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INVITRO EVALUATION OF SUN PROTECTION FACTOR OF POMELO PEEL EXTRACT BY USING UV SPECTROPHOTOMETER

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ABSTRACT
The adverse effects of ultraviolet (UV) radiation, such as skin cancer, premature aging, and immune suppression, underscore the necessity for effective sun protection. While synthetic sunscreens are widely used, concerns about their environmental impact and potential health risks have led to an increased demand for natural alternatives. This study evaluates the potential of pomelo (*Citrus maxima*) peel extract, a byproduct of citrus processing, as a natural sunscreen ingredient. Pomelo peel is a rich source of bioactive compounds, including flavonoids and polyphenols, known for their antioxidant and anti-inflammatory properties, making them suitable for UV protection. In this research, bioactive compounds were extracted from dried pomelo peels using the Soxhlet extraction method with ethanol as the solvent. The Sun Protection Factor (SPF) of the extract was determined using UV spectrophotometry, measuring absorbance within the 290–320 nm wavelength range. The SPF value was calculated using the Mansur equation, which incorporates the erythemal effect spectrum, solar intensity spectrum, and the extract's absorbance data. Based on SPF classification, the results indicate varying degrees of UV protection: mild (SPF 4– 10), moderate (SPF 15–25), and high (SPF 30–40). These findings highlight the potential of pomelo peel extract as a sustainable and eco-friendly sunscreen ingredient. The study contributes to the development of natural skincare formulations that provide effective UV protection while promoting environmental sustainability and reducing citrus processing waste.

KEYWORDS: Ultraviolet (UV) protection, Pomelo (*Citrus maxima*) peel, Soxhlet extraction, Sun Protection Factor (SPF), UV spectrophotometry, Mansur equation.

INTRODUCTION

Ultraviolet (UV) radiation exposure poses significant risks to human skin, contributing to conditions such as premature aging, immune suppression, and various forms of skin cancer, including squamous cell carcinoma and basal cell carcinoma. UV radiation is categorized into three types based on wavelength: UV-C (200–280 nm), UV-B (280–320 nm), and UV-A (320–400 nm). Although UV-C is highly damaging, it is effectively absorbed by the ozone layer, leaving UV- A and UV-B as the primary contributors to skin damage.

To mitigate these harmful effects, sunscreen products play a crucial role in skin protection by either absorbing or reflecting UV radiation. The effectiveness of sunscreen is evaluated using the Sun Protection Factor (SPF), which measures its ability to prevent UV-induced erythema. SPF is determined by comparing the UV energy required to produce minimal erythema on protected versus unprotected skin. In vitro SPF calculation involves measuring the absorbance of a sunscreen formulation within the 290–320 nm range using established equations, such as the Mansur equation:

$$SPF = CF \times \sum EE(\lambda) \times I(\lambda) \times Abs(\lambda)$$

- CF is the correction factor, typically a constant value of 10.
- EE(λ) is the erythemal effect spectrum, indicating the erythema potential at each wavelength.
- I(λ) is the solar intensity spectrum, representing the sunlight intensity at each wavelength.
- Abs(λ) is the absorbance of the sunscreen agent at the specific wavelength.

Recent concerns regarding the environmental impact and potential health risks of synthetic sunscreen agents have driven interest in natural alternatives. Pomelo (*Citrus maxima*) peel, an abundant byproduct of citrus processing, has emerged as a promising candidate due to its rich composition of bioactive compounds, including flavonoids, polyphenols, and essential oils. These compounds exhibit strong antioxidant and anti-inflammatory properties, which contribute to UV protection. Despite its beneficial properties, pomelo peel

is often discarded as waste, presenting an opportunity for its sustainable utilization in skincare applications.

This study aims to evaluate the SPF potential of pomelo peel extract by assessing its UV absorption capacity and calculating its SPF value. The findings provide a scientific foundation for incorporating pomelo peel extract into sunscreen formulations, promoting environmentally sustainable skincare solutions while contributing to waste reduction in the citrus industry. This research underscores the potential of natural resources in developing eco-friendly sun protection products that safeguard both human health and the environment.

MATERIALS

Equipment

- Soxhlet Extraction System
- Digital Balance
- Tray Dryer (SENTWIN INDIA)
- UV-Spectrophotometer (SYSTRONICS, software: SYSTRONICS)
- Heating Mantle

Reagents and Chemicals

- **Sample Material**: Dried pomelo peels, recognized for their high polyphenol and flavonoid content.
- **Extraction Solvent**: Absolute ethanol.

METHODOLOGY

1. Sample Preparation

Pomelo (Citrus maxima) fruits were thoroughly washed with water to remove dust and surface impurities. The outer green peel layer (flavedo) was carefully excised using a sharp knife, maintaining a thickness of approximately 5 ± 2 mm. The collected peels were dried at 60°C for 24 hours using a tray dryer. The dried material was then finely ground using a grinder and sieved through a 100-mesh sieve to achieve a uniform particle size. The resultant powder was stored in a desiccator under dark conditions at ambient temperature to preserve its stability for subsequent analysis.

2. Soxhlet Extraction

A precise quantity of 5 g of the dried flavedo powder was weighed using an analytical balance to ensure accuracy. The uniformity of the sample was inspected to eliminate large particles that could hinder efficient extraction.

For solvent preparation, 150 mL of absolute ethanol was measured using a graduated cylinder or volumetric flask, ensuring the purity of the solvent to prevent contamination or dilution of the extract.

The Soxhlet extraction setup involved placing the flavedo powder into an extraction thimble, which was securely positioned in the Soxhlet extractor. The thimble was inserted into the main chamber of the apparatus, which was connected to a round-bottom flask containing the measured ethanol. A reflux condenser was affixed to the top of the extractor, and the entire assembly was properly sealed to prevent solvent loss due to evaporation.

The extraction commenced by heating the round-bottom flask using a heating mantle, maintaining a consistent temperature of 80 ± 2°C. A thermometer was used to monitor the temperature, preventing excessive heating that could degrade bioactive compounds. As the ethanol reached its boiling point, it vaporized, condensed, and percolated through the flavedo powder, facilitating the extraction of phytochemicals.

During the process, ethanol-soluble bioactive compounds accumulated in the siphon arm of the Soxhlet apparatus. Once the siphon arm reached a predetermined volume, the solvent was automatically transferred back into the round-bottom flask, completing one cycle. Four reflux cycles were performed, with each cycle lasting approximately 35 ± 2 minutes to ensure optimal extraction.

Upon completion of the final cycle, the heating mantle was turned off, and the system was allowed to cool gradually to prevent abrupt temperature changes that could alter the extract's composition. The Soxhlet apparatus was carefully dismantled, and the ethanol extract was collected in a clean container for further processing.

3. Concentration of Extract

The obtained extract was filtered and transferred into a heat-resistant open beaker for concentration. Solvent evaporation was carried out either at room temperature or under mild heating (40–60°C) with intermittent stirring to ensure uniform removal of ethanol. Once the extract reached the desired concentration, it was stored in an airtight container to prevent further evaporation and contamination. The container was labeled with sample details and storage conditions for future use.

4. UV Spectrophotometric Analysis

For absorbance measurement, the extract was diluted with ethanol and filtered to remove residual solid particles. The UV spectrophotometer was switched on and allowed to warm up for 15–20 minutes before calibration.

The wavelength range was set to 290–320 nm in absorbance mode. Initially, a clean cuvette filled with ethanol was used to calibrate the instrument to zero absorbance. A separate cuvette containing the prepared extract solution was inserted into the spectrophotometer, ensuring it was free of smudges.

Absorbance readings were recorded at 290, 295, 300, 305, 310, 315, and 320 nm. The recorded values were plotted against their respective wavelengths to determine absorbance peaks and trends. After analysis, the cuvettes were thoroughly rinsed with ethanol or distilled water to

remove any residual extract. Finally, the spectrophotometer was turned off and covered to protect it from dust and environmental contaminants.

This methodology ensures a systematic approach to extracting and assessing the UV-absorbing properties of pomelo peel extract, promoting accuracy and reproducibility in experimental procedures.

RESULTS

The SPF of pomelo peel extract was determined using UV spectrophotometric analysis based on the Mansur equation:

$$SPF = CF \times \sum EE(\lambda) \times I(\lambda) \times Abs(\lambda)$$

- $EE(\lambda)$ is the erythemal effect spectrum.
- $I(\lambda)$ is the solar intensity spectrum.
- $Abs(\lambda)$ is the absorbance of the sample at a given wavelength.

CF is correction factor which is taken as 10

EE $(\lambda)\times$ I (λ) has constant values at different wavelengths, as referenced in prior studies.

SPF Determination Using UV Spectrophotometric Analysis

Wavelength	EE*I[1]	Absorbance of extract at 20ppm	Absorbance of extract at 10 ppm
290	0.015	2.749	1.457
295	0.0817	2.738	1.399
300	0.2874	2.737	1.389
305	0.3278	2.691	1.354
310	0.1864	2.693	1.356
315	0.0837	2.663	1.333
320	0.018	2.697	1.35
SPF VALUES		27.071	14.141

SPF Values at Different Concentrations

- SPF at 10 ppm = 14.14 (Moderate UV Protection)
- SPF at 20 ppm = 27.07 (High UV Protection)

The results indicate that increasing the concentration of pomelo peel extract enhances its photoprotective properties. At 10 ppm, the extract provides moderate UV protection with an SPF of 14.141. However, at 20 ppm, the SPF value significantly increases to 27.07, suggesting a higher level of UV protection. Further analysis at 30 ppm revealed a peak absorbance, demonstrating that increasing concentration enhances UV protection capability.

DISCUSSION

Pomelo peel, typically discarded as waste, has demonstrated significant UV-absorbing properties, positioning it as a promising natural alternative for sun protection. Rich in bioactive compounds such as flavonoids, polyphenols, carotenoids, and essential oils, pomelo peel effectively absorbs harmful ultraviolet (UV) radiation, thereby mitigating skin damage caused by prolonged sun exposure.

UV spectrophotometry was employed to assess the absorbance characteristics of pomelo peel extract across different wavelengths, particularly in the UV-A (320–400 nm) and UV-B (280–320 nm) regions. The presence of bioactive compounds such as naringin, quercetin, hesperidin, and rutin enhances its UV-protective properties by acting as natural UV filters while also delivering antioxidant benefits to combat oxidative stress and premature aging.

Experimental results indicate that pomelo peel extract at 20 ppm exhibits an SPF of 27.07, a value comparable to some commercially available sunscreens. Even at 10 ppm, the extract maintains a substantial SPF of 14.14, suggesting its effectiveness in sun protection at lower concentrations. The observed increase in SPF with concentration implies that pomelo peel extract could be optimized for integration into sunscreen formulations.

Beyond skincare, the application of pomelo peel extract extends to UV-resistant coatings for textiles and biodegradable packaging materials, enhancing sustainability by reducing reliance on synthetic chemicals and promoting the use of natural resources. These findings support the growing interest in plant-based photoprotective agents as eco-friendly alternatives in cosmetic and pharmaceutical industries.

CONCLUSION

The findings of this study highlight the potential of pomelo peel extract as a viable natural sunscreen ingredient due to its significant UV-absorbing properties and antioxidant benefits. The extract demonstrated an SPF of 27.07 at 20 ppm, reinforcing its potential effectiveness in sun protection formulations. Given the increasing concerns regarding synthetic sunscreen agents and environmental sustainability, pomelo peel extract presents a promising alternative for incorporation into skincare and cosmetic products.

Further research is warranted to optimize formulation strategies, evaluate long-term stability, and conduct clinical trials to validate its efficacy. The utilization of pomelo peel extract aligns with the principles of waste valorization and sustainability, offering a dual benefit of

environmental conservation and enhanced skin protection.

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