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A Holistic Analysis of Sun Protection Factor and Its Relevance in Sunscreen Efficiency

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Abstract
The sun protection factor (SPF) plays a pivotal role in determining the efficacy of sunscreen products in shielding the skin from the harmful effects of ultraviolet (UV) radiation. This comprehensive review delves into the multifaceted aspects of SPF, from its historical origins to its modern-day implications. The objective is to provide a holistic understanding of SPF, encompassing its definition, extraction methods, SPF formula, factors influencing its effectiveness, and examples of some plant materials used for the determination of the SPF factor. *Azadirachta indica* (Indian lilac) (SPF), *Ocimum sanctum* (holy basil), *Centella asiatica* (Asian pennywort), and *Hibiscus rosa sinensis* (shoeblack plant) are a few examples of plants from which leaf extracts were extracted and studied.

Keywords: UV Radiation, SPF, Holistic, Extract

Introduction

In an era marked by increasing environmental awareness and a growing concern for skin health, the role of effective sun protection has gained unparalleled significance. The sun's ultraviolet (UV) radiation, while essential for life on Earth, poses a substantial threat to human skin. Long-term exposure to UV rays can cause various side effects, including sunburn, premature aging, and an increased risk of skin cancer. As a result, the need for reliable and measurable methods to protect the skin against these risks has become very important [1-3]. Since ancient times, humans have used various types of natural substances to protect the skin from harmful substances in the external environment. Apart from other harmful substances, ultraviolet radiation is the most important substance that disrupts the function and appearance of the skin. The radiation emitted by the sun consists of different wavelengths of UVC (280–100 nm), UVB (290–320 nm), and UVA (320–400 nm) [5-7]. UVC is the most biologically harmful radiation, but it is filtered and absorbed by the ozone layer. Sunlight, despite being a source of life and energy, causes serious health problems such as sunburn, pigmentation, wrinkles, dermatitis, hives, aging, suppression of the immune system, and increased skin cancer. Sun-protective clothing and sunglasses are not enough to eliminate all these health risks and are not very comfortable. Therefore, sunscreen is a common practice in different parts of the world [8-10].

Table 1: Pro's and Con's of SPF

Pro's	***Con's***
UV Protection: *SPF indicates a sunscreen's ability to shield the skin from harmful ultraviolet (UV) radiation, reducing the risk of sunburn and skin damage.*	***UVB Emphasis:*** *SPF primarily measures UVB protection, leaving out UVA rays that can contribute to skin damage, aging, and long-term skin issues.*
Comparative Rating: *SPF values help consumers compare the relative effectiveness of different sunscreen products. A higher SPF indicates stronger UVB protection.*	***Misinterpreted Safety:*** *High SPF values can give a false sense of invulnerability, leading to inadequate reapplication and prolonged sun exposure.*
Guidance for Duration: *SPF suggests how much longer a person can stay in the sun without burning compared to unprotected skin. It provides a guideline for safe sun exposure.*	***Decreasing Returns****: SPF increases don't offer linearly proportional protection. For instance, SPF 30 doesn't provide twice the protection of SPF 15.*
Skin Health: *Proper SPF use can prevent sunburn, skin damage, and the associated risk of skin cancer, promoting healthier skin over time.*	***Limited Duration:*** *Regardless of SPF, sunscreen must be reapplied frequently to maintain its effectiveness, especially after swimming or sweating.*
Reduced Aging: *Effective SPF application helps prevent premature aging caused by UV exposure, including wrinkles, fine lines, and age spots.*	***Neglecting holistic protection:*** *Relying solely on high SPF might lead to neglecting other protective measures like shade, clothing, and avoiding peak sun hours.*

Extraction Methods Used:

Extraction methods are used to extract compounds from plant materials. These methods are relevant when isolating natural compounds, such as those with potential sun-protective properties, from plant sources. Some common extraction methods used are:

- ***Solvent Extraction***: This method involves soaking the plant material in a solvent (such as ethanol, methanol, or hexane) to dissolve the target compounds. The solvent is then evaporated to leave behind the extracted compounds [11-13].
- ***Steam Distillation***: Particularly suitable for extracting essential oils from aromatic plants, steam distillation uses steam to carry volatile compounds from the plant material. The steam is then condensed to separate the essential oil from the water.
- ***Cold Press Extraction***: This method is used for extracting oils from citrus fruits and involves mechanically pressing the rind to release the essential oil.
- ***Supercritical Fluid Extraction***: A high-pressure and high-temperature process using supercritical fluids (such as carbon dioxide) to extract compounds It's often used for delicate compounds as it avoids the use of high temperatures.
- ***Maceration:*** Plant material is soaked in a solvent for an extended period, allowing the solvent to slowly extract compounds. This is suitable for extracting delicate compounds that might be damaged by more aggressive methods.
- ***Soxhlet Extraction***: This is a continuous extraction method where the solvent is repeatedly cycled through the plant material using a setup called a Soxhlet extractor. This is often used for compounds that are less soluble in the solvent [14-15].
- ***Ultrasound-Assisted Extraction***: Ultrasonic waves are used to break down cell walls and enhance the extraction process by improving contact between the solvent and plant material.
- ***Microwave-Assisted Extraction:*** Similar to ultrasound-assisted extraction, microwaves are used to heat the solvent and accelerate the extraction process.

The choice of extraction method depends on the nature of the compound being extracted, the plant material, and the desired properties of the extracted substance. Each method has its advantages and limitations in terms of efficiency, selectivity, and potential impact on the integrity of the extracted compounds [16-18].

Determination of the sun protective factor (SPF)

a.) ***Determination of SPF***: Trying to categorize a sunscreen product based on its UVB protection factor alone has failed to provide adequate protection. In addition to this, other factors, such as the type of sunscreen and how it interacts with the environment, have also contributed to its effectiveness. The relative differences between the active constituents of different sunscreen products make their classification very important in scientific studies. This is because their water resistance and absorption spectra are different. In any case, there are numerous variables influencing the assurance of sun calculated measurements, as for illustration, the utilization of distinguishing chemical solvents whereby the sunscreens are broken up, the ratio and concentration of various sunscreens, the type of emulsion, the impacts and cognitive ability of the vehicle components employed within the detailing, the relationship of the vehicle with the human skin, the expansion of other dynamic fixings, the pH framework, and the emulsion's rheological characteristics, among other factors, which can increment or diminish the ultraviolet (UV) retention of any given sunscreen. The presence of sunscreen specialists in commercial items is critical for quality control purposes and for checking their conformance to the existing enactment. In addition, in order to guarantee satisfactory photoprotective activity during utilization, the stability of the sunscreen within the wrapped item has to be determined [19-21].

b.) ***In vitro UVB methodology***: Administrative organizations such as the FDA and COLIPA conduct *in vivo* testing on human subjects, utilizing an erythemal endpoint to determine the SPF of a topical sunscreen. These are expensive and time-consuming tests that are not down to earth for schedule item assessment. That being said, there are still numerous questions around both the logical precision and reproducibility of *in vivo* estimations. It isn't measurably substantial to test, as it were, an awfully small number of volunteers, and it is possibly perilous to subjects. So, both moral and legitimate contemplations point to the more extensive acknowledgment over time of *in vitro* estimation strategies. The high changeability of *in vitro* comes about because it proposes that fundamental considerations ought to be centered on substrate determination, reenacting the human skin surface, and homogenous item application [22-24].

The substrate plate is the fabric to which the sun care item is connected. It must be UV-straightforward, non-fluorescent (i.e., no perceptible fluorescence when uncovered beneath UVR and measured with the spectrophotometer), photostable, and dormant towards all fixings of the arrangements to be tried. It must also have optical and physical-chemical properties similar to those of the skin. Therefore, the sunscreen's in-vitro test is centered on figures of absorbance (estimated from transmittance) or deliberately reflectance through a thin layer of sunscreen applied to a rough surface, sometime recently, and following exposure to carefully controlled measurements of UV radiation from a known source [25-26].

Commonly utilized substrates are roughened polymethylmethacrylate (PMMA) plates, Transpore, Vitro-Skin, roughened quartz plates, and Teflon (PTFE). The weakened UVB concentration, utilizing diverse UV light sources, is recognized radiometrically and changed to genuine SPF esteem by means of a calibration bend based on diffuse spectroscopy transmission or estimations of UV transmission through a lean film item connected on different UV-transparent substrates, which is based on a broad number of estimations performed [27-29]. The spectral transmittance of a sunscreen in the UV spectral spectrum may be used to estimate an *in vitro* SPF value based on conventional erythematic and solar data. The *in vitro* SPF is computed as follows:

$$SPF_{Spectrophotometer} = CF \times \sum EE(\lambda) \times I(\lambda) \times Abs(\lambda)$$

c.) ***In vivo*** **UVB methodology*:*** *In vivo* testing includes applying sunscreen to a bunch of volunteers and exposing their skin to controlled amounts of UV radiation. The

objective is to determine the degree of UV exposure required to cause negligible redness (erythema) with and without the sunscreen. Here's how the method works:

- **Volunteer Determination**:

A diverse bunch of volunteers with distinctive skin types is chosen. Their skin's sensitivity to UV radiation is determined.

- **Test Zone Arrangement:**

Little test zones on the volunteers' skin are stamped, ordinarily on the back, where sunscreen application will happen.

- **Sunscreen Application:**

Diverse sunscreen items with shifting SPF values are connected to the test regions. A standard thickness of sunscreen application is maintained.

- **UV Introduction**:

The test zones are exposed to controlled UV radiation from a sun-based test system. This radiation imitates the UV range of daylight.

- **Erythema Estimation:**

After the UV introduction, the skin is watched for redness. The negligible erythema measurement (MED) is recorded for each test zone with and without sunscreen.

- **SPF Calculation:**

The SPF value is calculated by isolating the MED for secured skin from the MED for unprotected skin. For example, if it takes 300 seconds for the skin with sunscreen to show negligible redness and 10 seconds for skin exposed to sunlight, the SPF is calculated as 300/10 = 30.

$$SPF = \frac{\text{minimal erythema dose in sunscreen-protected skin}}{\text{minimal erythema dose in non-sunscreen-protected skin}}$$

Spectrophotometric determination of sunscreen efficacy of selected plant agents

Azadirachta indica (Indian lilac), *Ocimum sanctum* (holy basil), *Centella asiatica* (Asian pennywort), and *Hibiscus rosa sinensis* (shoeblack plant) leaves All harvested plant material was rinsed with tap water and dried in under the shade for 7 days.

The dried plant matter was pulverized with an electric mill and passed through a No. 40 sieve to obtain a fine powder. A fine powder was used for extraction using an appropriate solvent.

- **Extraction of Plant Material**

Hydroalcoholic extract of the plant matter prepared by the soaking method. 70 g of every plant matter was extracted with 80% ethanol; the extract was subsequently filtrated with Whatman filter paper, the resultant filtrate was obtained. The filtrate is concentrated under reduced pressure and at 40 °C employing a rotary evaporator. The purified extract was subsequently placed in desiccators to eliminate the remaining solvent. The yield % of every single extract was computed [12].

- **Sample Preparation**

Stock solutions were prepared by dissolving 10 mg of each plant extract in 100 mL of ethanol to a concentration of 100 g/mL and filtering through Whatman filter paper to obtain a clear solution. Three dilutions of 40 g/mL, 50 g/mL, and 60 g/mL were prepared from the stock solution. All samples were examined in succession from 200 nm to 400 nm using a UV-Vis spectrophotometer. Baseline correction was performed using the solvent used for plant material extraction. Next, with an 80% ethanol solution as a blank, the absorbance of the sample was measured using a 1 cm quartz cell. Absorption of leaf extracts of *Azadirachta indica* (Indian lilac), *Ocimum sanctum* (holy basil), *Centella asiatica* (Asian pennywort), and *Hibiscus rosa sinensis* (shoeblack plant) was calculated.

- ***In vitro* SPF determination**

The sunscreen effectiveness of several plant extracts was tested using a quick and reliable *in vitro* approach. Final concentrations of 40 g/ml, 50 g/ml, and 60 g/ml of every plant extract were prepared from the initial stock solution, and every extract was scanned three times at five intervals at wavelengths 290-320.

These values were computed as an average, and the absorbance value was expressed as EE as the absorbance for a given concentration of each extract [13].

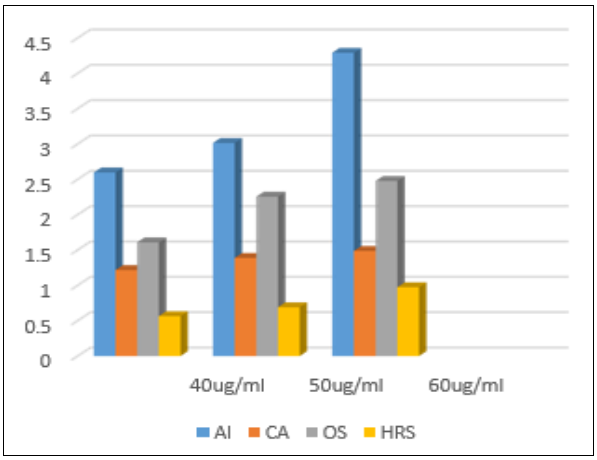

Fig 1: Graphic Presentation of SPF value of different extracts

Conclusion

In this detailed examination, we looked into the complicated realm of the sun protection factor (SPF) and its essential role in determining the effectiveness of sunscreen lotions. The voyage has led us from the historical history of SPF standards to the nuances of its measuring procedures and the dynamics of its interaction with UV light. The percentages of various plant extracts utilized were 5.8% for *Azadirachta indica* (Indian lilac), 4.5% for *Ocimum sanctum* (holy basil), 3.8% for *Centella asiatica* (Asian pennywort), and 5.2% for *Hibiscus rosa sinensis* (Shoeblack plant). The findings revealed that Azadirachta indica had the largest extract content in hydroalcoholic solvent among the four plants implemented for the research. The *in vitro* SPF screening approach might be effective in creating sunscreen cosmetic goods as an alternative to *in vivo* SPF determination. In this work, several plant extracts were assessed by UV spectroscopy. Research findings demonstrate that hydroalcoholic extracts of certain plant materials have sun protection capabilities and may be employed as sunscreen agents during cosmetic development. *Azadirachta indica* exhibited a better photoprotective effect than other herbal extracts, but *Hibiscus rosa sinensis* showed a lesser photoprotective impact on protective effect. These recommended herbal treatments may produce greater benefits when taken in conjunction. As we close our review, let us be aware that the hunt for sun protection doesn't stop here. It's a continuous journey that intertwines science,

perception, and practice. Through continued study, public education, and ethical product development, we may jointly traverse the world of sun resistance with fresh knowledge and caution.

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