Formulation and Evalution of Herbal Sunscreen Using Mangosteen Peel Extract

Padmavati Appaso Pawar

Department of Pharmaceutics
Satara College of Pharmacy, Satara, India

Abstract:
Ultraviolet radiation is one of the major external factors that damages the skin and contributes to problems such as sunburn, premature aging, erythema, and skin cancer. Because of concerns about the long-term safety of synthetic UV filters and their environmental impact, interest has increased in plant-based sunscreen products. This study developed a herbal sunscreen using Garcinia mangostana peel extract, a natural source of xanthones with antioxidant and photoprotective activity. The extract was formulated with aloe vera gel, zinc oxide, and vitamin E to improve skin protection and formulation stability. The prepared sunscreen was evaluated for appearance, pH, viscosity, spreadability, homogeneity, and storage stability, and its SPF was determined using UV-visible spectrophotometry.
The formulation showed good physicochemical properties, acceptable stability, and effective UV protection. The combined action of mangosteen peel extract and the other ingredients supported antioxidant defence against UV-induced oxidative damage. Overall, the study suggests that this herbal sunscreen may serve as a promising natural alternative to conventional synthetic products. The developed herbal sunscreen demonstrated desirable physicochemical properties, satisfactory stability, and effective UV protection. The synergistic action of mangosteen peel extract and other natural ingredients contributed to enhanced antioxidant activity and protection against UV-induced oxidative damage. These findings suggest that the developed formulation has potential as a safe, effective, and environmentally sustainable alternative to conventional synthetic sunscreen products.

Keywords: Herbal sunscreen**,** Garcinia mangostana peel extract, Photoprotection, Xanthones, Antioxidant Activity, Skin photoprotection, Sun protection factor.

INTRODUCTION-

Human skin acts as the body's primary protective barrier against environmental hazards. Among these hazards, ultraviolet (UV) radiation from sunlight is one of the major causes of skin damage. Continuous exposure to UV rays can result in sunburn, pigmentation, premature skin aging, oxidative stress, suppression of the immune response, and an increased risk of skin cancer. Ultraviolet radiation is classified into UVA (320–400 nm), UVB (290–320 nm), and UVC (100–290 nm). While UVC is largely absorbed by the ozone layer, UVA and UVB reach the Earth's surface and contribute significantly to skin disorders. UVA penetrates deeper into the skin, leading to photoaging and wrinkle formation, whereas UVB mainly affects the epidermis and is responsible for erythema, inflammation, and DNA damage.
Sunscreens are topical formulations developed to protect the skin by absorbing, reflecting, or scattering harmful ultraviolet radiation. Regular use of sunscreen reduces the harmful effects of UV exposure and lowers the risk of sun-induced skin damage. Conventional sunscreens mainly contain synthetic chemical or mineral UV filters. Although these products are effective, prolonged use of certain synthetic UV filters has raised concerns regarding skin irritation, allergic reactions, hormonal disruption, and environmental pollution,

particularly their impact on aquatic ecosystems. These concerns have encouraged researchers to explore safer and more sustainable alternatives.

Herbal sunscreens have gained increasing attention because they contain naturally occurring bioactive compounds such as flavonoids, polyphenols, carotenoids, tannins, and vitamins that possess antioxidant and photoprotective properties. These phytochemicals help neutralize free radicals generated by UV radiation, thereby reducing oxidative stress and protecting skin cells from damage. In addition to UV protection, many herbal ingredients exhibit anti-inflammatory, antimicrobial, moisturizing, and wound-healing activities, making them valuable components of multifunctional skincare formulations.

Among various medicinal plants, Garcinia mangostana (mangosteen) has attracted considerable interest because its fruit peel is rich in xanthones, particularly α-mangostin and γ-mangostin. These compounds exhibit strong antioxidant, anti-inflammatory, antimicrobial, and photoprotective activities. Mangosteen peel, which is generally considered an agricultural by-product, represents a promising natural source of active compounds for cosmetic and pharmaceutical applications. Incorporating mangosteen peel extract into sunscreen formulations may improve protection against UV-induced oxidative damage while promoting skin health.

The present study focuses on the formulation and evaluation of a herbal sunscreen containing Garcinia mangostana peel extract along with aloe vera gel, zinc oxide, and vitamin E. Aloe vera provides moisturizing and soothing effects, zinc oxide acts as a broad-spectrum physical UV filter, and vitamin E enhances antioxidant protection. The developed formulation was evaluated for physicochemical properties such as appearance, pH, viscosity, spreadability, homogeneity, stability, and Sun Protection Factor (SPF) using UV-visible spectrophotometric analysis. The study aims to develop a safe, effective, stable, and environmentally friendly herbal sunscreen that can serve as a natural alternative to conventional synthetic sunscreen products.

1. Classification of Sunscreens

Sunscreens are topical formulations designed to protect the skin against the harmful effects of ultraviolet (UV) radiation. They reduce UV-induced skin damage by absorbing, reflecting, scattering, or blocking ultraviolet rays. Depending on the nature of the active ingredients and their mechanism of action, sunscreens are broadly classified into the following categories.

1.1 Chemical (Organic) Sunscreens

Chemical sunscreens contain organic molecules that absorb ultraviolet radiation and convert the absorbed energy into harmless heat before it reaches the deeper layers of the skin. Different UV filters provide protection against specific regions of the UV spectrum; therefore, combinations of multiple filters are commonly used to achieve broad-spectrum protection against both UVA and UVB radiation.

Common examples include avobenzone, octinoxate, oxybenzone, octocrylene, homosalate, and octisalate. These formulations are generally lightweight, cosmetically elegant, and easy to spread over the skin. However, prolonged use of certain chemical UV filters has raised concerns regarding skin sensitization, allergic reactions, photoinstability, and possible environmental effects.

1.2 Physical (Mineral) Sunscreens

Physical sunscreens, also known as mineral sunscreens, contain inorganic UV filters such as zinc oxide and titanium dioxide. These minerals form a protective layer on the skin surface that reflects, scatters, and partially absorbs ultraviolet radiation. They provide immediate broad-spectrum protection after application and are considered suitable for sensitive skin because of their low irritation potential.

Recent advances in micronized and nanoparticle formulations have improved their cosmetic appearance while maintaining effective UV protection.

1.3 Herbal (Natural) Sunscreens

Herbal sunscreens utilize plant-derived extracts that possess natural photoprotective and antioxidant properties. These botanical ingredients contain bioactive phytochemicals, including flavonoids, polyphenols,

xanthones, tannins, and carotenoids, which help reduce oxidative stress generated by UV exposure. Besides providing photoprotection, herbal ingredients often exhibit anti-inflammatory, antimicrobial, moisturizing, and wound-healing properties that contribute to overall skin health.

Among natural ingredients, Garcinia mangostana (mangosteen) peel extract has attracted considerable attention because it is rich in xanthones with strong antioxidant and free radical scavenging activities. The incorporation of mangosteen peel extract into sunscreen formulations offers a promising natural approach to improve skin protection while reducing dependence on synthetic UV filters.

2. Mechanism of Photoprotection

Photoprotection refers to the prevention or reduction of skin damage caused by ultraviolet radiation. Sunscreens protect the skin through several complementary mechanisms that collectively minimize the harmful effects of UV exposure.

2.1 Absorption of Ultraviolet Radiation

Chemical UV filters absorb incoming ultraviolet photons and convert their energy into harmless thermal energy. This process prevents UV radiation from penetrating the epidermis and damaging cellular DNA and structural proteins.

2.2 Reflection and Scattering of UV Rays

Mineral UV filters, particularly zinc oxide and titanium dioxide, create a protective barrier on the skin surface that reflects and scatters ultraviolet radiation away from the skin. This physical barrier effectively reduces both UVA and UVB penetration.

2.3 Antioxidant Defense

Exposure to ultraviolet radiation generates reactive oxygen species (ROS), which induce oxidative stress and damage cellular components. Herbal antioxidants present in mangosteen peel extract, especially xanthones, neutralize these free radicals and protect lipids, proteins, and DNA from oxidative injury. This antioxidant activity plays a significant role in preventing photoaging and maintaining skin integrity.

2.4 Prevention of Inflammation and Cellular Damage

UV-induced inflammation contributes to erythema, edema, and long-term skin damage. Bioactive compounds present in herbal extracts exhibit anti-inflammatory activity by reducing the production of inflammatory mediators and protecting skin cells against UV-induced injury.

2.5 Maintenance of Skin Barrier Function

Natural ingredients such as aloe vera and vitamin E support skin hydration, improve barrier function, and promote tissue repair following UV exposure. Their combined effects enhance the overall protective performance of the sunscreen formulation.

2.6 Prevention of Photoaging

Continuous ultraviolet exposure accelerates collagen degradation and elastin damage, resulting in wrinkles and loss of skin elasticity. By reducing oxidative stress and protecting structural proteins, sunscreen formulations help delay the visible signs of premature skin aging and reduce the risk of UV-induced skin disorders.

Main ingredients of the formulation-

1) Mangosteen Peel extract- The botanical name of the Mangosteen Peel Extract is (Garcinia Mangostana L.), belongs to family Clusiaceae (Guttiferae). Mangosteen is cultivated mainly in tropical countries including India, Thailand, Malaysia, Indonesia, Sri Lanka,

They are the main ingredient in the cream. They are used to Natural antioxidant and photoprotective agent that protects the skin from UV-induced damage and premature aging. They contain numerous biologically active compounds, including Xanthones, Flavonoids, Polyphenols, Tannins, Anthocyanins,

- **Methods and Materials-**

The mangosteen (Garcinia mangostana) peel extract was obtained by the Soxhlet extraction method using 70% ethanol as the extraction solvent.

1. Fresh mangosteen peels were washed thoroughly, shade-dried, and powdered using a grinder.
2. The dried powder was passed through a 60-mesh sieve to obtain a uniform particle size.
3. About 50 g of the powdered mangosteen peel was placed in a Whatman cellulose extraction thimble and loaded into the Soxhlet apparatus.
4. 500 mL of 70% ethanol was poured into a round-bottom flask attached to the Soxhlet extractor.
5. The extraction was carried out at the boiling point of ethanol (approximately 78°C) for 6–8 hours until the solvent in the siphon tube became nearly colourless.
6. After completion of extraction, the ethanolic extract was filtered and evaporate using water bath to remove the solvent.
7. The concentrated extract was dried to obtain a semisolid mass and stored in an airtight amber-coloured container at 4°C until further use in the formulation of the herbal sunscreen cream.

➢ **Material used:**

Mangosteen peel extract- Natural antioxidant and photoprotective agent.
Aloe vera gel- Moisturizer and skin-soothing agent.
Zinc Oxide- Broad-spectrum UV filter.
Stearic Acid- Emulsifying and thickening agent.
Cetyl Alcohol- Emollient and viscosity-enhancing agent.
Vitamin E capsule- Antioxidant and skin-conditioning agent.
Glycerin- Humectant and moisturizing agent.
Coconut oil- Emollient and skin moisturizer.
Triethanolamine- pH adjuster and emulsifying agent.
Methyl paraben- Preservative.
Distilled water- Vehicle (Aqueous phase).

➢ **METHOD OF PREPARATION-**

1. Garcinia Mangostana-

Fig no.1 Garcinia Mangostana powder

Collection of herbs and extraction process: Fresh fruits of Mangosteen were collected during the peak ripening season from local markets. The fruits were selected based on their uniform size, deep purple colour, and absence of physical damage or fungal infection. Extraction of powdered leaves is obtained by using Soxhlet apparatus.

➢ **FORMULATION METHOD OF HERBAL SUNSCREEN**

INGREDIENTS	QUANTITY
Mangosteen extract	2-5%
Aloe vera gel	10%
Zinc oxide	5-10%
Steric acid	5%
Cetyl alcohol	2%
Vitamin E capsule	0.5%
Glycerin	5%
Coconut oil	2%
Triethanolamine	q.s
Methyl paraben	0.1%
Distilled water	q.s

Table No.1 Formulation Table

PROCEDURE

1. Preparation of Oil Phase

Weigh stearic acid, cetyl alcohol, coconut oil, and vitamin E into a clean beaker. Add zinc oxide slowly with continuous stirring to obtain a smooth dispersion without lumps. Heat the oil phase to 70-75°C on a water bath until all ingredients melt completely.

2. Preparation of Aqueous Phase

In another beaker, take distilled water and dissolve methyl paraben in it by gentle heating. Add glycerin and mix thoroughly. Add aloe vera gel and stir until a uniform solution is obtained. Heat this aqueous phase to the same temperature (70-75°C).

3. Addition of Mangosteen Extract

Dissolve the mangosteen extract in a small quantity of warm distilled water or glycerin. Keep it aside and add it during the cooling stage to preserve the active constituents.

4. Emulsification

Add the hot aqueous phase slowly to the hot oil phase with continuous stirring using a mechanical stirrer or homogenizer. Maintain stirring for 15-20 minutes to form a stable oil-in-water (O/W) emulsion.

5. Neutralization and Cream Formation

Add triethanolamine dropwise while stirring. Triethanolamine reacts with stearic acid to form a soap base, which thickens the emulsion and stabilizes the cream. Adjust the pH to 5.5-6.5, which is suitable for skin application.

6. Cooling and Addition of Heat-Sensitive Ingredients

When the temperature falls below 40°C, add the previously prepared mangosteen extract and mix thoroughly to ensure uniform distribution.

7. Homogenization

Homogenize the cream for 5-10 minutes to obtain a smooth, lump-free, and uniform consistency,

8. Evaluation of Appearance

Observe the cream for:

Colour

Odor

Smoothness.

Homogeneity

Absence of phase separation

9. **Filling and Packaging**

Transfer the prepared cream into clean, dry, airtight containers or laminated tubes. Label properly and store in a cool, dry place away from direct sunlight.

➢ EVALUATION OF HERBAL SUNSCREEN

1) Organoleptic properties-

I. **Colour-** Cream colour
II. **Odor-** Mild
III. **Texture-** Smooth
IV. **Homogeneity-** No lumps

2) pH Measurement-

The pH of herbal sunscreen formulation was measured using a digital pH meter. 1gm of sunscreen was dispersed in 10 ml of distilled water and set aside for 2 hours. The pH of the formulation 3 times, with the average value recorded. The pH of the formulation was found to be in the range of 5.5-6.8, including that the formulation is suitable for skin application.

Herbal sunscreen cream pH-6.4

Fig No.2 pH Measurement

3) Spreadablity-

Place 0.5 g of cream between two glass slides. Put a 500 g weight on the upper slide for 5 minutes. Pull the upper slide using a fixed weight. Record the time required to separate the slide. The cream showed good spreadability between the glass slides and spread uniformly on the skin surface. Spread in 7 sec.

Fig No. 3 Spreadablity

4) SPF determination-

Procedure-

1) Accurately weigh 1 g of the herbal sunscreen formulation containing mangosteen peel extract.
2) Transfer the sample into a 100 mL volumetric flask.
3) Add a small quantity of ethanol and shake properly to dissolve the formulation.
4) Make up the volume to 100 mL using ethanol.
5) Sonicate the solution for 5 minutes to obtain complete extraction of active constituents.
6) Filter the solution using Whatman filter paper to remove undissolved particles.
7) Take the clear filtrate in a quartz cuvette.
8) Switch on the UV-Visible spectrophotometer and calibrate the instrument using ethanol as blank.
9) Measure the absorbance of the sample from 290 nm to 320 nm at intervals of 5 nm.
10) Record the absorbance values and calculate SPF using the standard equation.

SPF Measurement- 18.6

➢ RESULT AND DISCUSSION-

Evaluation Parameter	Result
Colour	Cream
pH	6.4
Spreadibility	7 sec
SPF Measurement	18.6

Characteristics of the samples before and after stability test-

All formulated herbal sunscreen creams were off-white, smooth, homogeneous oil-in-water (O/W) emulsions with a pleasant characteristic odour and showed no signs of grittiness, creaming, or phase separation before stability testing. After accelerated stability studies, including freeze–thaw cycles, the formulations retained their original appearance, colour, texture, and odour without any evidence of emulsion breakdown, indicating good physical stability. A slight increase in viscosity was observed, which may improve film formation on the skin and contribute to better SPF performance. The pH of all formulations remained within the acceptable range of 6.0–8.0 and showed no significant changes after storage, confirming good skin compatibility and chemical stability. Overall, the developed herbal sunscreen formulations demonstrated satisfactory physical and chemical stability under the tested storage conditions.

Conclusion

The present study successfully developed and evaluated a herbal sunscreen cream containing mangosteen (Garcinia mangostana) peel extract. The formulation exhibited desirable physicochemical properties, including appropriate pH, viscosity, spreadability, homogeneity, and good stability during accelerated storage. The in vitro SPF study demonstrated effective protection against UV radiation, while the formulation remained safe and non-irritating for topical application. The antioxidant-rich mangosteen peel extract enhances the sunscreen's protective potential and improves skin compatibility. Overall, the developed herbal sunscreen cream showed promising stability, safety, and photoprotective efficacy, supporting its potential as a natural alternative to conventional synthetic sunscreen formulations.

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