RESEARCH PAPER

Formulation and Evaluation of Herbal Sunscreen Cream Containing *Clitoria ternatea* and *Butea monosperma* Extracts

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ABSTRACT

Ultraviolet (UV) radiation is one of the major environmental factors responsible for various skin disorders such as erythema, premature aging, hyperpigmentation, oxidative stress, and skin cancer. Continuous exposure to UVA and UVB radiation results in damage to cellular proteins, lipids, and DNA, thereby increasing the risk of dermatological complications. Conventional synthetic sunscreens are effective in protecting the skin from UV radiation; however, prolonged use of synthetic UV filters has been associated with adverse effects including skin irritation, allergic reactions, endocrine disruption, and environmental toxicity. Therefore, the development of herbal sunscreen formulations has gained considerable attention due to their safety, biocompatibility, antioxidant activity, and eco-friendly nature.

The present study was aimed at the formulation and evaluation of a herbal sunscreen cream using natural plant-derived ingredients with photoprotective potential. The formulation incorporated ethanolic extracts of Clitoria ternatea (Butterfly pea flower) and Butea monosperma (Palas flower) as the major active ingredients along with Aloe vera gel, coconut oil, zinc oxide, Vitamin E, stearic acid, cetyl alcohol, glycerine, and rose oil. Multiple formulations (F1–F6) were prepared using different concentrations of gelling and stabilizing agents to optimize the physicochemical characteristics and Sun Protection Factor (SPF) of the cream.

The prepared formulations were evaluated for pH, viscosity, spreadability, stability, homogeneity, appearance, and SPF value. Among all the batches, formulation F3 demonstrated optimum characteristics including satisfactory pH, enhanced spreadability, superior viscosity, absence of phase separation, and highest SPF value. The results indicated that the combination of herbal extracts exhibited significant photoprotective and antioxidant activity. The study concludes that herbal sunscreen creams prepared from plant-based ingredients can serve as a safe, effective, and economical alternative to synthetic sunscreens.

Keywords: Herbal sunscreen, Clitoria ternatea, Butea monosperma, SPF, Aloe vera, photoprotection, antioxidant.

How to cite this article: Shejul VS, Chitte MG, Sitaphale GR, Tathe PR. Formulation and Evaluation of Herbal Sunscreen Cream Containing Clitoria ternatea and Butea monosperma Extracts. Int J Drug Deliv Technol. 2026;16(57s): 483-492. DOI: 10.25258/ijddt.16.57s.60

Source of support: Nil

Conflict of interest: None

1. INTRODUCTION

Sunscreen is a topical formulation designed to protect the skin against the harmful effects of ultraviolet (UV) radiation emitted from sunlight. Excessive exposure to UV radiation is associated with several acute and chronic skin disorders including sunburn, erythema, hyperpigmentation, premature aging, immune suppression, and skin cancer [1]. Due to increasing environmental pollution, depletion of the ozone layer, and changing climatic conditions, the intensity of UV radiation reaching the earth's surface has increased significantly, making photoprotection an essential component of skin care.

Ultraviolet radiation is mainly classified into UVA (320–400 nm), UVB (290–320 nm), and UVC (100–290 nm). UVA rays penetrate deep into the dermis and are

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primarily responsible for photoaging and pigmentation, whereas UVB rays mainly affect the epidermal layer causing erythema, inflammation, and sunburn [2]. UVC rays are mostly absorbed by the atmospheric ozone layer and do not normally reach the earth's surface.

Sunscreens provide protection through two major mechanisms: absorption of UV radiation and reflection or scattering of UV rays. Based on their mechanism of action, sunscreens are broadly categorized into chemical sunscreens and physical sunscreens. Chemical sunscreens absorb UV radiation and convert it into harmless heat energy, while physical sunscreens act by reflecting and scattering UV rays from the skin surface [3].

Conventional sunscreens commonly contain synthetic chemicals such as oxybenzone, octinoxate, avobenzone, and octocrylene. Although these agents provide effective UV protection, their prolonged use has been associated with various adverse effects including allergic dermatitis, irritation, hormonal disturbances, and environmental hazards [4]. Therefore, there is a growing interest in herbal sunscreen formulations prepared using naturally derived plant constituents possessing antioxidant, anti-inflammatory, and photoprotective activities.

Herbal sunscreens offer several advantages over synthetic formulations. Natural phytoconstituents such as flavonoids, tannins, anthocyanins, carotenoids, polyphenols, and vitamins exhibit strong antioxidant and UV-absorbing properties. These compounds not only protect the skin from UV-induced damage but also help in reducing oxidative stress and premature aging [5]. Herbal formulations are generally safer, biodegradable, eco-friendly, and suitable for sensitive skin.

Among the medicinal plants explored for photoprotective activity, Clitoria ternatea and Butea monosperma have gained considerable attention due to their rich phytochemical composition. Clitoria ternatea contains anthocyanins, flavonoids, and phenolic compounds which possess antioxidant and UV-protective activity [6]. Similarly, Butea monosperma contains flavonoids, tannins, glycosides, and phenolic constituents with strong anti-inflammatory and antioxidant properties [7].

Aloe vera gel is another widely used herbal ingredient in skincare products because of its soothing, moisturizing, wound healing, and anti-inflammatory properties [8]. Coconut oil acts as an emollient and natural moisturizer, while zinc oxide serves as a physical UV blocker that provides broad-spectrum protection against both UVA and UVB radiation [9].

The present study was therefore undertaken to formulate and evaluate a herbal sunscreen cream containing extracts of Clitoria ternatea and Butea monosperma along with other herbal and natural ingredients. The objective of the study was to develop a stable, safe, effective, and cosmetically acceptable sunscreen cream with enhanced SPF value and photoprotective activity.

2. BACKGROUND OF THE STUDY

Several researchers have explored the use of herbal ingredients in sunscreen formulations due to their antioxidant and UV-protective properties.

Prateek Pandey et al. (2023) formulated and evaluated a herbal sunscreen containing Curcuma sativum, Solanum lycopersicum, and Aloe barbadensis. The study demonstrated significant antioxidant activity and improved SPF values due to the synergistic effect of phytoconstituents [10].

Yemini Shah et al. (2023) developed herbal sunscreen creams using Glycyrrhiza glabra, Tinospora cordifolia, and Terminalia arjuna. The formulations exhibited acceptable physicochemical properties and effective UV protection determined by in vitro SPF analysis [11].

Mukund Donglikar et al. (2017) prepared a herbal sunscreen formulation using quercetin, curcumin, resveratrol, and safranal. The study reported enhanced antioxidant activity and broad-spectrum photoprotection due to the polyphenolic compounds present in the formulation [12].

Anupriya Sundriyal et al. (2024) formulated a herbal sunscreen stick containing ethanolic extract of Pyrostegia venusta. The prepared formulation demonstrated acceptable stability, good spreadability, and promising SPF values [13].

Samaria Nasreen et al. formulated a multifunctional herbal sunscreen using papaya, lavender oil, tomato extract, aloe vera, honey, and green tea extract. The study reported excellent antioxidant activity, skin hydration, and photoprotective effects [14].

Rozinaparvin Iqbal Patel et al. developed a topical herbal sunscreen formulation containing rosemary seed oil, coconut oil, olive oil, grape seed oil, carrot seed oil, and almond oil. The formulation exhibited broad-spectrum protection and enhanced antioxidant activity [15].

Fatima Haider et al. (2022) formulated and evaluated a herbal sunscreen cream using beetroot, flax seed, and green tea extracts. The study demonstrated high SPF values and significant free radical scavenging activity [16].

Rahul Mehta et al. (2021) developed a broad-spectrum herbal sunscreen cream containing sesame oil, jojoba oil, Emblica officinalis, licorice, and turmeric extracts. The optimized formulation exhibited good spreadability, acceptable pH, and enhanced SPF values [17].

Ali Khalili Sadaghiani et al. (2020) prepared a herbal sunscreen formulation using Elaeagnus angustifolia

extract, sesame oil, and sea buckthorn oil. The optimized formulation exhibited an SPF value of approximately 16 and good physical stability during storage studies [18].

The literature survey clearly indicates the increasing importance of herbal ingredients in sunscreen formulations due to their antioxidant, anti-inflammatory, moisturizing, and photoprotective properties.

3. WORK OBJECTIVES

1. To formulate a stable herbal sunscreen cream using natural ingredients.

2. To evaluate the physicochemical properties of the prepared formulations.

3. To determine the Sun Protection Factor (SPF) of the formulated creams.

4. To study the spreadability, viscosity, homogeneity, and stability of the formulations.

5. To optimize the formulation with maximum UV protective activity.

6. To develop a safe and skin-friendly sunscreen preparation.

4. NECESSITY OF INVESTIGATION

The increasing incidence of skin disorders caused by UV radiation has created a significant demand for effective and safe sunscreen formulations. Synthetic sunscreens available in the market often contain chemicals such as oxybenzone and octinoxate which may cause allergic reactions, hormonal disturbances, and environmental toxicity [19]. Furthermore, prolonged use of synthetic sunscreens may lead to irritation, sensitization, and accumulation of harmful residues on the skin.

Herbal sunscreens represent a promising alternative because they contain naturally occurring phytoconstituents with antioxidant and UV-protective properties. Natural compounds such as flavonoids, tannins, anthocyanins, and carotenoids not only absorb UV radiation but also protect the skin against oxidative stress and inflammation [20].

The present study was therefore designed to develop an effective herbal sunscreen cream using Clitoria ternatea and Butea monosperma extracts with enhanced SPF value, better safety profile, and improved cosmetic acceptability.

5. MATERIALS AND METHODS

5.1 Materials Used

The following materials were used in the preparation of herbal sunscreen cream:

Sr. No.	Ingredient	Category	Function
1	Butterfly pea flower extract	Active ingredient	UV protection, antioxidant
2	*Butea monosperma* extract	Active ingredient	Antioxidant, anti-inflammatory
3	Aloe vera gel	Active ingredient	Moisturizer, soothing agent
4	Coconut oil	Oil phase	Emollient
5	Zinc oxide	Physical sunscreen	UV blocker
6	Vitamin E	Antioxidant	Photoprotection
7	Stearic acid	Gelling agent	Cream consistency
8	Cetyl alcohol	Stabilizer	Thickener
9	Glycerine	Humectant	Moisturizer
10	Triethanolamine	pH adjuster	Neutralizer
11	Rose oil	Fragrance agent	Skin conditioning
12	Distilled water	Vehicle	Solvent

5.2 Equipments Used

Sr. No.	Equipment	Purpose
1	Weighing balance	Accurate weighing
2	Beakers	Mixing ingredients
3	Hot plate with stirrer	Heating and mixing
4	Mortar and pestle	Powder preparation
5	Soxhlet apparatus	Extraction process
6	pH meter	pH determination
7	UV spectrophotometer	SPF determination
8	Water bath	Controlled heating
9	Glass rods	Stirring
10	Refrigerator	Storage

6. CLITORIA TERNATEA (BUTTERFLY PEA FLOWER)
Biological Source
Clitoria ternatea Linn. belongs to the family Fabaceae and is commonly known as Butterfly pea flower or Aparajita.

Chemical Constituents
• Anthocyanins

• Flavonoids

• Triterpenoids

• Phenolic compounds

• Alkaloids

• Saponins

Pharmacological Actions
• Antioxidant

• Anti-inflammatory

• Photoprotective

• Anti-aging

• Antimicrobial

Use in Sunscreen
The anthocyanins and flavonoids present in Clitoria ternatea absorb UV radiation and reduce oxidative stress caused by free radicals.

6.2 Butea monosperma
Biological Source
Butea monosperma belongs to the family Fabaceae and is commonly known as Palas or Flame of the Forest.

Chemical Constituents
• Flavonoids

• Tannins

• Glycosides

• Sterols

• Phenolic compounds

Pharmacological Actions
• Antioxidant

• Anti-inflammatory

• Antimicrobial

• Hepatoprotective

Use in Sunscreen
The flavonoids and tannins present in Butea monosperma provide antioxidant activity and natural UV absorption.

6.3 Aloe Vera
Biological Source
Aloe vera gel is obtained from the leaves of Aloe barbadensis Miller.

Pharmacological Actions
• Moisturizing

• Wound healing

• Anti-inflammatory

• UV protective

Use in Sunscreen
Aloe vera helps in soothing sun-exposed skin and improves hydration.

7. EXTRACTION PROCESS

Fresh flowers of Clitoria ternatea and Butea monosperma were collected and washed thoroughly with distilled water. The flowers were shade dried for several days and then pulverized into coarse powder using a grinder.

The powdered material was subjected to ethanolic extraction using a Soxhlet apparatus. Approximately 95% ethanol was used as the solvent for extraction because of its ability to extract flavonoids, anthocyanins, tannins, and phenolic compounds effectively. The extraction process was continued for 6–8 hours until complete extraction was achieved.

The obtained extract was filtered through muslin cloth followed by Whatman filter paper. The filtrate was concentrated under reduced pressure using a rotary evaporator to obtain a semisolid extract. The concentrated extract was stored in an airtight amber-colored container at 4°C for further use.

8. FORMULATION OF HERBAL SUNSCREEN CREAM

The herbal sunscreen cream was prepared using the emulsification method.

Table 1: Composition of Herbal Sunscreen Cream Formulations (F1–F6)

Ingredients (% w/w)	F1	F2	F3	F4	F5	F6
Clitoria ternatea Extract	2.0	2.0	2.0	2.0	2.0	2.0
Butea monosperma Extract	2.0	2.0	2.0	2.0	2.0	2.0
Aloe vera Gel	10.0	10.0	10.0	10.0	10.0	10.0
Zinc Oxide	5.0	6.0	7.0	4.0	5.0	4.0
Coconut Oil	8.0	8.0	8.0	8.0	8.0	8.0
Vitamin E	1.0	1.0	1.0	1.0	1.0	1.0
Stearic Acid	6.0	7.0	8.0	5.0	5.5	6.0
Cetyl Alcohol	2.0	2.5	3.0	2.0	2.0	2.5
Glycerine	4.0	4.0	4.0	4.0	4.0	4.0
Triethanolamine	1.0	1.0	1.0	1.0	1.0	1.0
Rose Oil	0.5	0.5	0.5	0.5	0.5	0.5
Distilled Water	q.s. to 100	q.s. to 100	q.s. to 100	q.s. to 100	q.s. to 100	q.s. to 100

Procedure

Step 1: Preparation of Aqueous Phase
Stearic acid and cetyl alcohol were dispersed in distilled water with continuous stirring. The herbal extracts were added slowly to the aqueous phase.

Step 2: Preparation of Oil Phase
Coconut oil, rose oil, Vitamin E, and zinc oxide were mixed and heated at 60–70°C until a uniform oily phase was obtained.

Step 3: Emulsification
The oil phase was slowly added to the aqueous phase with continuous stirring to obtain an oil-in-water emulsion.

Step 4: Addition of Aloe Vera Gel
After cooling the emulsion to room temperature, Aloe vera gel was added with continuous stirring.

Step 5: pH Adjustment
Triethanolamine was added dropwise to adjust the pH of the formulation between 5.5 and 6.5.

The prepared cream was filled into sterile airtight containers and stored for further evaluation.

9. RESULTS

The present investigation was carried out to formulate and evaluate a herbal sunscreen cream containing Clitoria ternatea (Butterfly pea flower) extract and Butea monosperma extract along with Aloe vera gel, zinc oxide, coconut oil, Vitamin E, and other excipients. Multiple formulations (F1–F6) were prepared to optimize the concentration of gelling agents and evaluate their effect on physicochemical properties and photoprotective activity.

The prepared formulations were evaluated for organoleptic characteristics, pH, viscosity, spreadability, homogeneity, stability, irritancy, and Sun Protection Factor (SPF). The results obtained are discussed below.

9.1 Phytochemical Screening

Preliminary phytochemical evaluation of the herbal extracts confirmed the presence of important bioactive

constituents responsible for antioxidant and photoprotective activity.

Shinoda Test for Flavonoids
The ethanolic extracts of Clitoria ternatea and Butea monosperma were subjected to the Shinoda test by adding magnesium turnings and concentrated hydrochloric acid.

Observation
Formation of pink to reddish coloration indicated the presence of flavonoids in both extracts.

Interpretation
The positive Shinoda test confirmed the presence of flavonoids and anthocyanins, which are responsible for UV absorption and antioxidant activity. These phytoconstituents contribute significantly to the SPF value and protective activity of the sunscreen formulation.

9.2 Organoleptic Evaluation
Organoleptic evaluation was performed to assess the appearance, colour, odor, texture, and homogeneity of the prepared formulations.

Table 2: Organoleptic Evaluation of Herbal Extracts

Parameter	**Butterfly Pea Flower Extract**	***Butea monosperma* Extract**
Colour	Deep Blue	Yellowish Orange
Odour	Characteristic	Characteristic
Texture	Smooth	Smooth
Appearance	Semisolid	Semisolid

Discussion
The deep blue colour of Butterfly pea flower extract is mainly due to anthocyanin pigments, whereas Butea monosperma extract exhibited yellowish-orange colour because of flavonoids and phenolic compounds. Both extracts possessed smooth consistency and characteristic odor without any unpleasant smell, indicating suitability for topical application.

9.3 pH Determination
The pH of topical formulations is an important parameter because formulations with unsuitable pH may cause skin irritation and affect skin barrier integrity.

The pH of all formulations was determined using a calibrated digital pH meter.

Table 3: pH Comparison of Formulations

Batch	**F1**	**F2**	**F3**	**F4**	**F5**	**F6**
pH	5.7	5.8	5.9	5.6	5.7	5.6

Discussion
All formulations exhibited pH values within the acceptable range for topical application (5.5–6.5). Batch F3 showed an optimum pH of 5.9, which is close to the natural pH of human skin. This indicates that the formulation is less likely to cause irritation and is suitable for prolonged skin application.

The slightly acidic nature of the creams may also help maintain skin barrier function and inhibit microbial growth.

9.4 Viscosity Determination
Viscosity plays a crucial role in determining the consistency, spreadability, stability, and patient acceptability of topical formulations.

The viscosity of each formulation was measured using a Brookfield viscometer.

Table 4: Viscosity Comparison

Batch	F1	F2	F3	F4	F5	F6
Viscosity (cP)	3400	3600	4000	3000	3100	3200

Discussion

Among all batches, F3 exhibited the highest viscosity value (4000 cP), indicating optimum consistency and stability. The increased viscosity in F3 may be attributed to the ideal concentration of stearic acid and cetyl alcohol used as gelling and stabilizing agents.

Formulations F4–F6 showed comparatively lower viscosity values due to reduced concentration of zinc oxide and variations in emulsifier content. Lower viscosity formulations may exhibit poor retention on the skin surface and reduced stability.

The optimized viscosity of F3 contributed to better spreadability and enhanced residence time on the skin.

9.5 Spreadability Study

Spreadability determines the ease with which the cream can be uniformly applied over the skin surface.

Table 5: Spreadability Comparison

Batch	F1	F2	F3	F4	F5	F6
Spreadability (cm)	5.2	5.5	6.0	4.8	5.0	4.7

Discussion

Batch F3 demonstrated maximum spreadability (6.0 cm), indicating superior application characteristics and ease of spreading on the skin surface.

Good spreadability is essential for uniform distribution of sunscreen agents over the skin, thereby ensuring effective photoprotection. The optimized balance between viscosity and emollient content in F3 contributed to its superior spreadability.

Formulations with lower spreadability values may require more force for application and may not distribute evenly on the skin.

9.6 Homogeneity and Appearance

All prepared formulations were visually inspected for colour, consistency, phase separation, and grittiness.

Table 6: Homogeneity and Appearance

Batch	Appearance	Homogeneity	Phase Separation
F1	Smooth cream	Good	Absent
F2	Smooth cream	Good	Absent
F3	Smooth bluish cream	Excellent	Absent
F4	Slightly thick	Good	Absent
F5	Thick cream	Moderate	Absent
F6	Thick cream	Moderate	Slightly observed

Discussion

Batch F3 exhibited excellent homogeneity with smooth texture and absence of phase separation. The formulation possessed aesthetically pleasing bluish colour due to anthocyanins present in Butterfly pea extract.

No grittiness or aggregation was observed in optimized formulations, indicating proper emulsification and dispersion of ingredients.

F6 showed slight instability during storage, which may be due to imbalance in oil-water ratio and insufficient emulsification.

9.7 SPF Determination

Sun Protection Factor (SPF) is one of the most important parameters used to evaluate sunscreen efficacy.

The SPF values of the formulations were determined using UV spectrophotometric analysis.

Table 7: SPF Value Comparison

Batch	F1	F2	F3	F4	F5	F6
SPF	16.5	17.2	18.7	15.3	16.0	15.7

Discussion

Batch F3 exhibited the highest SPF value (18.7), indicating superior UV protective activity. The enhanced SPF value may be attributed to:

• Presence of flavonoids and anthocyanins in Butterfly pea extract

• Antioxidant activity of Butea monosperma

• UV reflecting property of zinc oxide

• Synergistic effect of Vitamin E and Aloe vera gel

The combination of herbal antioxidants and physical sunscreen agents provided broad-spectrum photoprotection against UVA and UVB radiation.

The SPF values obtained suggest that the prepared herbal sunscreen cream can effectively protect the skin against harmful UV rays and may help prevent sunburn, photoaging, and oxidative skin damage.

9.8 Stability Study

Stability studies were performed to evaluate the physical stability and SPF retention of the optimized formulation during storage.

Table 8: Stability Observation of Optimized Batch (F3)

Day	SPF Value
0	18.5
7	18.7
15	19.0
30	18.8

Discussion

The optimized formulation F3 remained stable throughout the study period without any signs of:

• Phase separation

• Colour change

• Microbial growth

• Significant viscosity change

The SPF values remained nearly constant during the 30-day stability study, indicating good physical and chemical stability of the formulation.

The stability may be attributed to proper emulsification, suitable concentration of stabilizers, and antioxidant protection offered by herbal constituents.

Observation

• No redness

• No itching

9.9 Irritancy Test

The prepared cream was evaluated for skin irritation by topical application on a small area of skin.

• No edema

• No irritation

Discussion

The absence of irritation indicates that the prepared herbal sunscreen cream is safe for topical use. Natural ingredients such as Aloe vera, coconut oil, and herbal extracts contributed to the soothing and skin-friendly nature of the formulation.

9.10 Optimization of Formulation

Among all six formulations, batch F3 was selected as the optimized formulation based on the following characteristics:

Table 9: Justification for Optimized Batch F3

Parameter	Observation
pH	5.9
Viscosity	4000 cP
Spreadability	6.0 cm
Homogeneity	Excellent
Stability	Stable
SPF	18.7
Irritancy	Absent

DISCUSSION

Batch F3 demonstrated optimum balance between viscosity and spreadability along with superior SPF value and stability. The formulation showed excellent cosmetic acceptability and smooth texture.

The enhanced photoprotective activity of F3 can be attributed to the synergistic effect of herbal antioxidants, zinc oxide, and Vitamin E. The formulation effectively combined antioxidant, moisturizing, anti-inflammatory, and UV-protective properties.

Therefore, F3 was considered as the optimized herbal sunscreen formulation.

10. CONCLUSION

The present study successfully formulated and evaluated a herbal sunscreen cream containing Clitoria ternatea extract, Butea monosperma extract, Aloe vera gel, zinc oxide, coconut oil, and Vitamin E.

The prepared formulations exhibited satisfactory physicochemical properties including acceptable pH, viscosity, spreadability, homogeneity, and stability. Among all batches, formulation F3 showed superior performance with highest SPF value, optimum viscosity, excellent spreadability, and absence of irritation.

The results confirmed that herbal ingredients rich in flavonoids, anthocyanins, and phenolic compounds possess significant photoprotective and antioxidant activities. The incorporation of natural ingredients not only enhanced UV protection but also improved skin moisturization and reduced the risk of irritation associated with synthetic sunscreens.

The study concludes that herbal sunscreen creams can serve as safe, effective, economical, and eco-friendly alternatives to synthetic sunscreen formulations.

11. FUTURE SCOPE

1. Clinical evaluation of the formulation on human volunteers.

2. Evaluation of long-term stability under accelerated conditions.

3. Development of herbal sunscreen gel, lotion, and spray formulations.

4. Incorporation of additional herbal antioxidants for higher SPF values.

5. Investigation of nano-herbal sunscreen systems for enhanced skin penetration and stability.

6. Commercial development of eco-friendly herbal sunscreen products.

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