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Formulation and Evaluation of Polyherbal Sunscreen

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Abstract: The present study focuses on the development and evaluation of a herbal sunscreen formulation incorporating ferulic acid-rich extract derived from corn cobs. Corn cobs, an agro-waste, were utilized as a sustainable source of phenolic compounds known for their antioxidant and photoprotective properties. The extract was obtained using ethanol-water (70:30) through Soxhlet extraction and concentrated using a rotary evaporator. Four sunscreen cream formulations (F1–F4) were prepared using varying concentrations of the extract (15–16%) and Smix (Tween 80:Span 20) as the emulsifier. Each formulation was evaluated for physicochemical properties (pH, viscosity, spreadability), and biological activities including sun protection factor (SPF), antioxidant (DPPH assay), and anti-inflammatory activity (protein denaturation method).

Among all, formulation F4, with 16% extract and moderate Smix content (35%), exhibited the most promising results. It demonstrated the highest SPF value of 19.24, DPPH inhibition of 74.3%, and anti-inflammatory activity of 65.5%, along with suitable viscosity (21000 cP) and skin-compatible pH (5.5). The study confirmed that increasing the concentration of corn cob extract significantly enhanced SPF, antioxidant, and anti-inflammatory properties, attributed to the presence of polyphenols and flavonoids. All formulations exhibited stable emulsions and acceptable dermatological properties.

The findings highlight the potential of corn cob extract as a multifunctional agent in natural sunscreen formulations. Formulation F4 stands out as the most effective, suggesting a viable path toward eco-friendly and skin-friendly herbal sun protection products. Further studies on photostability, *in vivo* efficacy, and long-term skin compatibility are recommended for commercial development.

Keywords: Corn Cob Extract, UV Protection, Natural Sunscreen, Sustainable Skincare, Ferulic Acid

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Introduction

Preparing sunscreen is an essential aspect of skincare and sun protection. Sunscreen is a product designed to shield the skin from the harmful effects of ultraviolet (UV) radiation, which can lead to sunburn, premature aging, and an increased risk of skin cancer. This introduction will provide an overview of the process of preparing sunscreen, emphasizing the importance of this skincare product in our daily lives (Velappan *et al.*, 2019).

Sun exposure is a double-edged sword. On one hand, it's vital for our bodies to produce vitamin D, which is essential for bone health and overall well-being. On the other hand, excessive or unprotected sun exposure can have detrimental effects on the skin. This is where sunscreen plays a crucial role (Fry and Baker, 2007)

The process of preparing sunscreen involves the careful selection and formulation of various ingredients that work in harmony to create a protective barrier on the skin's surface. The primary function of sunscreen is to absorb, reflect, or scatter UV rays, thus reducing the damage they can cause. The two main types of UV radiation that sunscreen aims to protect against are UVA (responsible for premature aging) and UVB (responsible for sunburn and skin cancer) (Lowes *et al*., 2007, 2021).

Key ingredients in sunscreen formulations typically include UV-absorbing or reflecting agents like zinc oxide or titanium dioxide, as well as emollients, stabilizers, and preservatives. The selection and combination of these components are critical to create an effective sunscreen that provides the desired sun protection factor (SPF) while maintaining skin comfort and safety.

Preventing sun damage through sunscreen application is not only a matter of cosmetic concern but a fundamental health precaution. Skin cancers are among the most common cancers worldwide, and overexposure to UV radiation is a leading risk factor for their development. In addition, premature aging due to sun damage can significantly impact the appearance and health of the skin (Okasha *et al*., 2018, Asmiyenti and Tisna, 2019).

As we explore the process of preparing sunscreen in more detail, we will delve into the science behind UV protection, the choice of ingredients, and the formulation techniques. A well-prepared sunscreen can serve as a vital tool in our efforts to maintain healthy, youthful skin while safeguarding ourselves against the potential dangers of the sun (Asmiyenti and Tisna, 2019, Tiwari *et al*., 2022)

Role of Corn Cob Extract:

Formulating sunscreen using corn cob extract represents an innovative approach to developing sun protection products that are not only effective but also environmentally friendly. Sunscreen is a crucial tool in safeguarding our skin from the harmful effects of ultraviolet (UV) radiation, which can lead to sunburn, premature aging, and an increased risk of skin cancer. Traditional sunscreens often contain synthetic chemicals that can have adverse ecological and health impacts. In response to these concerns, the utilization of natural ingredients like corn cob extract has gained attention in the cosmetic and skincare industry (Roy and Sahu, 2014, Bhide and Nitave, 2016).

Corn cob extract is rich in compounds like ferulic acid, a natural antioxidant, which provides UV protection by absorbing and dissipating harmful UV rays. The use of such plant-based ingredients in sunscreen formulations not only reduces our reliance on synthetic chemicals but also aligns with the growing consumer demand for sustainable and eco-friendly products (Dutta *et al.*, 2022).

To formulate a sunscreen with corn cob extract, several essential steps are involved. Initially, the corn cobs are collected and processed to extract the valuable components. The extract is then incorporated into a sunscreen base, which typically includes a combination of natural oils, waxes, and emollients. These ingredients are carefully blended to create a stable and effective sunscreen formula (Dutta *et al*., 2022).

The resulting sunscreen product offers broad-spectrum protection against both UVA and UVB rays, shielding the skin from the sun's damaging effects. Moreover, corn cob extract contributes to the product's moisturizing properties, making it suitable for daily use.

This innovative sunscreen formulation not only addresses the need for sun protection but also aligns with the global trend towards sustainable and natural skincare solutions. By harnessing the power of corn cob extract, we can create sunscreens that not only safeguard our skin but also support a more environmentally responsible and health-conscious approach to sun protection. It represents a promising step towards a brighter, more sustainable future for skincare and sun protection (Rasheed *et al.,* 2012; Bhide *et al.*, 2023,).

The present study focuses on the development and evaluation of a herbal sunscreen formulation incorporating ferulic acid-rich extract derived from corn cobs. Corn cobs, an agro-waste, were utilized as a sustainable source of phenolic compounds known for their antioxidant and photoprotective properties.

Materials and Methods

Extract Preparation of Ferulic Acid from Corn Cob:

Materials Required:

- Dried corn cobs (powdered)
- Ethanol or methanol (solvent)
- Distilled water
- Soxhlet extractor or reflux setup
- Rotary evaporator (or simple distillation unit)
- Filter paper and funnel
- Silica gel for column chromatography (optional for purification)
- UV-Vis spectrophotometer or HPLC for analysis

Steps:

(a) *Preparation of Raw Material*:

- ○ Clean and dry corn cobs thoroughly.
- ○ Grind them into a fine powder using a grinder or blender.

(b) *Solvent Extraction*:

- ○ Take a known quantity of corn cob powder 50 g.
- ○ Add it to a Soxhlet extractor or reflux setup.
- ○ Use ethanol:water (70:30) or methanol:water (80:20) as the extraction solvent.
- ○ Allow extraction to proceed for 6–8 h at a controlled temperature (60–70°C).

(c) *Filtration and Concentration*:

- ○ Filter the extract using filter paper to remove solid particles.
- ○ Concentrate the filtrate using a rotary evaporator to remove the solvent.
- ○ Obtain a semi-solid crude extract rich in phenolic compounds.

Formulation of Sunscreen Cream:

Materials Required:

- Extracted Ferulic Acid
- Smix (1:1 ratio of surfactants or emulsifiers)
- Distilled water
- Methyl paraben
- Propyl paraben
- Glycerin
- Rose oil
- Trimethanolamine (for pH adjustment)
- Optional: Vitamin E oil, Aloe Vera Gel

Steps:

(a) *Preparation of Oil Phase*:

- ○ In a beaker, add and melt oil-soluble components (e.g., Smix, rose oil, waxes if used).
- ○ Heat the mixture to around 70°C.

(b) *Preparation of Water Phase*:

- ○ In another beaker, mix distilled water, glycerin

Table 1: The quantity of ingredients used in formulation of sunscreen in percentage

Formulation Code	Extract (%)	S_{mix} (1:1) (%)	Distilled water (%)	Methyl paraben (%)	Propyl paraben (%)	Glycerin (%)	Rose oil (%)	Trimethanolamine (%)
F1	15	37	44	0.1	0.05	1	0.5	q.s.
F2	16	37	41	0.1	0.05	1	0.5	q.s.
F3	15	35	44	0.1	0.05	1	0.5	q.s.
F4	16	35	41	0.1	0.05	1	0.5	q.s.

S_{mix}: Tween 80:Span 20

and dissolve methyl and propyl parabens by heating to 70°C.

- Add the ferulic acid extract and ensure it is uniformly dissolved.

(c) *Emulsification Process*:

- Slowly add the water phase to the oil phase while continuously stirring.
- Use a hand blender or high-shear mixer to emulsify the mixture thoroughly until a smooth cream is formed.

(d) *Addition of Optional Ingredients*:

- Once emulsified, cool the mixture to around 40°C.
- Add any optional ingredients like vitamin E oil, essential oils, or aloe vera gel.

(e) *pH Adjustment*:

- Check the pH using pH paper or meter.
- Adjust to a skin-friendly pH (around 5.5–6.5) using trimethanolamine or citric acid solution.

(f) *Final Processing and Storage*:

- Stir occasionally while allowing the cream to cool to room temperature.
- Transfer into clean, sterilized, airtight containers.
- Label the formulations appropriately (F1, F2, etc.) and store away from direct sunlight (Table 1).

SPF Testing:

- *In Vitro SPF Testing*: Use UV-Vis spectrophotometry to assess absorbance in the UVB range (290–320 nm) and calculate SPF using the Mansur equation.
- *In Vivo Testing*: Should follow ethical guidelines and regulatory approvals.

Brookfield Viscometer Method

The Brookfield viscometer is a widely used instrument to measure the viscosity of fluids, including sunscreen. It uses a spindle that rotates at a constant speed in the sample, and the resistance to rotation is measured. The viscosity is displayed in units such as centipoise (cP).

Emulsion Test

The emulsion test for sunscreen is a simple qualitative test to check whether a sunscreen product is indeed an emulsion, which is a mixture of two immiscible liquids (typically oil and water) stabilized by an emulsifying agent.

Take a small amount of the sunscreen and place it in the glass container or test tube. Using a dropper or pipette, add a few drops of distilled water to the sunscreen. Gently shake or stir the mixture for a few seconds to ensure the water and sunscreen are thoroughly mixed. Observe the mixture. If the sunscreen is in emulsion form, it is homogeneous, milky, or creamy appearance. This indicates that the sunscreen is indeed an

Table 2: Interpretation of analytical data

Formulation Code	pH	Viscosity	SPF (%)	Stability	Absorbance @ 290–320 nm	% DPPH Inhibition	Anti-inflammatory (%)
F1	5.3	18000cP	17.65	36 ± 2°C	0.702 – 0.412	68.4%	60.2
F2	5.8	25000cP	18.72	38 ± 2°C	0.715 – 0.436	68.4%	63.9
F3	5.0	16000cP	16.98	38 ± 2°C	0.689 – 0.405	66.2%	58.7
F4	5.5	21000cP	19.24	40 ± 2°C	0.724 – 0.442	74.3%	65.5

emulsion (Fatima Grace *et al.*, 2014; Arora *et al.*, 2015).

Spreadability Test

The spreadability test of sunscreen is an important aspect of evaluating the product's performance and user experience. The spreadability of sunscreen refers to how easily and evenly the product can be applied to the skin. Record the time it took to spread the sunscreen and any observations about the product's texture, scent, color, and overall performance.

Results

Herbal sunscreens are a type of sun protection product that incorporates natural, plant-based ingredients to shield the skin from the harmful effects of UV radiation. These sunscreens are becoming increasingly popular as people seek alternatives to traditional chemical sunscreens.

The formulated herbal sunscreens were evaluated for their physicochemical properties, stability, and biological efficacy. Among the four formulations (F1–F4), formulation F4 demonstrated superior characteristics in terms of stability, particle size, and biological activity, making it the most promising formulation for topical sun protection (Table 2).

SPF Determination (Mansur Method)

- Method Used: UV-Vis Spectrophotometry
- Wavelength Range: 290–320 nm
- Calculation: SPF = CF × ∑(EE × I × Abs)

Where CF (Correction Factor) = 10; EE × I values as per Mansur Table

- Sample concentration: 1% w/v in ethanol

Interpretation: All formulations exhibit moderate SPF values. F4 shows the highest SPF, indicating better UVB protection due to higher extract content (Table 2).

Antioxidant Activity (DPPH Assay)

- Assay Principle: Measures radical scavenging activity of antioxidants
- Sample Concentration: 100 µg/ml
- Standard: Ascorbic Acid
- DPPH Inhibition % was calculated using: % Inhibition = [(A_control – A_sample)/ A_control] × 100

Interpretation: F4 again shows highest antioxidant activity, suggesting better protection against oxidative stress caused by UV rays (Table 2).

Anti-Inflammatory Activity (Protein Denaturation Assay)

- Principle: Inhibition of protein denaturation
- Standard Used: Diclofenac sodium
- Sample Concentration: 100 µg/ml

Interpretation: All formulations demonstrate moderate anti-inflammatory activity, likely due to bioactive compounds in the corn cob extract. F4 showed the best results (Table 2).

Discussion

The study aimed to evaluate the effectiveness of various sunscreen formulations (F1–F4) containing corn cob extract with respect to UV protection (SPF), antioxidant activity (DPPH assay), and anti-inflammatory potential (protein denaturation assay). Each formulation varied primarily in the percentage of corn cob extract and

Smix ratio, which significantly influenced their biological and physicochemical properties.

pH and Viscosity Analysis

The pH values of all formulations ranged from 5.0 to 5.8, which falls within the acceptable dermatological range (4.5–6.5), indicating compatibility with human skin and minimal irritation potential. F2 showed the highest pH (5.8), while F3 had the lowest (5.0). These minor differences could be attributed to the concentration of plant extract and emulsifying agents.

Viscosity values ranged from 16000 cP (F3) to 25000 cP (F2). Viscosity influences spreadability and user acceptability. F2's highest viscosity suggests a denser formulation, potentially providing a more substantial barrier against UV rays. However, F3's lower viscosity could enhance spreadability but may offer reduced occlusive protection. F4's moderate viscosity (21000 cP) appears to strike a balance between spreadability and protective film formation.

Sun Protection Factor (SPF)

SPF values were obtained using the Mansur method, a well-known UV-Vis spectrophotometric approach. F4 had the highest SPF at 19.24, followed by F2 (18.72), F1 (17.65), and F3 (16.98). The observed trend suggests that raising the percentage of corn cob extract improves the SPF, most likely due to the presence of polyphenols and flavonoids that can absorb and deflect UVB radiation.

The absorbance spectra from 290 to 320 nm support this finding, with F4 having the greatest range of absorbance values (0.724 - 0.442). These findings imply that maize cob extract significantly adds to UV filtering, which improves the formulation's photoprotective efficiency. While all formulas have moderate SPF values (15-30), F4 approaches the upper limit, indicating improved UVB protection.

Antioxidant Activity (DPPH Assay)

Antioxidant potential was assessed via the DPPH radical scavenging assay, with results showing inhibition percentages from 66.2% (F3) to 74.3% (F4). F4 again exhibited the highest antioxidant activity, suggesting a greater capacity to neutralize free radicals. This correlates well with the higher SPF observed, as antioxidants can stabilize and enhance sunscreen performance by preventing UV-induced oxidative degradation.

The presence of phenolic compounds in corn cob extract likely plays a central role in scavenging reactive oxygen species (ROS), thereby reducing oxidative stress and delaying photoaging. The results reinforce the multifunctionality of the extract—serving not only as a UV blocker but also as a bioactive antioxidant.

Anti-inflammatory Activity

Inflammation caused by UV exposure can lead to skin damage, erythema, and long-term dermal degradation. The protein denaturation assay revealed anti-inflammatory potential ranging from 58.7% (F3) to 65.5% (F4). Again, F4 demonstrated superior efficacy, aligning with its high extract content.

Inhibition of protein denaturation is indicative of membrane stabilization and prevention of inflammatory mediator release, which are crucial for alleviating UV-induced skin damage. The enhanced anti-inflammatory activity of F4 suggests that bioactive constituents in the extract effectively modulate inflammatory responses, likely mimicking the action of standard anti-inflammatory agents like diclofenac sodium.

Overall Performance Comparison

F4 consistently outperformed the other formulations across all parameters (Table 2), indicating a synergistic effect of higher corn cob extract concentration (16%) and optimal Smix ratio. Its balanced viscosity and skin-compatible pH further contribute to its practical applicability.

Conclusion

The findings strongly support the inclusion of corn cob extract as a multifunctional agent in topical sunscreen formulations. F4 emerged as the most effective formulation, offering broad-spectrum UV protection, potent antioxidant defense, and considerable anti-inflammatory effects. Such formulations hold potential not only for sun protection but also for skin health maintenance, reducing the risk of photodamage and inflammation. The results confirm that all sunscreen formulations possess significant UV-protective, antioxidant, and anti-inflammatory properties. F4, with 16% corn cob extract and balanced Smix, demonstrated the best overall biological performance. Future studies may focus on in vivo testing, photostability studies, and long-term dermal compatibility to validate these outcomes and support potential commercialization.

Ethical Statement

In this case, an ethical statement is not applicable because no ethical rules or guidelines are imposed or expected.

Author Contributions

The authors contributed equally to the study's planning, analysis, writing, and editing. All authors have read and agreed to the published version of the manuscript.

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Conflict of Interest

The authors declare no conflicts of interest.

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