FORMULATION AND EVALUATION OF HERBAL SUNSCREEN: AN ASSESSMENT TOWARDS SKIN PROTECTION FROM ULTRAVIOLET RADIATION

Rishi Manoj Sutawane [1], Prof. Tejashree Kedar[2], Prof. A.B. Darekar[3], Mansi Sonawne[4,] Sagar Khole[5]

[1].Student of KVN Naik Shikshan Prasarak Sanstha's Institute of Pharmaceutical Education and Research, Nashik - 422002, Maharashtra, India.

[2]. Professor of KVN Naik Shikshan Prasarak Sanstha's Institute of Pharmaceutical Education and Research, Nashik.

[3]. Principal of KVN Naik Shikshan Prasarak Sanstha's Institute of Pharmaceutical Education and Research, Nashik.

[4.] Student of KVN Naik Shikshan Prasarak Sanstha's Institute of Pharmaceutical Education and Research, Nashik - 422002, Maharashtra, India.

[5] .Student of KVN Naik Shikshan Prasarak Sanstha's Institute of Pharmaceutical Education and Research, Nashik - 422002, Maharashtra, India.

Abstract:-

In today's fast-paced and urbanized lifestyle, human skin is increasingly exposed to environmental stressors including harmful ultraviolet (UV) radiation and synthetic chemical compounds, which often result in adverse health effects such as premature aging, oxidative damage, inflammation, and, most notably, skin cancer. Sunscreen plays a vital role in protecting the skin by absorbing or reflecting harmful UVA and UVB rays, thereby preventing sunburn, photoaging, actinic keratosis, and other UV-induced skin disorders. However, growing awareness of the toxicological effects associated with conventional sunscreens has sparked an interest in natural and herbal alternatives that are safer, effective, and environmentally friendly. This study focuses on the formulation and evaluation of herbal-based topical sunscreens incorporating plant-based polyphenols and oils with medicinal properties. These herbal ingredients include turmeric sunscreen formulations were evaluated for various parameters such as physicochemical characteristics, sun protection factor (SPF), antioxidant activity, thermal and chemical stability, photostability, non-mutagenicity, and non-irritancy.

Keywords: Herbal Sunscreen, SPF (Sun Protection Factor), UV Radiation, Sunburn, Skin Protection, Antioxidants, Photoprotection, Skin Cancer Prevention.

1. Introduction

The ultraviolet (UV) radiation with increasing exposure due to environmental and lifestyle changes, the demand for effective sun protection has significantly risen. Sunscreen formulations play a vital role in protecting the skin from harmful effects such as sunburn, photoaging, skin pigmentation, and even melanoma. These topical products act by absorbing, reflecting, or scattering UVA and UVB rays to prevent premature aging, inflammation, and skin damage. While numerous synthetic sunscreens are available in the market, they often pose risks including allergic reactions, hormonal disruptions, and potential carcinogenicity.

In response to these concerns, herbal-based sunscreens have gained popularity due to their safety, antioxidant properties, and natural photoprotective effects. Bioactive compounds such as polyphenols, flavonoids, and herbal oils not only enhance SPF but also offer multifunctional benefits like anti-inflammatory, wound healing, antifungal, and antiproliferative activities. The present study focuses on the development of stable and effective herbal sunscreen formulations using natural ingredients such as aloe vera powder, turmeric powder, zinc oxide, sesame oil, glycerine, beeswax, rosemary powder, and sandalwood powder. These components are selected for their medicinal properties and potential to provide broad-spectrum UV protection while ensuring skin safety and compatibility.

- **Classification of sunscreen and the mechanism of photoprotection:-**

sunscreen is classified as either topical or systemic based on the route of administration topical sunscreen are divided into two classes on their mechanism of protection.

Organic sunscreen

Inorganic sunscreen

Organic Sunscreen:- Organic sunscreen works by absorbing into skin and converting UV rays into heat .it is thin and ideal for everyday use allow for skincare ingredients to be added easily. Organic sunscreen actives chemical carbon-based compound .it contains on mineral active ingredient.

Inorganic sunscreen:- These are the particles that scatter and reflect UV rays back to the environment they act as physical barrier to indent ultraviolet and UV light .they are considered broad spectrum as they cover entire ultraviolet spectrum .the Inorganic sunscreen are also referred to as sunblock.

- **Mechanism of protection**

Sunscreen act by preventing and minimizing the damaging effects of the ultraviolet sun rays following exposure to the sunscreen have been demonstrated to increase the tolerance of the skin to UV exposure. They work on two mechanisms Scattering and reflection of UV energy from the skin surface mineral based on inorganic sunscreen works on this mechanism they provide a coating that blocks sun rays from penetrating through the skin . Absorption of the UV energy by converting it to heat energy thus reducing its harmful effects and reduce the depth which can penetrate the skin organic sunscreen works on this mechanism.

2. Role of ingredients used in formulation

- **Aloe Vera Powder (Aloe barbadensis miller)** :- Soothing agent, provides hydration and reduces inflammation. Also has minor UV protective effects.

Figure 1 ALOE VERA POWDER

- **Turmeric Powder (Al kurkum) :-** Anti-oxidant and anti-inflammatory. Contains curcumin, which helps neutralize free radicals and provides mild UV protection.

Figure 2 TURMERIC POWDER

- **Zinc Oxide (Calamine)** :- Primary physical sunscreen agent. Reflects and scatters UV rays (broad-spectrum UVA/UVB protection).

Figure 3 ZINC OXIDE

- **Sesame Oil (S** PF properties. Rich in antioxidants and helps in nourishing a

Figure 4 SESAME OIL

- **Glycerine :-** Humectant, retains skin moisture and helps maintain skin hydration.

Figure 5 GLYCERINE

- **Beeswax (Cera alba) :-** Acts as a thickening agent and forms a protective barrier on the skin, improving water resistance.

Figure 6 BEESWAX

- **Rosemary pow** ntioxidant and preservative properties, can also help protect skin from damage due to UV exposure.

Figure 7 ROSEMARY POWDER

- **Sandalwood powder (Chandan) :-** Act as a natural sunscreen component and also provide skin-soothing and anti-inflammatory benefits. It can also help with skin pigmentation and even skin tone.

Figure 8 SANDALWOOD POWDER

3. Materials and Methods

Ingredients	Batch 1(g) (20gm)	Batch 2(g) 20(gm)	Batch 3(g) (20gm)
Aloe vera powder	0.5	0.4	0.6
Turmeric powder	1.0	1.1	0.9
Zinc oxide	10.25	10.25	10.25
Sesame oil	5.8	6.2	6.0
Glycerine	0.6	0.5	0.7
Beeswax	0.7	0.5	0.6
Rosemary powder	0.3	0.3	0.3
Sandalwood powder	0.85	0.75	0.65

Table 1:- Composition of herbal sunscreen formulation.

- **In Silico and In Vitro Sun Protection Factor (SPF) determination**

The sunscreen formulation's efficacy can be identified by calculating the sun protection factor (SPF), which is defined as the UV energy required to produce a Minimal Erythemal Dose (MED) in protected skin, divided by the UV energy required to produce a MED in unprotected skin:

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

The minimal erythemal dose (MED) is defined as the lowest time interval or dosage of UV light irradiation sufficient to produce minimal, perceptible erythema on the unprotected layer of skin.

In Vitro SPF values of oily formulations containing vegetable oils and/or organic UV filters were calculated spectrophotometrically and observed absorbance values at 5 nm intervals (290-330nm) were calculated spectrophotometrically by using the formula:

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

where,

- CF = Correction Factor (10)
- EE($\boldsymbol{\lambda}$) = Erythemal Effect Spectrum
- I($\boldsymbol{\lambda}$) = Solar Intensity of Radiation with wavelength $\boldsymbol{\lambda}$

- Abs(**λ**) = Absorbance of the sunscreen product at wavelength **λ**
- EE × I = Constant Value

Wavelength (nm)	EE x I
290	0.0150
295	0.0817
300	0.2874
305	0.3278
310	0.1864
315	0.0839
320	0.0180
325	0.0030
330	0.0005
Total	1.0037

Table 2 :- Relationship between erythemal effect (EE) and radiation intensity (I) at each wavelength (**λ**)

Wavelength (nm)	Absorbance
290	2.2339
295	2.6337
300	3.0569
305	3.4096
310	3.7624
315	3.5272
320	2.8218
325	2.1163
330	1.4109

Table 3 :- UV light absorbed by the cream at each wavelength (absorbance)

This gives the contribution to SPF from each wavelength:

Wavelength (nm)	EE x I x Abs
290	0.0335
295	0.2152
300	0.8786
305	1.1177
310	0.7013
315	0.2959
320	0.0508
325	0.0063
330	0.0007

Table 4 :- Multiply EE × I × Absorbance

- **Final SPF calculation**

SPF=10×(0.0335+0.2152+0.8786+1.1177+0.7013+0.2959+0.0508+0.0063+0.0007)

SPF=10×3.3000 = **33.0**

4. Development of Formulation

Step 1: Preparation of Ingredients

Weigh all ingredients accurately according to the formulation. Sift herbal powders (Aloe vera, Turmeric, Sandalwood and Rosemary powders) to remove lumps and ensure even distribution.

Set up a double boiler or water bath for controlled heating.

Step 2: Oil Phase Preparation (Heating Phase A)

In a heat-safe glass beaker, add: Beeswax, Sesame oil.

Place the beaker in the double boiler and gently heat to 70-75°C, stirring occasionally until the beeswax melt completely.

Keep this oil phase warm while preparing the water phase.

Step 3: Water Phase Preparation (Heating Phase B)

In a separate heat-safe beaker, add: Glycerine, Herbal powders (Aloe vera, Turmeric, Sandalwood, Rosemary).Heat to 70-75°C using the double boiler, stirring gently to dissolve the powders.

Ensure the water phase is well mixed and at the same temperature as the oil phase.

Step 4: Emulsification (Combining Oil & Water Phases)

Slowly pour the water phase (B) into the oil phase (A) while continuously blending with a high-shear mixer or stick blender. Blend for 5-10 minutes until a uniform, creamy emulsion forms. Remove from heat and continue stirring as it cools.

Step 5: Cooling Phase (Incorporation of UV-Blocking Agents & Antioxidants)

Once the emulsion cools to 40°C, add: Zinc oxide (non-nano, gradually with stirring)

Use a spatula or low-speed mixer to blend thoroughly, ensuring even dispersion of the sunscreen agents.

Step 6: Final Mixing & Homogenization

Continue stirring for another 5-10 minutes to achieve a smooth, creamy texture. Perform a pH check (ideal range: 6-7) and adjust, if necessary, with aloe vera or natural pH balancers.

Step 7: Filling & Packaging

Transfer the sunscreen into sanitized, airtight containers while still slightly warm (not hot).

Use airless pump bottles or UV-protected jars to prevent contamination and oxidation.

5. Subjective properties :-

- **In Vitro evaluation by UV Spectroscopy**

1 gm quantity of formulated cream was weighted, transferred to 100 ml volumetric flask and diluted to volume with n butyl alcohol. Further, it was kept for ultra-sonication for 5 min and filtered through a cotton filter, discarding the initial 10 ml. Afterwards 5 ml aliquot was transferred to 25 ml volumetric flask and the volume was adjusted with n-propyl alcohol. The absorption spectra of samples were obtained in the range of 290-400 nm using 1 cm quartz cell and n butyl alcohol as blank solution. The absorption data obtained in the range of 290-330 nm every 5 nm interval. The absorbance values and results of formulation I, II and III are shown in table 3,4.

- **Sun Protection Factor Determination**

SPF of formulated creams were calculated by the application of equation :

$$\mathbf{SPF = CF \times {}^{290}\textstyle\sum_{330} EE(\lambda) \times I(\lambda) \times Abs(\lambda)}$$

The formulation prepared was scanned under UV Spectrometer and the obtained absorbance for 290 to 330 nm. These values are multiplied with EE × I value and the obtained values are multiplied by the correction factor 10.

- **pH Determination**

PH denotes "Potential of Hydrogen" and is a scale used to specify the acidity or basicity of an aqueous solution. Acidic solutions are measured to have lower pH values than basic or alkaline solutions. The cream in general has a pH of 6 to 9.

Parameters	Batch I	Batch II	Batch III
Appearance	Smooth, Opaque	Smooth, Opaque	Smooth, Opaque
Colour	Brownish white	Brownish white	Brownish white
Consistency	Good	Good	Good
Texture	Fair	Good	Very good
Irritation	Non	Non	Non
Spread-ability	Good	Good	Good
Extrudability	Fair	Good	Good
pH	7.3	7.1	6.8
SPF	22.43	28	33

Table 5 :- Evaluation of Herbal Sunscreen Cream

6. Results and Discussion

Results of our study revealed that 100% of selected herbal sunscreens are photostable in the UVB range, and 71% of them are stable in both UVA and UVB range. Subjective study by in vivo SPF determination revealed that 98% of the sunscreens effectively provide protection to the skin from sunburns. Overall data obtained after quality evaluation study substantiate that all products are safe and efficacious. Total SPF obtained from formulation is 33 SPF. To be effective in preventing sunburn and other skin damage ,a sunscreen product should have a wide range of absorbance. during the storage and handling of cosmetic formulation spread-ability and viscosity are the prime parameter which affects the formulation acceptability. the formulated cream exhibited no redness, inflammation and irritation .when formulation was kept for long time, it found that no change in colour of cream.

Figure 10 MOCKUP DESIGN OF FINAL PRODUCT PACKAGING

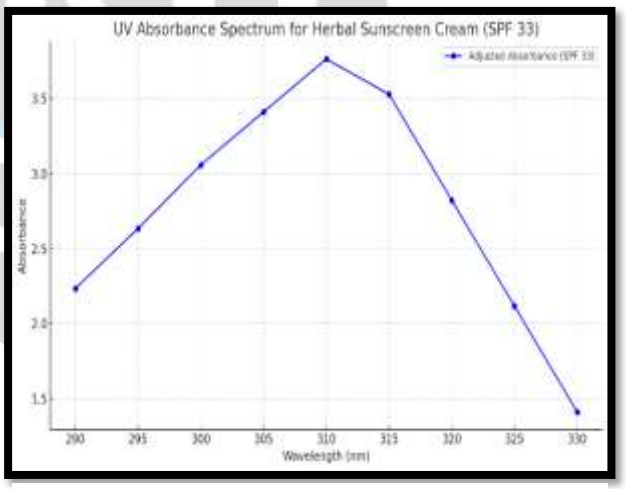

Figure 9 ABSORBANCE GRAPH

7. Conclusion

The current study aimed to create a stable herbal sunscreen with a suitable SPF. UV Radiation causes various precarious and damaging effects on the skin. It causes skin cancer, hyperpigmentation, photo-aging, sunburn and skin irritation. Herbal cosmetics possess property to protect skin from damaging effects of sun rays with no comedogenic and side effects. The present review focuses on the scientific account of herbals in cosmetics. Active constituents extracted from herbals have a potent UV shielding effect. The study attempted to develop herbal sunscreen cream using extract of butterfly pea flower and examined their efficacy for preventing sun burn.

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