increased interest in herbal cosmetics containing safer and environmentally sustainable natural ingredients.

Plant-derived pigments are being widely explored as alternatives to synthetic colorants because of their low toxicity, biodegradability, and additional biological properties such as antioxidant and antimicrobial activities (Patil *et al*., 2025). Several studies have reported the successful use of botanical pigments in herbal lipstick formulations with good stability and safety profiles (Raji *et al*., 2025, Table 1).

Butea monosperma (Fabaceae), commonly known as "Flame of the Forest" or "Palash," contains bright orange-red pigments rich in flavonoids, chalcones, and aurones, which possess antioxidant, antimicrobial, and anti-inflammatory activities (Sourabh *et al*., 2023). These phytochemicals may provide additional protective benefits to lip tissue exposed to environmental stressors (Michalak *et al*., 2023). However, limited studies are available on the use of *Butea monosperma* flower extract in lipstick formulations.

Therefore, the present study aimed to formulate and evaluate a herbal lipstick using aqueous extract of *Butea monosperma* flowers as a natural colorant. Three formulations were prepared to optimize pigment incorporation and physical stability. The optimized formulation was evaluated for organoleptic properties, melting point, spreadability, stability, pH, skin irritation, and FTIR compatibility to assess its suitability as a safe and stable herbal cosmetic product.

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MATERIALS AND METHODS

All chemicals used were of analytical reagent grade and were procured from SRL Chemicals. FTIR analysis was performed using a Bruker FTIR spectrophotometer. Evaluation parameters were selected according to BIS guidelines for cosmetic lipsticks (BIS 9875:1990).

Collection and Authentication of Plant Material

Fresh flowers of *Butea monosperma* were collected from the Narsapur forest area near our institution. The plant material was taxonomically authenticated by Dr. Madhava Chetty, Associate Professor, Department of Botany, Sri Venkateswara University, Tirupati.

Animals

New Zealand rabbits of either sex weighing approximately 2 kg were used for the skin irritation study. The animals were acclimatized for two weeks under standard laboratory conditions. All procedures were performed according to CPCSEA guidelines and approved by the Institutional Animal Ethics Committee (Regd. No: 1358/PO/Re/S/10/CPCSEA).

Extraction of Natural Dye

Shade-dried petals of *Butea monosperma* were macerated in distilled water for 3 days followed by reflux extraction for 3 hr. The extract was filtered, concentrated, and vaccum-dried at 60°C to obtain a stable crystalline powder, which was stored in airtight containers until further use (Lakshmi *et al.*, 2022). The aqueous extraction yielded 2.0% (w/w) dried extract, calculated based on the weight of the shade-dried flower petals powder.

Formulation of Lipstick

Lipstick formulations were prepared using standard reported procedures by melting and blending waxes, oils, and other excipients under controlled temperature (Sharma *et al.*, 2021). The *Butea monosperma* extract was incorporated into the molten base, poured into moulds, and allowed to solidify. Among the three formulations prepared, Formula 3 showed the best pigment dispersion and physical uniformity without phase separation and was selected for further evaluation. The formulation composition is provided in Table 2, and the formulated lipsticks are shown in Figure 1.

Evaluation of Lipstick

Melting Point

The melting point was determined by the capillary tube method using a digital melting-point apparatus. A 10 mm lipstick column was filled into a capillary tube, and the analysis was performed in triplicate.

Breaking Point

The lipstick was subjected to increasing weight until breakage occurred. This test evaluated the mechanical strength and resistance to fracture.

Force of Application

The force required to apply the lipstick was assessed using a shadow graph balance. Lipstick was applied at a 45° angle on coarse brown paper to cover a 1 sq. inch area. The recorded pressure corresponded to the application force and firmness of the lipstick.

Spreadability

Spreadability was evaluated by applying the lipstick over a 3 cm length on a glass slide and visually assessing the smoothness and uniformity of the film. The formulation was graded as Excellent, Intermediate, or Unsatisfactory based on uniformity and fragmentation.

Surface Abnormalities

Formulations were inspected visually for defects such as crystal formation, sweating, fungal contamination, or surface irregularities.

Stability Studies

Stability studies were conducted under room temperature (24.0 ± 3.0°C) and elevated temperature (40.0 ± 2.0°C) conditions. Preliminary stability was assessed for 3 days, while long-term stability was evaluated for 60 days on days 3, 7, 15, 30, and 60. Parameters such as color, odor, appearance, melting point, and spreadability were monitored throughout the study.

pH Determination

As lipsticks are anhydrous, pH was determined from the aqueous fraction obtained by dissolving a small quantity of lipstick in ethanol followed by the addition of distilled water. The pH of the resulting extract was measured using a calibrated pH meter.

Skin Irritation Test

Three rabbits were divided into two test groups and one control group. Marketed lipstick was applied to one rabbit, and the formulated lipstick to another, while the third served as untreated control. The application site was monitored for visible signs of irritation compared with the control.

FTIR Analysis

FTIR spectra of the dried *Butea monosperma* flower extract and the lipstick formulation were recorded using a Bruker FTIR spectrophotometer (model Alpha 2-01054) equipped with Opus software. Spectra were obtained in the range of 400–4000 cm^{-1}

to assess chemical compatibility and functional group integrity (Sandhya *et al.*, 2023).

Statistical analysis

All the experiments were performed in triplicate and the results were expressed as Mean ± S.D (n=3).

RESULTS

Organoleptic Properties

The formulated herbal lipstick exhibited a smooth, glossy, and uniform reddish-orange appearance characteristic of *Butea monosperma* extract, without cracks, air bubbles, or particle agglomeration. The fragrance remained pleasant throughout the study period.

Melting Point

The melting point of the lipstick was found to be 69.0±0.05°C, indicating high thermal stability suitable for tropical climates. No batch-to-batch variation was observed.

Breaking Point

The breaking point values were within 8.0±0.7, demonstrating good mechanical strength. The lipstick remained intact under moderate pressure, confirming suitability for handling and application.

Force of Application

The lipstick required a moderate force of application, producing a uniform layer on the substrate. No streaks or resistance were observed, suggesting optimal firmness and glide properties.

Spreadability

The lipstick showed excellent spreadability, forming a consistent, smooth film without fragmentation or deformation. The film adhered well to the glass slide and exhibited uniform color distribution.

Surface Abnormalities

No surface defects such as sweating, crystallization, mold growth, or bloom formation were observed during the study. The surface remained smooth and stable.

Stability Studies

The lipstick remained stable under both room and elevated temperature conditions throughout the study period. No significant changes were observed in color, odor, appearance, melting point, or spreadability during short-term and long-term stability studies. The formulation also showed no signs of softening, phase separation, or surface defects, confirming its physical stability under normal storage conditions.

pH Determination

The pH of the hydroalcoholic extract of the lipstick was 6.8, falling within the acceptable dermal pH range. All the results for physicochemical parameters were given in Table 3.

Skin Irritation Test

No signs of erythema, redness, edema, or irritation were observed in the rabbits treated with the formulated lipstick. The results were comparable to the control and marketed product. It was shown in Figure 2.

FTIR Analysis

FTIR analysis was performed to evaluate the chemical compatibility of *Butea monosperma* extract within the lipstick formulation. The extract exhibited broad peaks at 3845–3573 cm^{-1} corresponding to O–H and N–H stretching vibrations of phenolic and flavonoid compounds, which were retained in the lipstick spectrum at 3661–3910 cm^{-1}, indicating preservation of major functional groups after formulation. Carbonyl stretching peaks shifted slightly from 1725–1691 cm^{-1} in the extract to 1739 cm^{-1} in the lipstick, suggesting weak interactions between phytoconstituents and excipients. Aromatic C=C vibrations observed at 1584–1512 cm^{-1} in the extract were retained with minor shifts in the formulation. Characteristic C–O and C–N stretching bands were also observed in the fingerprint region (1241.67, 1172.39, 1043.59, and 991.21 cm^{-1}). Additional peaks

Figure 1: Representative photographs of three formulations. (A) Formulation 1 showing uneven pigment distribution and phase separation. (B) Formulation 2 representing increased hardness and pigment separation persisted. (C) Formulation 3 exhibiting improved pigment uniformity.

Table 1: Summary of Plant Materials Used in Herbal Lipstick Formulations reported in the Literature.

Name of the plant	Botanical name and Family	Part used	References
Dragon fruit Beetroot Turmeric	*Hylocereus polyrhizus*, Cactaceae *Beta vulgaris,* Amaranthaceae *Curcuma longa*, Zingeberaceae	Fruits Roots Rhizomes	Trupti *et al.*, 2025
Beetroot	*Beta vulgaris*, Amaranthaceae	Roots	Tejaswi *et al.*, 2025
			Ajit *et al.*, 2025
Paper flower Beetroot saffron	*B. spectabilis*, Nyctaginaceae *Beta vulgaris*, Amaranthaceae *Crocus sativus*, Iridaceae	Flowers Roots Flowers	Sakthivel *et al.*, 2025
Rio red Strawberry Pomegranate Litchi Beetroot	*Citrus* × *paradise*, Rutaceae *Fragaria x ananassa*, Rosaceae *Punica granatum*, Lythraceae *Litchi chinensis*, Sapindaceae *Beta vulgaris,* Amaranthaceae	Fruits Fruits Fruits Fruits Roots	Anusha *et al.*, 2025
Beetroot Pomegranate	*Beta vulgaris,* Amaranthaceae *Punica granatum*, Lythraceae	Root Fruit peel	Bagang *et al.*, 2025
Beetroot Strawberry Tomato	*Beta vulgaris*, Amaranthaceae *Fragaria x ananassa*, Rosaceae *L. lycopersicum*, Solanaceae	Roots Fruits Fruits	Aditya *et al.*, 2025
Mangosteen	*Garcinia mangostana,* Clusiaceae	Peel	Amalia *et al.*, 2025
Purple cabbage	*Brassica oleracea*, Brassicaceae	Leaves	Hariharan *et al.*, 2025
Royal Poinciana	*Delonix regia*, Fabaceae	seeds	Shailesh *et al.*, 2025
Cockscomb	*Celosia cristata*, Amaranthaceae	Flowers	Pradeep *et al.*, 2025
Cactus	*Opuntia dilleniid*, Cactaceae	Fruits	Alburyhi *et al.*, 2025
Pomegranate	*Punica granatum*, Lythraceae	Fruit rind	Shravani *et al.*, 2026

NA: Not available; N/A: Not applicable.

at 2916 and 2848 cm^{-1} corresponded to aliphatic C–H stretching from waxes and oils. Overall, the FTIR results confirmed the structural stability and compatibility of the extract within the lipstick matrix (Figure 3).

DISCUSSION

The formulated herbal lipstick containing *Butea monosperma* extract satisfied the essential quality parameters required for cosmetic application. During formulation optimization, three different compositions were prepared to identify the most suitable base for incorporating the water-soluble plant extract. Formula 1 exhibited uneven pigment distribution and phase separation due to poor compatibility between the aqueous extract and the predominantly oily base, a limitation similarly reported in previous herbal lipstick formulations. Formula 2 showed improved hardness because of increased wax content; however, pigment separation persisted, indicating inadequate dispersion of the hydrophilic extract. A stable and homogeneous formulation was achieved in Formula 3 by pre-dispersing the extract in propylene glycol before incorporation into the wax–oil matrix. Propylene glycol has been widely recognized as an effective co-solvent capable of improving compatibility between hydrophilic and lipophilic components in cosmetic systems (Barel *et al.*, 2014). Therefore, Formula 3 was selected as the optimized formulation for further evaluation.

The optimized lipstick exhibited uniform coloration, smooth texture, and satisfactory aesthetic appearance, indicating efficient incorporation of the natural pigment within the wax–oil base. Similar observations have been reported for herbal lipsticks prepared using beetroot, hibiscus, and annatto pigments, where homogeneous pigment dispersion contributed to improved texture and consumer acceptability. The observed melting point falls within the acceptable range and demonstrated adequate thermal stability suitable for tropical climatic conditions and was found to be within acceptable limits specified by BIS standards for lipsticks (Bureau of Indian Standards, 1990). Mechanical properties such as breaking point and force of application also remained within acceptable limits, indicating a desirable balance between hardness and smooth application. Comparable findings have been reported previously, where excessive softness resulted in poor durability while highly rigid formulations reduced spreadability and consumer comfort (Agustina *et al.*, 2020).

The formulation remained physically stable during both short-term and long-term storage under room and elevated temperature conditions. No sweating, crystallization, fungal growth, or texture changes were observed, indicating good resistance to environmental stress and strong compatibility among formulation excipients. Similar stability profiles have been described in earlier studies on herbal lipsticks containing natural pigments and wax–oil blends (Bhagwat *et al.*, 2017). The pH is compatible and within the acceptable range for lip products and did not produce any irritation during animal testing. Previous studies have similarly reported pH values between 5.5 and 6.9 for herbal lipsticks formulated with botanical pigments, suggesting compatibility with the natural skin barrier (Lwin *et al.*, 2020).

Figure 2: Skin irritation test in rabbits. (A) Control group treated with saline showing normal skin with no signs of irritation. (B) Test group treated with the formulated herbal lipstick demonstrating absence of erythema, edema, or irritation. (C) Marketed lipstick–treated rabbit showing comparable skin profile with no significant irritation.

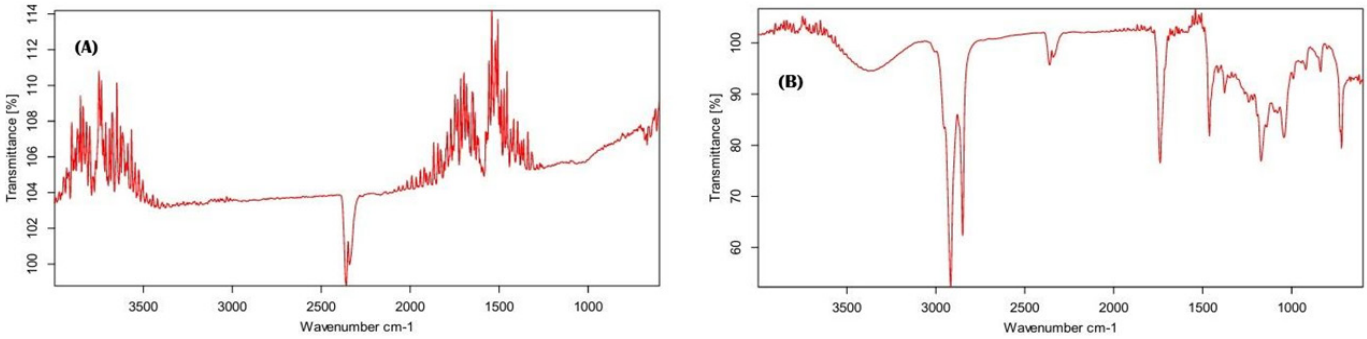

Figure 3: FTIR spectra of plant extract and formulated lipstick. A. The FTIR spectrum of the extract shows characteristic peaks corresponding to major phytochemical functional groups. B. The spectrum of the lipstick formulation (right) demonstrates the presence and retention of these functional groups after incorporation into the cosmetic matrix.

Table 2: Proportion of ingredients used in lipstick formulation.

Ingredients	Formula 1 (30 g)	Formula 2 (30 g)	Formula 3 (30 g)
Extract	0.5 g	0.5 g	0.5 g
Bees wax	5 g	1 g	0.9 g
Carnauba wax	5 g	1 g	0.1 g
Ozakerite wax	-	2 g	0.6 g
Propylene glycol	5 mL	1 mL	0.2 mL
Mineral oil	-	-	0.35 mL
Cetyl alcohol	-	-	0.25 gm
Isopropyl myristate	-	-	0.1 mL
Lanolin	-	-	0.25 gm
Castor oil	6 mL	3 mL	1.5 mL
Liquid paraffin	8 mL		-
Coconut oil	-	2 mL	-
Perfume, anti-oxidant and preservative	2-3 drops	2-3 drops	2-3 drops

Table 3: Physical evaluation of Herbal Lipstick.

Parameter	Observation
Colour & Appearance	Smooth, uniform, reddish orange
Melting Point	69.0±0.05°C
Breaking Point	8.0±0.7
Force of Application	Good
Spreadability	Excellent
Surface Abnormalities	None
Stability study	No bleeding or crystallization
pH	6.8±0.01
Skin Irritation	No irritation

Furthermore, the absence of erythema or edema confirmed the dermatological safety of the formulation.

FTIR analysis confirmed the chemical compatibility of *Butea monosperma* extract within the lipstick matrix. The retention of characteristic phenolic and flavonoid functional groups after formulation indicated the structural stability of the bioactive constituents. Similar FTIR findings have been reported for natural pigment-based cosmetic formulations, where preservation of functional groups suggested absence of chemical degradation during processing (Barel *et al*., 2014). Overall, the present findings validate *Butea monosperma* flower extract as a promising natural pigment for lipstick formulations with good stability, safety, and functional performance, supporting its potential as a sustainable alternative to synthetic colorants in cosmetic products.

Despite these encouraging findings, the present study has certain limitations. Future studies should include accelerated stability testing, microbiological quality evaluation, and clinical assessment in human volunteers to further establish the long-term safety and commercial applicability of the formulation.

CONCLUSION

The herbal lipstick formulated with *Butea monosperma* flower extract exhibited good physical stability, smooth application, and desirable aesthetic properties. The optimized formulation showed uniform color distribution, acceptable pH, and no signs of irritation, confirming its dermatological safety. Stability studies demonstrated resistance to temperature-induced changes, while FTIR analysis confirmed chemical compatibility between the extract and excipients. Overall, the findings support the potential of *Butea monosperma* as a safe and effective natural colorant for herbal lipstick formulations.

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ABBREVIATIONS

FTIR: Fourier transform infrared spectroscopy; **BIS:** Bureau of Indian Standards.

CONFLICT OF INTEREST

The authors declare that there is no conflict of interest.

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