Indian Journal of Health Care, Medical & Pharmacy Practice Vol 5; Issue 1, Jan-Jun 2024, ISSN 2583-2069

Research Article

# HERBAL SUNSCREEN DEVELOPMENT: SPF, ANTIOXIDANTS, COMPARATIVE ANALYSIS

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**DOI:** https://doi.org/10.59551/IJHMP/25832069/2024.5.1.90



Received: 16 April, 2024, Decision for Acceptance: 14 May, 2024

## Abstract

*Introduction:* The effective sun protection amidst growing concerns about UV radiation's impact on skin health, the integration of ancient herbal wisdom with modern scientific advancements has gained prominence. This convergence has led to a renewed interest in herbal skincare formulations as alternatives to conventional sunscreens. Rooted in centuries-old medicinal practices, herbal remedies offer a promising avenue for shielding the skin from UV damage while nourishing it with botanical benefits.

*Objective:* This study aims to develop herbal sunscreen creams enriched with polyphenols from Lemon, Tomato, and Aloe vera, evaluate their SPF, assess antioxidant activity, and compare their efficacy with commercial formulations, offering insights into their potential as natural sun protection alternatives.

*Materials and Methods:* The study utilized Lemon (*Citrus limon*), Tomato (*Solanum lycopersicum*), and Aloe vera (*Aloe barbadensis*) extracts as primary ingredients. Extraction methods were employed to obtain bioactive compounds from each plant, followed by phytochemical screening to identify their chemical constituents. The sunscreen formulations were prepared by combining these extracts with excipients such as cetostearyl alcohol, stearic acid, and carbopol. Various physical parameters, SPF values, and antioxidant activity were evaluated to assess the formulations' efficacy and stability.

*Results:* Extraction yielded 0.98g, 1.85g, and 1.57g of extracts per 100g of raw material for Lemon, Tomato, and Aloe vera, respectively. Phytochemical screening revealed distinct profiles of bioactive compounds in each extract. Formulation development resulted in three sunscreen formulations, each containing different proportions of plant extracts and excipients. SPF determination showed that Formulation 3 exhibited the highest SPF value, indicating superior protection against UV radiation compared to the other formulations.

*Conclusion:* The research demonstrates the potential of herbal sunscreen formulations in providing effective sun protection while harnessing the antioxidant properties of botanical extracts. The formulations exhibited desirable physical characteristics and significant SPF values, highlighting their promise as natural alternatives to conventional sunscreens. Further refinement and optimization could enhance their efficacy and stability, positioning them as compelling options in skincare and sun protection.

**Keywords:** Herbal Sunscreen Formulation, Polyphenols, SPF Determination, Antioxidant Activity, Comparative Analysis

## 1. Introduction

In the ever-evolving landscape of skincare and wellness, the convergence of ancient herbal wisdom with modern scientific advancements has become a focal point in the quest for effective sun protection. Rooted in centuries of traditional medicine practices, herbal remedies have garnered renewed attention in contemporary healthcare, particularly in skincare formulations. This resurgence is driven by escalating concerns surrounding the detrimental impact of ultraviolet (UV) radiation on skin health, prompting a shift towards natural alternatives to conventional sunscreens[1].

Harnessing the therapeutic potential of medicinal plants, herbal skincare formulations offer a promising avenue for shielding the skin from the harmful effects of UV radiation. As the demand for natural solutions continues to rise, cosmetics, serving not only as tools for beautification but also as protective agents, play a pivotal role. With consumers increasingly gravitating towards herbal cosmetics, there is a burgeoning market for high-quality formulations that marry efficacy with botanical benefits.

The classification of cosmetics, ranging from skincare to haircare and beyond, underscores the diverse functions and compositions of these products. Within this spectrum, herbal ingredients are being extensively studied for their wound healing properties, aiming to develop safe and effective remedies with minimal toxicity[2].

Understanding the intricacies of sunlight, particularly UV radiation, is fundamental in devising comprehensive sun protection strategies. UV radiation, comprising UVA, UVB, and UVC rays, poses varying degrees of risk to skin health. While UVA rays contribute to premature aging and pigmentation, UVB rays are primarily responsible for sunburn and DNA damage, elevating the risk of skin cancer[3].

This research sets out to formulate an herbal sunscreen that not only rivals conventional counterparts in efficacy but also nurtures and nourishes the skin. By amalgamating the principles of herbal medicine, cosmetic science, and dermatology, it aims to bridge the gap between traditional wisdom and modern innovation in skincare. Through a meticulous exploration of botanical extracts, formulation techniques, and scientific insights, this endeavor seeks to pave the way for a new era of natural sun protection, rooted in the rich legacy of herbal medicine[4].

## 2. Research Objectives

1. Develop and evaluate an herbal sunscreen cream incorporating antioxidant-rich polyphenols from Lemon, Tomato, and Aloe vera.
2. Determine the Sun Protection Factor (SPF) of the formulated herbal sunscreen.
3. Assess the antioxidant activity of polyphenols in the herbal sunscreen formulation.
4. Compare the SPF of the herbal sunscreen with commercially available formulations to evaluate its competitiveness as a natural alternative.

## 3. Requirements

### 3.1 Plants

- Lemon - *Citrus limon*: Lemon, scientifically known as *Citrus limon*, is a versatile citrus fruit prized for its vibrant flavor and numerous health benefits. Widely cultivated for its acidic yellow fruits, lemon trees yield a rich source of vitamin C, essential for collagen production and skin health. Lemon peel and juice, valued for their antioxidant and antimicrobial properties, are commonly used in skincare formulations to promote a clear and radiant complexion.
- Tomato - *Solanum lycopersicum*: Tomatoes, botanically classified as *Solanum lycopersicum*, are edible berries renowned for their umami flavor and culinary versatility. Rich in vitamins C and K, potassium, and antioxidants like lycopene, tomatoes offer a myriad of health benefits. With natural antibacterial properties, tomatoes help regulate oil production, prevent acne breakouts, and promote a smoother, more balanced com-

plexion, making them a valuable ingredient in skincare formulations.

- Aloe Vera - *Aloe barbadensis miller*: Aloe vera, belonging to the genus Aloe, is a succulent plant species prized for its medicinal properties. Known for its soothing effects on the skin, aloe vera gel is commonly used in skincare products to relieve minor burns, sunburns, and skin irritations. Its hydrating and emollient properties make it a popular ingredient in moisturizers, lotions, and ointments, promoting skin hydration and regeneration.

### 3.2 Excipients

- Cetearyl Alcohol: Cetearyl alcohol, a blend of fatty alcohols primarily composed of cetyl and stearyl alcohols, serves as a versatile emulsion stabilizer and texture enhancer in cosmetic formulations. With its emollient properties, cetearyl alcohol helps impart a smooth and creamy texture to skincare products, making them feel luxurious and moisturizing on the skin.
- Stearic Acid: Stearic acid, a saturated fatty acid commonly found in nature, acts as a thickening agent and emulsifier in cosmetic formulations. With its waxy texture, stearic acid helps stabilize emulsions and improve the consistency of creams and lotions, providing a rich and velvety feel to skincare products.
- Cetyl Alcohol: Cetyl alcohol, derived from natural sources such as coconut oil or palm oil, serves as an emollient and emulsifying agent in skincare formulations. Its waxy texture helps trap moisture in the skin, making it feel soft and supple. Cetyl alcohol also enhances the spreadability of creams and lotions, ensuring easy application and absorption into the skin.
- Methylparaben: Methylparaben is a commonly used preservative in cosmetic formulations, including skincare products. With its antimicrobial properties, methylparaben helps prevent microbial growth and contamination, ensuring the safety and stability of skincare formulations over time.
- Propylparaben: Propylparaben, another type of paraben preservative, is often used in conjunction with methylparaben to provide broad-spectrum antimicrobial protection in cosmetic formulations. Like methylparaben, propylparaben helps extend the shelf life of skincare products by inhibiting the growth of bacteria, yeast, and mold.

## 4. Material and Methods

### 4.1 Extraction

The extraction process aimed to obtain bioactive compounds from Lemon (*Citrus limon*), Tomato (*Solanum lycopersicum*), and Aloe vera (*Aloe barbadensis*). Lemon peels were cold-pressed to extract essential oils and bioactive compounds while preserving their delicate constituents. Solvent extraction, using non-polar solvents like hexane or ethyl acetate, was employed for Tomato to extract lipophilic compounds such as lycopene and carotenoids. Aloe vera gel was obtained through cold maceration to maintain the integrity of sensitive components like polysaccharides and enzymes. Additionally, phytochemical tests were conducted to identify alkaloids, flavonoids, tannins, saponins, glycosides, phenols, and terpenoids in the extracts, providing insights into their chemical composition and potential pharmacological properties[5].

### 4.2 Sunscreen Formulation and Excipients

The formulation process involved preparing cream bases through emulsification, combining lipophilic substances with hydrophilic ingredients. Extracts of Lemon, Tomato, and Aloe vera were incorporated into the formulation, along with excipients like cetostearyl alcohol, stearic acid, and carbopol. Excipients such as propylene glycol, methylparaben, and cetyl alcohol were used to control the physicochemical properties of the formulation[6,7].

### 4.3 Evaluation of Formulation

Physical parameters such as appearance, color, and homogeneity were assessed to ensure product

quality. Spreadability and extrudability, crucial for user experience, were measured using standardized methods. Viscosity, pH, and thermal stability were determined to evaluate the formulation's consistency, skin compatibility, and shelf life, respectively. Sun Protection Factor (SPF) was calculated using a UV-visible spectrophotometer and Mansur mathematical equation, providing a quantitative measure of the product's efficacy in blocking UV radiation. Antioxidant activity was evaluated using the DPPH method to assess the formulation's potential additional benefits beyond UV protection. In-vitro occlusion studies and stability testing were conducted to understand the formulation's performance under various conditions and its shelf life for practical application[8,9].

## 5. Results and Discussion

### 5.1 Extraction

The study aimed to develop and assess sunscreen cream formulations from Lemon, Tomato, and Aloe vera extracts. Extraction yielded 0.98g, 1.85g, and 1.57g per 100g of raw material, respectively (Table 5.1)[5]. These variations suggest differences in photoprotective compound concentrations.

**Table 5.1: Extraction yield (100 gram raw material)**

| S. No. | Crude drug | Yield Obtained (Grams) |
|---|---|---|
| 1. | Lemon (*Citrus limon*), | 0.98 |
| 2. | Tomato (*Solanum Lycopersicon*) | 1.85 |
| 3. | Aloe-vera (*Aloe barbadensis*) | 1.57 |

### 5.2 Phytochemical Screening

Phytochemical screening of Lemon, Tomato, and Aloe vera extracts revealed distinct profiles. Lemon showed glycosides, flavonoids, alkaloids, and tannins. Tomato had glycosides, steroids, flavonoids, phlobatannins, tannins, and phenols. Aloe vera contained steroids, flavonoids, and tannins. Absent were cardiac glycosides in Lemon and Aloe vera, and alkaloids in Aloe vera.

**Table 5.2: Phytochemical Screening Lemon, Tomato, and Aloe vera**

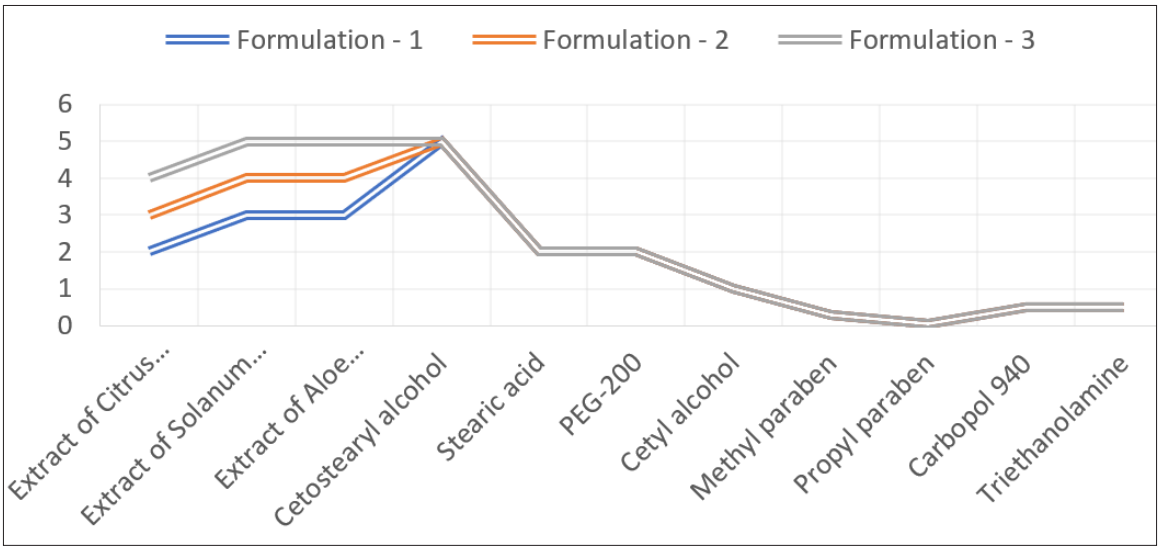
| Phytochemical | Lemon (*Citrus limon*) | Tomato (Solanum Lycopersicon) | Aloe vera (*Aloe barbadensis*) |
|---|---|---|---|
| Saponins | Absent | Absent | Present |
| Glycosides | Present | Present | Absent |
| Steroids | Absent | Present | Present |
| Flavonoids | Present | Present | Present |
| Alkaloids | Present | Absent | Absent |
| Tannins | Present | Present | Present |
| Phlobatannins | Absent | Present | Absent |
| Phenols | Absent | Present | Absent |
| Cardiac glycosides | Absent | Absent | Absent |

### 5.3 Formulation Development

A tailored sunscreen formulation was crafted by meticulously adjusting ingredient quantities, drawing insights from comprehensive literature review. The resulting formula, informed by diverse research findings, aimed to optimize UV protection and overall efficacy in skincare[8,9]. Following formula table 5.3 was developed and employed:

**Table 5.3: Contents of sunscreen**

| Ingredients | Formulation 1 | Formulation 2 | Formulation 3 | Role of Ingredients in formulation |
|---|---|---|---|---|
| Extract of *Citrus limon* | 2 | 3 | 4 | UV protection |
| Extract of *Solanum Lycopersicon* | 3 | 4 | 5 | UV protection |
| Extract of *Aloe barbadensis* | 3 | 4 | 5 | UV protection |
| Cetostearyl alcohol | 5 | 5 | 5 | Emulsion stabilizer/ surfactant |
| Stearic acid | 2 | 2 | 2 | Thickener |
| PEG-200 | 2 | 2 | 2 | Emollients |
| Cetyl alcohol | 1 | 1 | 1 | Thickening agent |
| Methyl paraben | 0.3 | 0.3 | 0.3 | Preservative |
| Propyl paraben | 0.06 | 0.06 | 0.06 | Preservative |
| Carbopol 940 | 0.5 | 0.5 | 0.5 | To provide high viscosity to formulation |
| Triethanolamine | 0.5 | 0.5 | 0.5 | Chelating agent |
| Disodium EDTA | q.s. | q.s. | q.s. | Reduce the acidity or alkalinity of the formulation |




**Graph 5.1: Ingredient Quantity Ratio**

The graph illustrates the varying quantities of ingredients across three different sunscreen formulations, providing a visual comparison of their compositions. Each ingredient's proportion is clearly depicted, aiding in understanding the formulation's balance and emphasis on specific components.

The compiled table 5.4 combines various characteristics of three different sunscreen formulations. It includes attributes such as extrudability, spreadability, irritation study results, thermal stability, occlusion factor stability, color, odor, appearance, consistency, and pH values for each formulation. These details offer a comprehensive overview of the properties and performance of each sunscreen variant, aiding in comparative analysis and formulation optimization.

**Table 5.4: Characteristics of three different sunscreen formulations**

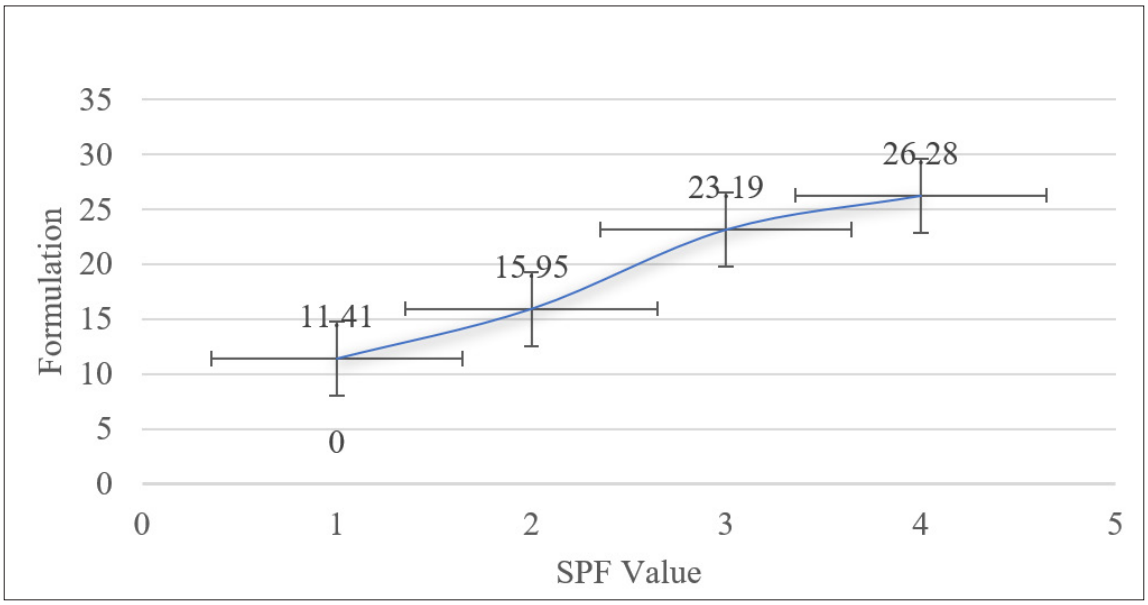
| S. No. | Characteristics | Formulation 1 | Formulation 2 | Formulation 3 |
|---|---|---|---|---|
| 1 | Extrudability | Good | Good | Excellent |
| 2 | Spreadability (gm. cm/seconds) | 12 | 15 | 16 |
| 3 | Irritation Study | Non-irritant | Non-irritant | Non-irritant |
| 4 | Thermal Stability | Unstable | Unstable | Stable |
| 5 | Occlusion factor Stability | 78 | 81 | 87 |
| 6 | Colour | Greenish Creamy | Greenish Creamy | Greenish Creamy |
| 7 | Odour | Characteristic | Characteristic | Characteristic |
| 8 | Appearance | Cream like | Cream like | Cream like |
| 9 | Consistency | Smooth | Smooth | Smooth |
| 10 | pH | 6.4 | 6.98 | 6 |
| 11 | Spreadability | 12 | 12.5 | 19.5 |

**Table 5.5: Characteristics of three different sunscreen formulations**

| Wavelength (λ nm) | EE (λ) x I (λ) | F 1 | F 1 | F 2 | F 2 | F 3 | F 3 | Standard | Standard |
|---|---|---|---|---|---|---|---|---|---|
| | | Abs. (λ) | EE (λ) x I (λ) x Abs. (λ) | Abs. (λ) | EE (λ) x I (λ) x Abs. (λ) | Abs. (λ) | EE (λ) x I (λ) x Abs. (λ) | Abs. (λ) | EE (λ) x I (λ) x Abs. (λ) |
| **290** | **0.015** | 1.024 | 0.01536 | 1.126 | 0.01689 | 1.976 | 0.02964 | 1.993 | 0.029895 |
| **295** | **0.0817** | 1.041 | 0.0850497 | 1.159 | 0.09469 | 2.312 | 0.18889 | 2.675 | 0.2185475 |
| **300** | **0.2874** | 1.138 | 0.3270612 | 1.16 | 0.33338 | 2.617 | 0.75213 | 3.145 | 0.903873 |
| **305** | **0.3278** | 1.1406 | 0.37388868 | 1.84 | 0.60315 | 2.41 | 0.79 | 2.791 | 0.9148898 |
| **310** | **0.1864** | 1.162 | 0.2165968 | 2.15 | 0.40076 | 2.014 | 0.37541 | 1.95 | 0.36348 |
| **315** | **0.0839** | 1.218 | 0.1021902 | 1.38 | 0.11578 | 1.81 | 0.15186 | 1.96 | 0.164444 |
| **320** | **0.018** | 1.21 | 0.02178 | 1.7 | 0.0306 | 1.75 | 0.0315 | 1.82 | 0.03276 |
| **Total** | **1** | | 1.14192658 | | 1.59526 | | 2.31942 | | 2.6278893 |
| **Multiplication with correction factor (10)** | **10** | | **11.4192658** | | **15.9526** | | **23.1942** | | **26.278893** |

The following table 5.5 provides a detailed comparison of Sun Protection Factor (SPF) values calculated for three different sunscreen formulations and a standard formulation across various UV wavelengths. By multiplying erythemal effectiveness and UV intensity with absorption coefficients, SPF values are derived, indicating the level of protection offered by each formulation against UV radiation. The results demonstrate that Formulation 3 exhibits the highest SPF value, suggesting superior protection against sunburn and skin damage compared to the other formulations.

The graph illustrates the SPF determination process for the formulated sunscreen products. By plotting the SPF values against the different formulations, it provides a visual representation of their efficacy in protecting against UV radiation. The data points on the graph allow for easy comparison of SPF levels, aiding in the assessment of each formulation's sun protection capabilities.




**Graph 5.2: SPF Value comparison Chart**

## 6. Conclusion

The extensive evaluation of the formulated herbal sunscreen compositions unveiled promising attributes across various parameters, including viscosity, pH levels, extrudability, spreadability, and sun protection efficacy. These formulations exhibited desirable characteristics such as pseudoplastic behavior, maintaining suitable pH for skin barrier integrity, good extrudability and spreadability, and significant sun protection indicated by SPF values. Moreover, they demonstrated stability under stress conditions, with select formulations showing superior resilience. Overall, the findings underscore the potential of these herbal sunscreens to offer effective sun protection with skin compatibility and stability [10]. Further research and refinement could enhance these formulations, potentially positioning them as compelling alternatives in skincare and sun protection.

## Conflict of Interest: None

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Cite this article Swami P et al, Herbal Sunscreen Development: Spf, Antioxidants, Comparative Analysis. Indian Journal of Health Care, Medical & Pharmacy Practice.2024; 5(1) 64-71.