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FORMULATION AND EVALUATION OF SUNSCREEN CREAM USING BUTTERFLY PEA FLOWER EXTRACT

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INTRODUCTION

Overview of Skin and Sun Exposure

Skin is the largest organ of the human body and acts as a protective barrier against environmental factors such as microorganisms, chemicals, and radiation. It plays an important role in maintaining body temperature, preventing water loss, and protecting underlying tissues. Therefore, proper skin protection is essential to maintain its health and function.

Exposure to sunlight is a major environmental factor affecting the skin. While moderate sunlight is beneficial for vitamin D synthesis, excessive exposure can be harmful. Sunlight contains ultraviolet (UV) radiation, which can cause sunburn, skin irritation, premature aging (photoaging), pigmentation, and in severe cases, skin cancer. Continuous exposure to UV rays also leads to the generation of free radicals, which damage skin cells and accelerate skin aging. Hence, protecting the skin from harmful effects of sunlight is necessary for maintaining healthy skin.

Overview of UV Radiation (UVA, UVB)

Ultraviolet (UV) radiation is a form of electromagnetic radiation emitted by the sun, with wavelengths shorter than visible light but longer than X-rays. It is divided into three main categories based on wavelength: UVA, UVB each having distinct characteristics and effects on the skin.

UVA (320–400 nm)

UVA radiation constitutes approximately 95% of the UV radiation reaching the Earth's surface. It penetrates deeply into the dermal layer of the skin and is primarily responsible for photoaging, including wrinkles, loss of elasticity, and pigmentation. UVA can also generate reactive oxygen species (ROS), leading to indirect DNA damage and long-term skin deterioration.

UVB (290–320 nm)

UVB radiation has higher energy than UVA but penetrates only the superficial layers of the skin (epidermis). It is mainly responsible for sunburn (erythema) and plays a key role in causing direct DNA damage, which can lead to mutations and increase the risk of skin cancer. UVB intensity varies with season, altitude, and time of day.

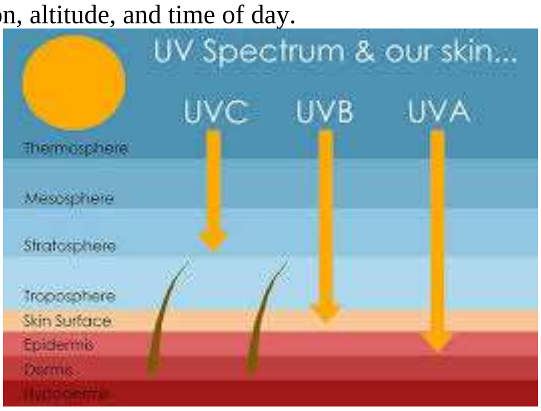

Figure 1: UV spectrum on our skin

Concept of Broad-Spectrum Sunscreen

Broad-spectrum sunscreen refers to a formulation that provides protection against both **UVA (320–400 nm)** and **UVB (290–320 nm)** radiation. Since both types of UV rays contribute to skin damage through different mechanisms, effective sun protection requires coverage across this entire UV range. UVB radiation primarily affects the outer layer of the skin (epidermis) and is responsible for **sunburn (erythema)** and direct DNA damage. In contrast, UVA penetrates deeper into the dermis and is mainly associated with **photoaging, pigmentation, and indirect DNA damage** through oxidative stress. Therefore, protection against only one type of UV radiation is insufficient. Broad-spectrum sunscreens are specifically designed to **block or absorb both UVA and UVB rays**, ensuring comprehensive skin protection. This is achieved by incorporating a combination of active ingredients, such as:

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- **Mineral (physical) filters** like zinc oxide (ZnO) and titanium dioxide (TiO_2), which reflect and scatter UV radiation

The effectiveness of sunscreen against UVB is commonly measured using the **Sun Protection Factor (SPF)**, while UVA protection is indicated by parameters such as **PA rating or UVA protection factor (UVA-PF)**. In summary, the concept of broad-spectrum sunscreen is based on providing **complete protection against the full range of harmful UV radiation**, thereby reducing the risk of sunburn, premature aging, and skin cancer.

Harmful Effects of UV Exposure on Skin

Exposure to ultraviolet (UV) radiation has significant detrimental effects on the skin, ranging from acute damage to long-term pathological conditions. The severity of these effects depends on the intensity and duration of exposure, as well as individual skin type.

Sunburn (Erythema): Primarily caused by UVB radiation, sunburn is an acute inflammatory response characterized by redness, pain, and swelling. Severe exposure may lead to blistering and peeling of the skin.

Photoaging: Chronic exposure to UVA radiation leads to premature aging of the skin, known as photoaging. It includes the formation of wrinkles, fine lines, loss of skin elasticity, and rough texture due to degradation of collagen and elastin fibers.

Hyperpigmentation: UV radiation stimulates melanin production, resulting in tanning, dark spots, and uneven skin tone. Conditions such as melasma and age spots are commonly associated with prolonged UV exposure.

DNA Damage: UVB radiation directly damages the DNA in skin cells, causing mutations. UVA indirectly contributes to DNA damage through the generation of reactive oxygen species (ROS), which can alter cellular components.

Skin Cancer: Prolonged and repeated UV exposure is a major risk factor for various types of skin cancer, including basal cell carcinoma, squamous cell carcinoma, and malignant melanoma.

Immunosuppression: UV radiation can suppress the skin's immune response, reducing its ability to defend against infections and potentially promoting the development of skin tumors.

Dryness and Skin Barrier Damage: UV exposure disrupts the skin's natural barrier, leading to dehydration, increased transepidermal water loss (TEWL), and skin sensitivity.

Importance of Sunscreen in Skin Protection

Sunscreens are essential topical formulations designed to protect the skin from the harmful effects of ultraviolet (UV) radiation. Regular and proper use of sunscreen plays a crucial role in maintaining skin health and preventing both acute and chronic skin damage. One of the primary functions of sunscreen is to **protect against sunburn (erythema)** caused mainly by UVB radiation. By forming a protective barrier on the skin, sunscreens either absorb, reflect, or scatter UV rays, thereby minimizing their penetration into the skin layers. Sunscreens are particularly important in preventing **photoaging**, which is primarily induced by UVA radiation. Continuous exposure to UV rays accelerates the breakdown of collagen and elastin, leading to wrinkles, fine lines, and loss of skin elasticity. The use of sunscreen helps in preserving skin structure and maintaining a youthful appearance. Another critical role of sunscreen is the **reduction of skin cancer risk**. UV radiation can cause DNA damage and mutations that may lead to various forms of skin cancer. Broad-spectrum sunscreens, which protect against both UVA and UVB radiation, significantly reduce this risk when used consistently. Sunscreen also helps in preventing **hyperpigmentation and uneven skin tone** by limiting melanin overproduction triggered by UV exposure. This is particularly beneficial in managing conditions such as melasma and dark spots. Additionally, modern sunscreens, especially those containing herbal ingredients and antioxidants, provide **added protective benefits** by neutralizing free radicals and soothing the skin. This enhances the skin's defense mechanism against environmental stressors. In conclusion, sunscreen is a vital component of daily skincare, offering comprehensive protection against UV-induced damage. Its regular use not only prevents immediate effects like sunburn but also safeguards against long-term consequences such as premature aging and skin cancer.

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Figure 2: Sunscreen Cream

Ultraviolet (UV) Radiation

Ultraviolet (UV) radiation is a component of sunlight that has shorter wavelengths than visible light and is not visible to the human eye. It is mainly responsible for various biological effects on the skin. UV radiation is classified into three types based on wavelength: UVA, UVB, and UVC. **UVA rays (320–400 nm)** penetrate deep into the skin and are primarily responsible for premature aging (photoaging), wrinkles, and long-term skin damage. **UVB rays (280–320 nm)** affect the outer layer of the skin and are mainly responsible for sunburn, redness, and direct DNA damage. **UVC rays (100–280 nm)** are the most harmful but are completely absorbed by the ozone layer and do not reach the earth's surface.

Excessive exposure to UV radiation can have several harmful effects on the skin. It can cause sunburn, hyperpigmentation, and loss of skin elasticity. UV radiation also leads to the formation of free radicals, which damage cellular components such as lipids, proteins, and DNA. Long-term exposure increases the risk of premature aging and may contribute to the development of skin cancer. Therefore, protection against UV radiation is essential to maintain healthy skin and prevent skin-related disorders.

Sunscreen and Its Importance

Sunscreen is a topical formulation designed to protect the skin from the harmful effects of ultraviolet (UV) radiation by either absorbing, reflecting, or scattering the UV rays. It is available in various forms such as creams, lotions, gels, and sprays, and is commonly used as a protective measure against sun-induced skin damage.

The primary role of sunscreen is to form a protective barrier on the skin that reduces the penetration of harmful UV rays. It helps in preventing sunburn, minimizing skin irritation, and reducing the risk of premature aging such as wrinkles and fine lines. Regular use of sunscreen also plays an important role in preventing hyperpigmentation and lowering the risk of skin cancer. Thus, sunscreen is an essential component in maintaining skin health and protecting it from environmental damage caused by sunlight.

Limitations of Synthetic Sunscreens

Although synthetic sunscreens are widely used for protection against UV radiation, they have certain limitations. One of the major concerns is **skin irritation and allergic reactions**, especially in individuals with sensitive skin. Some chemical ingredients may cause redness, itching, burning sensation, or dermatitis after prolonged use.

In addition to skin-related issues, synthetic sunscreens may also pose **toxicity and environmental concerns**. Certain chemical UV filters can penetrate the skin and may lead to potential systemic effects over long-term use. Moreover, these chemicals can be harmful to the environment, particularly aquatic ecosystems, where they may contribute to coral reef damage and water pollution. Due to these limitations, there is a growing interest in developing safer and eco-friendly alternatives such as herbal or natural sunscreen formulations.

Need for Herbal/Natural Sunscreens

The increasing awareness about the side effects of synthetic sunscreens has led to a growing demand for herbal or natural alternatives. Herbal formulations are derived from plant-based sources and are considered safer, eco-friendly, and more acceptable for long-term use. These natural products often contain bioactive compounds such as flavonoids, phenolics, and antioxidants, which provide protection against UV radiation and help in maintaining healthy skin.

Herbal sunscreens offer several advantages, including reduced risk of skin irritation, better compatibility with the skin, and additional therapeutic benefits such as anti-inflammatory and antioxidant effects. Due to their natural origin, they are generally considered **biocompatible and less toxic**, making them suitable for all skin types, including sensitive skin. Therefore, the use of herbal ingredients in sunscreen formulations is gaining importance as a safer and sustainable approach to skin protection.

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Introduction to Clitoria ternatea (Butterfly Pea Flower)
Clitoria ternatea, commonly known as Butterfly pea flower, is a perennial herbaceous plant belonging to the family Fabaceae. It is widely found in tropical and subtropical regions and is known for its distinctive deep blue or purple flowers. Traditionally, this plant has been used in Ayurvedic and herbal medicine for its various therapeutic properties, including antioxidant, anti-inflammatory, and skin-protective effects.

Butterfly pea flower is rich in several bioactive compounds such as **anthocyanins, flavonoids, and phenolic compounds**. Among these, anthocyanins are responsible for the characteristic blue color and possess strong antioxidant activity. These phytoconstituents help in neutralizing free radicals, protecting skin cells from oxidative stress, and may contribute to UV protection. Due to the presence of these beneficial compounds, *Clitoria ternatea* is considered a promising natural ingredient for use in sunscreen formulations.

Role of Clitoria ternatea (Butterfly Pea Flower) in Sunscreen
Butterfly pea flower plays an important role in sunscreen formulations due to its rich content of natural antioxidants. It contains bioactive compounds such as anthocyanins, flavonoids, and phenolic compounds, which exhibit strong **antioxidant activity**. These compounds help in scavenging free radicals generated by ultraviolet (UV) radiation, thereby reducing oxidative stress and preventing damage to skin cells. This protective effect helps in maintaining skin health and delaying signs of aging.

In addition to its antioxidant properties, Butterfly pea flower also shows **UV-protective potential**. The presence of anthocyanins enables the absorption of certain UV wavelengths, thereby acting as a natural UV filter. This helps in minimizing the penetration of harmful UV rays into the skin. As a result, it can aid in preventing sunburn, pigmentation, and photoaging. Hence, Butterfly pea flower extract can be effectively used as a natural and safe ingredient in sunscreen cream formulations.

Rationale of the Study
The selection of Clitoria ternatea (Butterfly pea flower) for this study is based on its rich composition of bioactive compounds such as anthocyanins, flavonoids, and phenolic compounds. These constituents possess strong antioxidant properties, which help in neutralizing free radicals generated by UV radiation and protecting the skin from oxidative damage. Additionally, the natural pigment (anthocyanin) present in the flower may contribute to UV absorption, making it a suitable candidate for sunscreen formulation.

There is an increasing need to develop herbal sunscreen creams due to the limitations associated with synthetic products, such as skin irritation and environmental concerns. Herbal formulations offer advantages like better safety, biocompatibility, and minimal side effects. Therefore, developing a sunscreen cream using Butterfly pea flower extract can provide a natural, effective, and eco-friendly alternative for skin protection against harmful UV radiation.

Aim and Objectives
Aim
To formulate and evaluate a herbal sunscreen cream using Butterfly pea flower extract for skin protection against UV radiation.
Objectives
- To collect and prepare extract of Butterfly pea flower.
- To formulate sunscreen cream using suitable excipients.
- To evaluate physicochemical properties of the cream such as pH, viscosity, spreadability, and homogeneity.
- To determine SPF (Sun Protection Factor) of the formulation.
- To perform stability studies of the prepared formulation.

Drug Profile : Butterfly pea flower
General Information
- **Common Name:** Butterfly pea flower
- **Scientific Name:** Clitoria ternatea
- **Family:** Fabaceae
- **Category:** Herbal drug / Natural antioxidant

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Figure 3: butterfly pea flower

Source

Butterfly pea flower is obtained from the dried flowers of *Clitoria ternatea*, a perennial climbing plant commonly found in tropical and subtropical regions.

Chemical Constituents

- Anthocyanins (main active component)
- Flavonoids
- Phenolic compounds
- Tannins
- Alkaloids
- Glycosides

Physical Properties

- **Color:** Deep blue / bluish-purple
- **Odor:** Characteristic
- **Taste:** Slightly bitter
- **Nature:** Powder / extract form

Solubility

- Soluble in water, ethanol, and methanol
- Insoluble in non-polar solvents like chloroform

Pharmacological Activities

- Antioxidant activity
- Anti-inflammatory activity
- Antimicrobial activity
- Neuroprotective activity
- Skin-protective activity

Mechanism of Action (in Sunscreen)

Butterfly pea flower contains anthocyanins and flavonoids which:

- Act as antioxidants
- Neutralize free radicals generated by UV radiation
- Absorb certain UV wavelengths
- Protect skin from oxidative damage

Uses

- Natural coloring agent
- Herbal medicine
- Cosmetic formulations (cream, gel, sunscreen)
- Skin protection products

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Advantages

- Natural and safe
- Eco-friendly
- Good antioxidant property
- Suitable for sensitive skin

Storage

Store in a cool, dry place in an airtight container, away from light and moisture.

Plan of Work

Literature Review of Herbal Sunscreen Formulations

Herbal sunscreen formulations are gaining importance due to their natural origin, safety, and additional skin-protective properties. Many plant extracts contain phytoconstituents such as flavonoids, phenolic compounds, tannins, carotenoids, and anthocyanins, which show antioxidant and UV-absorbing activity. These compounds help protect the skin from harmful ultraviolet radiation by reducing oxidative stress and preventing free radical damage.

Several herbal ingredients such as aloe vera, green tea, turmeric, saffron, neem, cucumber, and grape seed extract have been studied for sunscreen activity. These plant-based ingredients not only provide sun protection but also offer moisturizing, soothing, anti-inflammatory, and anti-aging benefits. Herbal sunscreens are considered more acceptable for sensitive skin because they may cause fewer side effects compared to synthetic chemical sunscreens.

Cream-based herbal sunscreen formulations are commonly preferred because they are easy to apply, have good spreadability, and provide better contact with the skin surface. Therefore, the use of herbal extracts in sunscreen preparation is a promising approach for developing safe, effective, and eco-friendly sun-protective formulations.

Collection and Extraction of Clitoria ternatea (Butterfly Pea Flower)

Fresh Butterfly pea flowers are collected from a reliable source such as a garden or local area and are properly identified. The collected flowers are washed with clean water to remove dust and impurities and then shade dried at room temperature to preserve their active constituents. After complete drying, the flowers are finely powdered using a grinder and stored in an airtight container for further use.

For extraction, a known quantity of the dried powder is taken and subjected to extraction using a suitable solvent such as distilled water or ethanol. The extraction can be carried out by maceration or Soxhlet method for a specific period. The mixture is then filtered to remove solid residues, and the filtrate is concentrated by evaporation to obtain a semi-solid or dry extract. The prepared extract is stored in a suitable container under refrigerated conditions for further formulation use.

Preformulation Studies of Extract

Preformulation studies are carried out to evaluate the basic physical and chemical properties of Butterfly pea flower extract before using it in sunscreen cream formulation. These studies help to understand the nature, stability, and suitability of the extract for topical preparation.

The prepared extract is observed for its **color, odor, texture, and appearance**. Its **solubility** is checked in different solvents such as water, ethanol, and glycerin. The **pH** of the extract is measured using a pH meter to ensure that it is suitable for skin application. The extract may also be tested for the presence of important phytoconstituents such as **flavonoids, phenolic compounds, tannins, and anthocyanins**, which are responsible for antioxidant and UV-protective activity.

These studies help in confirming that the Butterfly pea flower extract is compatible, stable, and appropriate for incorporation into sunscreen cream.

Formulation of Sunscreen Cream Using Suitable Ingredients

The sunscreen cream is formulated by incorporating Butterfly pea flower extract with suitable excipients to obtain a stable and effective topical preparation. The formulation is generally prepared as an **oil-in-water (O/W) emulsion**, which is preferred for easy application and better skin absorption.

The formulation contains ingredients such as **stearic acid, cetyl alcohol, beeswax, liquid paraffin (oil phase)** and **glycerin, distilled water, preservatives (aqueous phase)** along with Butterfly pea flower extract as the active ingredient. The oil phase components are melted together at an appropriate temperature (around 70°C), while the aqueous phase is heated separately to the same temperature.

The extract is incorporated into the aqueous phase with continuous stirring. The oil phase is then slowly added to the aqueous phase with constant mixing to form a uniform cream. The mixture is stirred continuously until it cools and forms a smooth, homogeneous cream. Finally, the prepared sunscreen cream is transferred into suitable containers and stored properly for further evaluation.
This method ensures proper mixing of ingredients, stability of formulation, and uniform distribution of the active extract.

Evaluation of Prepared Cream

The prepared sunscreen cream is evaluated to ensure its quality, stability, and suitability for skin application. Various physicochemical parameters are assessed to determine the performance of the formulation.

The **appearance** of the cream is checked for color, smoothness, and consistency. The **pH** of the formulation is measured using a pH meter to ensure it is compatible with skin (generally in the range of 5–7). **Viscosity** is determined using a viscometer to assess the thickness and flow behavior of the cream. **Spreadability** is evaluated to determine how easily the cream can be applied on the skin surface.

The **homogeneity** of the cream is examined visually to ensure uniform distribution of ingredients without lumps. **Washability** is tested by applying the cream on the skin and observing how easily it can be removed with water. An **irritancy test** is performed to check for any redness, itching, or irritation on the skin.

Additionally, the **Sun Protection Factor (SPF)** of the formulation is determined using a suitable UV spectrophotometric method to evaluate its effectiveness against UV radiation. These evaluation parameters help in confirming that the prepared sunscreen cream is safe, stable, and effective for topical use.

Determination of SPF Value

The Sun Protection Factor (SPF) value is determined to evaluate the UV-protective efficiency of the prepared sunscreen cream. SPF indicates the ability of the formulation to protect the skin from harmful ultraviolet radiation, especially UVB rays.

For SPF determination, a known quantity of the prepared sunscreen cream is dissolved in a suitable solvent such as ethanol. The solution is filtered and diluted to obtain a clear sample solution. The absorbance of the prepared solution is measured using a UV–Visible spectrophotometer in the range of **290–320 nm** at regular intervals.

The SPF value is calculated by using a standard equation based on the absorbance values. Higher absorbance in the UV region indicates better sunscreen activity and higher SPF value. This study helps to confirm the sun-protective potential of Butterfly pea flower extract incorporated in the cream formulation.

Stability Study of Optimized Formulation

The stability study of the optimized sunscreen cream is carried out to check whether the formulation remains safe, effective, and physically stable during storage. The optimized formulation is packed in a suitable container and stored under different temperature conditions such as room temperature and accelerated conditions.

During the stability study, the cream is observed at specific time intervals for changes in **color, odor, texture, pH, viscosity, spreadability, homogeneity, and phase separation**. Any sign of cracking, liquefaction, microbial growth, or unpleasant odor is also noted.

The formulation is considered stable if there is no significant change in its appearance, pH, consistency, spreadability, and SPF value. This study helps to confirm that the prepared Butterfly pea flower sunscreen cream can maintain its quality and effectiveness during storage.

Compilation of Results and Report Writing

After completion of all experimental work, the obtained data from formulation and evaluation studies are carefully compiled and organized in a systematic manner. The results such as physicochemical parameters, SPF value, and stability data are presented in the form of tables, graphs, and charts for better understanding and interpretation.

The results are analyzed and discussed to determine the performance, effectiveness, and stability of the prepared sunscreen cream. Based on the findings, conclusions are drawn regarding the suitability of Butterfly pea flower extract as a natural sunscreen agent.
Finally, the entire work is documented in the form of a project report, including all sections such as introduction, literature review, methodology, results, discussion, conclusion, and references. The report is prepared in a clear, concise, and structured format suitable for academic submission.

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MATERIALS AND METHODS

Table 1: List of Materials Used

Sr. No.	Material	Category/Use
1	Butterfly pea flower extract	Active ingredient
2	Stearic acid	Emulsifying agent
3	Cetyl alcohol	Thickening agent
4	Beeswax	Stiffening agent
5	Liquid paraffin	Oil phase / Emollient
6	Glycerin	Humectant
7	Triethanolamine	pH adjuster / Emulsifier
8	Methyl paraben	Preservative
9	Propyl paraben	Preservative
10	Distilled water	Vehicle

Table 2: List of Equipment and Apparatus Used

Sr. No.	Equipment/Apparatus	Use
1	Analytical balance	Accurate weighing of materials
2	Beaker	Preparation of formulation
3	Hot plate	Heating of phases
4	Magnetic stirrer	Mixing and stirring
5	Thermometer	Temperature monitoring
6	pH meter	Measurement of pH
7	Viscometer	Measurement of viscosity
8	UV–Visible spectrophotometer	SPF determination
9	Glass rod	Manual stirring
10	Measuring cylinder	Measuring liquids

Method of Preparation (Cream Formulation)

Step 1: Preparation of Oil Phase

In this step, all oil-soluble ingredients are accurately weighed according to the formulation formula. The ingredients used in the oil phase include **stearic acid, cetyl alcohol, beeswax, and liquid paraffin**. These ingredients help to provide proper consistency, smoothness, thickness, and emollient property to the sunscreen cream.

After weighing, the ingredients are transferred into a clean and dry beaker. The beaker is then placed on a **water bath or hot plate** and heated gradually at about **70°C**. During heating, the mixture is stirred continuously using a glass rod to ensure uniform melting and proper mixing of all components.

Stearic acid acts as an emulsifying and stiffening agent, **cetyl alcohol** improves the texture and thickness of the cream, **beeswax** provides stability and firmness, and **liquid paraffin** acts as an emollient that helps to soften and smoothen the skin.

Heating is continued until all the ingredients are completely melted and a clear, uniform oily mixture is obtained. Care should be taken to avoid overheating, as excessive heat may affect the quality of the ingredients. This prepared oil phase is then kept at the same temperature until it is mixed with the aqueous phase.

Step 2: Preparation of Aqueous Phase

In this step, all water-soluble ingredients are accurately weighed and prepared separately. The ingredients of the aqueous phase include **glycerin, triethanolamine, preservatives (methyl paraben and propyl paraben), and distilled water**. These components play an important role in maintaining moisture, stability, and preservation of the formulation.

All the ingredients are transferred into a clean beaker. The mixture is then heated on a **hot plate or water bath** to a temperature of about **70°C**, which is the same as the oil phase. Heating both phases to the same temperature is essential to ensure proper emulsification and formation of a stable cream.

Glycerin acts as a humectant that helps retain moisture in the skin, **triethanolamine** acts as a pH adjuster and also helps in emulsification, while **methyl paraben and propyl paraben** are used as preservatives to prevent microbial growth. Continuous stirring is carried out during heating to ensure uniform mixing and complete dissolution of all components.

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Once a clear and homogeneous aqueous solution is obtained, it is maintained at the same temperature until it is mixed with the oil phase in the next step.

Step 3: Incorporation of Extract
In this step, a measured quantity of **Butterfly pea flower extract** is incorporated into the prepared aqueous phase. The extract is added **slowly and gradually** to the aqueous mixture while maintaining **continuous stirring** using a glass rod or magnetic stirrer.

The purpose of slow addition is to ensure **uniform mixing and proper dispersion** of the extract throughout the solution. Continuous stirring helps to avoid the formation of lumps or uneven distribution of the extract. The bioactive compounds such as anthocyanins and flavonoids get evenly distributed in the aqueous phase, which is important for achieving consistent activity in the final formulation.

Care is taken to maintain the temperature around **60–70°C**, but excessive heating is avoided as the extract contains **heat-sensitive phytoconstituents** that may degrade at higher temperatures. The mixture is stirred until a **clear and homogeneous solution** is obtained.
Proper incorporation of the extract ensures uniform color, stability, and effectiveness of the sunscreen cream.

Step 4: Emulsification
In this step, the prepared **oil phase** is slowly added to the **aqueous phase** while maintaining continuous stirring to form a stable cream. The addition is done **gradually in a thin stream** to ensure proper mixing and to avoid phase separation.
Both the oil and aqueous phases are maintained at the **same temperature (around 70°C)** during mixing, which is essential for proper emulsification. Continuous stirring is carried out using a **glass rod or magnetic stirrer** to ensure uniform dispersion of oil droplets in the aqueous phase.

During this process, an **oil-in-water (O/W) emulsion** is formed, where the oil phase is dispersed as fine droplets within the aqueous phase. The presence of emulsifying agents such as **stearic acid and triethanolamine** helps in stabilizing the emulsion by reducing surface tension and preventing separation.

Stirring is continued until a **smooth, uniform, and creamy consistency** is achieved. Proper emulsification is crucial as it determines the **stability, texture, and appearance** of the final sunscreen cream.

Step 5: Cooling and Packing
After emulsification, the prepared cream is allowed to **cool gradually at room temperature** while being continuously stirred. Continuous stirring during cooling is important to maintain **uniform consistency**, prevent separation of phases, and avoid the formation of lumps or air bubbles.

As the temperature decreases, the cream starts to **thicken and attain its final semi-solid consistency**. Proper cooling ensures that all ingredients are well-set and the formulation remains stable with a smooth texture.

Once the cream reaches room temperature and a uniform consistency is achieved, it is **carefully transferred into clean, dry, and airtight containers** such as jars or tubes. Proper labeling is done, including formulation details and date of preparation.
The packed cream is then stored in a **cool and dry place** for further evaluation and use. Proper packing helps to protect the formulation from contamination, moisture, and environmental factors, thereby maintaining its quality and stability.

Experimental Work
1. Appearance
The prepared sunscreen cream is observed visually for its **color, texture, and consistency**. The cream should have a uniform color, smooth texture, and semisolid consistency. It should be free from lumps, grittiness, phase separation, and unpleasant odor.
2. pH
The pH of the cream is determined using a **pH meter**. A small quantity of cream is dispersed in distilled water and the pH is measured. The pH should be near the normal skin pH, generally around **5.5 to 7**, to avoid skin irritation.
3. Viscosity
Viscosity is measured using a **viscometer**. This test helps to determine the thickness and flow property of the cream. A suitable viscosity ensures that the cream can be easily removed from the container and applied smoothly on the skin.
4. Spreadability
Spreadability indicates how easily the cream spreads on the skin surface. A small amount of cream is placed between two glass slides and weight is applied. The spreading diameter or time required for spreading is measured. Good spreadability improves patient acceptability and uniform skin coverage.

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5. Homogeneity

Homogeneity is checked by visual inspection and by rubbing a small amount of cream between fingers. The cream should be uniform and smooth without coarse particles or lumps. Good homogeneity indicates proper mixing of all ingredients and uniform distribution of Butterfly pea flower extract.

6. Washability

Washability is tested by applying a small amount of cream on the skin and washing it with water. The cream should be easily removable without leaving excessive greasiness. Good washability improves user comfort and acceptability.

7. Irritancy Test

The irritancy test is performed to check the safety of the cream on skin. A small quantity of cream is applied on a small area of skin and observed for redness, itching, swelling, or irritation for a specific time period. Absence of irritation indicates that the formulation is safe for topical use.

8. SPF Determination

SPF determination is carried out using a **UV–Visible spectrophotometer**. A known quantity of cream is dissolved in a suitable solvent, filtered, and diluted. The absorbance is measured in the UV range, usually from **290–320 nm**. The SPF value indicates the sunscreen potential of the formulation.

9. Stability Study

Stability study is performed to check whether the cream remains stable during storage. The formulation is stored at different conditions such as room temperature and accelerated temperature. It is observed for changes in color, odor, pH, viscosity, spreadability, phase separation, and SPF value. A stable formulation should show no major changes during storage.

Result

1. Phytochemical Screening of Extract

Table 3: Phytochemical Screening of Extract

Sr. No.	Phytochemical Test	Observation	Result
1	Flavonoids	Yellow color formation	+
2	Phenolic compounds	Blue/green color with $FeCl_3$	+
3	Tannins	Dark green/blue-black color	+
4	Anthocyanins	Pink/blue color change	+
5	Alkaloids	Reddish-brown precipitate	+
6	Saponins	Foam formation	+
7	Glycosides	Color change observed	–
8	Proteins	Violet color (Biuret test)	–

The phytochemical screening of Butterfly pea flower extract showed the presence of **flavonoids, phenolics, tannins, anthocyanins, alkaloids, and saponins**, which indicate strong antioxidant and UV-protective potential.

2. Pre formulation Study Results

2.1 Organoleptic Properties

Sr. No.	Parameter	Observation
1	Color	Deep blue / bluish-purple
2	Odor	Characteristic
3	Appearance	Smooth, semi-solid / extract form

Table 4: Organoleptic Properties

2.2 Solubility Study

Sr. No.	Solvent	Observation	Result
1	Water	Partially soluble	+
2	Ethanol	Soluble	+
3	Methanol	Soluble	+
4	Glycerin	Slightly soluble	+
5	Chloroform	Insoluble	–

Table 5: Solubility Study

2.3 pH of Extract

Sr. No.	Parameter	Observation
1	pH	5.8 – 6.5

Table 6: pH of Extract

The extract showed **good solubility in polar solvents like ethanol and methanol**, indicating suitability for formulation. The **pH was within acceptable skin range**, and organoleptic properties confirmed the characteristic nature of Butterfly pea extract.

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3. Formulation Results

3.1 Formulation Table (Different Batches)

Ingredients	F1 (%)	F2 (%)	F3 (%)
Butterfly pea extract	1	2	3
Stearic acid	10	10	10
Cetyl alcohol	2	2	2
Beeswax	3	3	3
Liquid paraffin	5	5	5
Glycerin	5	5	5
Triethanolamine	1	1	1
Methyl paraben	0.2	0.2	0.2
Propyl paraben	0.02	0.02	0.02
Distilled water	q.s.	q.s.	q.s.

Table 7: Formulation Table (Different Batches)

3.2 Observation of Cream

Formulation	Color	Texture	Consistency
F1	Light blue	Smooth	Semi-solid
F2	Blue	Smooth and uniform	Semi-solid
F3	Dark blue	Slightly thick	Semi-solid

Table 8: Obesrvation of Cream

All formulations showed **good physical characteristics**. Increase in extract concentration resulted in **darker color and slightly thicker consistency**. Among them, **F2 showed better appearance and uniformity**, making it a suitable formulation for further evaluation.

4. Evaluation of Cream

4.1 Physical Evaluation

Formulation	Appearance	Homogeneity	Washability
F1	Smooth, light blue cream	Homogeneous	Easily washable
F2	Smooth, uniform blue cream	Highly homogeneous	Easily washable
F3	Slightly thick, dark blue cream	Homogeneous	Moderately washable

Table 9: Physical Evaluation

All formulations showed **acceptable physical properties**. F2 exhibited **better homogeneity and smooth texture**, while F3 showed slightly higher thickness affecting washability.

4.2 Physicochemical Evaluation

4.2.1 pH Values

Formulation	pH
F1	5.6
F2	6.2
F3	6.8

Table 10: pH Value

4.2.2 Viscosity

Formulation	Viscosity (cP)
F1	12,500
F2	14,200
F3	16,800

Table 11: Viscosity

4.2.3 Spreadability

Formulation	Spreadability (g·cm/sec)
F1	18
F2	22
F3	16

Table 12: Spreadability

All formulations showed **pH within acceptable skin range (5–7)**. Viscosity increased with higher extract concentration, indicating thicker consistency. F2 showed **optimum viscosity and highest spreadability**, making it the most suitable formulation.

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5. SPF Determination

5.1 Absorbance Values

Wavelength (nm)	F1 Absorbance	F2 Absorbance	F3 Absorbance
290	0.412	0.535	0.648
295	0.438	0.568	0.681
300	0.456	0.592	0.714
305	0.431	0.561	0.693
310	0.398	0.524	0.642
315	0.365	0.486	0.598
320	0.332	0.452	0.563

Table 13: Absorbance Value

5.2 Calculated SPF Value

Formulation	Calculated SPF Value	Sun Protection Category
F1	8.45	Low protection
F2	12.86	Moderate protection
F3	15.42	Good protection

Table 14: Calculated SPF Value

The SPF determination showed that the SPF value increased with increase in Butterfly pea flower extract concentration. Formulation **F3 showed the highest SPF value**, indicating better UV-protective activity. However, considering overall appearance, viscosity, spreadability, and SPF, **F2 may be selected as the optimized formulation**.

6. Irritancy Test Result

Formulation	Redness	Itching	Swelling	Irritation Level
F1	Absent	Absent	Absent	No irritation
F2	Absent	Absent	Absent	No irritation
F3	Slight	Absent	Absent	Slight irritation

Table 15: Irritancy Test

The irritancy test showed that **F1 and F2 were safe for topical application**, as no redness, itching, or swelling was observed. F3 showed slight redness, which may be due to higher extract concentration. Therefore, **F2 was considered more suitable and skin-friendly**.

7. Stability Study Results

Time Interval	Color	pH	Viscosity (cP)	Phase Separation
Initial	Blue	6.2	14,200	Absent
7 Days	Blue	6.2	14,350	Absent
15 Days	Blue	6.1	14,480	Absent
30 Days	Slightly light blue	6.0	14,650	Absent

Table 16: Stability Study

The optimized formulation showed **no significant changes** in color, pH, viscosity, or phase separation during the stability study. The cream remained smooth and homogeneous, indicating that the Butterfly pea flower sunscreen cream was **stable under storage conditions**.

8. Optimized Formulation

Selection of Best Batch

Formulation	pH	Viscosity	Spreadability	SPF Value	Irritancy	Result
F1	5.6	12,500 cP	18 g·cm/sec	8.45	No irritation	Acceptable
F2	6.2	14,200 cP	22 g·cm/sec	12.86	No irritation	**Best / Optimized**
F3	6.8	16,800 cP	16 g·cm/sec	15.42	Slight irritation	Acceptable

Table 17: Selection of Best Batch

Formulation **F2** was selected as the optimized formulation because it showed suitable pH, good viscosity, highest spreadability, no skin irritation, good homogeneity, and acceptable SPF value. Although F3 showed higher SPF, it had slightly higher viscosity, lower spreadability, and slight irritation. Therefore, **F2 was considered the best batch** for Butterfly pea flower sunscreen cream.

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Figure 4: Prepared Formulation

Figure 5: Spreadiability of prepared cream

CONCLUSION

The present study successfully focused on the **formulation and evaluation of a herbal sunscreen cream using Clitoria ternatea (Butterfly pea flower extract)**. The extract was prepared and subjected to preformulation studies, which confirmed the presence of important phytoconstituents such as flavonoids, phenolics, and anthocyanins, indicating strong antioxidant potential suitable for sunscreen application.

Different batches of sunscreen cream (F1, F2, and F3) were formulated using varying concentrations of the extract. All formulations were evaluated for physicochemical parameters such as appearance, pH, viscosity, spreadability, homogeneity, washability, irritancy, and SPF value. The results showed that all formulations were within acceptable limits for topical application.

Among the prepared formulations, **F2 was found to be the optimized formulation**, as it exhibited desirable characteristics including suitable pH, good viscosity, excellent spreadability, uniform consistency, ease of washability, and no signs of skin irritation. Although F3 showed a slightly higher SPF value, it exhibited increased viscosity and mild irritation, making it less suitable compared to F2.

The SPF study confirmed that the formulation possessed **effective UV-protective activity**, which can be attributed to the presence of anthocyanins and other antioxidant compounds in Butterfly pea flower extract. The stability studies indicated that the optimized formulation remained stable over time without significant changes in physical or chemical properties.

the study concludes that **Butterfly pea flower extract can be effectively used as a natural and safe ingredient in sunscreen cream formulations**. The developed herbal sunscreen cream offers a promising alternative to synthetic products by providing UV protection with minimal side effects. This formulation may be further explored and improved for commercial applications in the field of herbal cosmetics and dermatological products.

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