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(RESEARCH ARTICLE)

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Formulation and evaluation of herbal sunscreen

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Abstract

Due to the hasty-paced life of today, our life is affected by pollution and harsh synthetic chemicals, hence, nature has rendered us with its everlasting notable ingredients of herbal. The major cause of sunburn is UV rays which leads to precarious skin cancer. Sunscreen is a topical product that absorbs or reflects some of the sun's UV radiation on the skin from excessive exposure to UV radiation. It has the potential to prevent sunburn & reduce the harmful effects of the sun such as premature aging & skin cancer. The Present research work portrays the formulations & evaluation of topical photoprotective, containing antioxidant, anti-malignant, wound healing, antifungal, antiaging, moisturizer, anti-inflammatory, antiproliferative activity, and other photo-protective polyphenols. The present research work renders a stable natural photoprotective formulation with antioxidant properties, high SPF, and more indispensable homogenous UVA/UVB protection.

Keywords: Sunscreen; Polyphenols; SPF; Sunburns

1. Introduction

UV protection is befitting very popular because of sunscreen's properties as a photo-protecting agent [1]. Sunscreen preparation is applied topically, and its purpose is to heal, prevent or resist skin from painful or harmful effects of sunburn, suntan, sun cancer, and premature skin aging and to escalate the level of Sun Protection Factor (SPF) [1,2,3]. Sunscreens are a natural defense mechanism to defend against precarious UV radiation from the skin, which is the outer covering layer of the body. Its ability to absorb, reflect or scatter some of the sun's UV radiation on the skin from extravagant exposure to ultraviolet radiation [1]. Skin melanoma, sunburn, photoaging, skin pigmentation, and various painful or precarious effects are caused by UVA and UVB rays [3,4]. Anti-oxidant, wound healing, antifungal, premature aging, moisturizer, anti-inflammatory, and antiproliferative activities are shown due to the key components of UV protection like flavonoids, phenolic compounds or herbal oils and also their UV rays absorption capacity in UV-A region [5].

There are ample sunscreen formulations available in the market, which are used to protect skin from sunburn and skin cancer and during the market survey, it is found that there are some adverse effects like cell mutation, DNA damage, hormone alteration, and eczema (allergic reaction) by the synthetic sunscreen agents. Various formulations have multifunctional sun protection activity and it is based on their efficacy of UV rays absorption apart but most of the formulations are of high cost and merged synthetic molecules have toxicity and are even carcinogenic [6].

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1.1. Shea Butter (*Vitellaria paradoxa*)

It is obtained from the fat of the shea nut. The shea tree originates from the savannas of Africa. Its potential is to melt at body temperature and to absorb rapidly into the skin and it gives results without leaving a greasy feeling. It is used as an antioxidant and it contains vitamins like A and E, both of which enhance skin cell regeneration and circulate blood below the skin's surface. The oil contains Cinnamic acid and provides vital protection against precarious UV rays [7].

Figure 1 Shea Butter

1.2. Beeswax (*Cera alba*)

It is derived from honeybees of the genus *Apis* and it is a natural wax. Mainly Beeswax foundation is used as an emulsifier and thickener and can also be used for emulsion stabilization. Beeswax is used for melting the solids to facilitate the mixing with the water phase's ingredients by heating and mixing method. Its most important purpose is to compose a creamy texture. [8]

Figure 2 Bees Wax

1.3. Rose Water (*Rosa damascena*)

It is extracted from the rose by liquid-liquid extraction [9]. One of the most important factors is that they have a good source of antioxidant activities and also be used for beautifying purposes for their sterling sunscreen [10].

Gelatin and its hydrolysates procured from fish gelatin of tilapia (*Oreochromis niloticus*) were found to possess a scavenging effect against reactive oxygen species of UV that renders precarious effects to the skin. It is a novel source of components that have potential in skin anti-aging products and is also used as an emulsifying agent [11].

Figure 3 Rose Water

Figure 4 Gelatin

1.4. Raspberry Seed Oil (*Rubus idaeus* seed) (RSO)

It is the fixed oil yielded from the seeds of the Raspberry and its components are fatty acids, and high concentrations of vitamins A and E, so appreciated in the cosmetics and pharmaceutical industries. Its potentials that are high antioxidant capacity and exhibited anti-inflammatory, anti-aging, anti-mutagenic, and antimicrobial properties and also used as an efficient moisturizer and emollient which aids to alleviate oxidative stress in the skin, is utilized in cosmetic emulsions for UV protection [12,13]. It assists to protect cells from oxidative damage and also aids with maintaining the structure of the collagen [13]. Use it to moisturize your face without blocking pores, so it is also non-comedogenic [15]. It has sun-protective qualities and is also rendered beneficial to people glancing for a mild, non-irritating moisturizer with a Sun Protection Factor (SPF) [16,17].

Figure 5 Raspberry Seed Oil

1.5. Olive oil (*Olea europaea*)

It is a fat derived from the olive fruit. Olive oil is made up of triglyceride esters of oleic acid and palmitic acid along with traces of squalene, sterols, (phytosterols, and tocosterols), and also consists of polyphenols like esters of Tyrosol and hydroxyl tyrosol including oleocanthal and oleuropein. Some flavonoids and lignans are also present. Olive oil has been

used as a home remedy for skin care. Squalene is utilized as an antioxidant, and moisturizer, and in topical sunscreen preparation, it is a convenient vehicle to carry other substances [18,19,20].

Figure 6 Olive Oil

1.6. Coconut Oil (*Cocos nucifera*)

It is a tropical plant that grows and is cultivated numerously by Indonesian people [21]. It contains fatty acids and is reported to possess antioxidant properties photoprotection, and other medicinal activities like anti-bacterial, skin barrier repair, anti-aging, wound healing, and moisturizing in atopic dermatitis treatment [22-28].

Figure 7 Coconut Oil

1.7. Grape Seed Oil (*Vitis vinifera*)

It is the most important source of polyphenols (60%-70%). It has the property of antioxidants with strong anti-inflammatory and antiproliferative activity. The polyphenolic phytoalexin namely resveratrol (trans-3,5,4'-trihydroxystilbene) is present in both the skin and seeds of grapes. It acts as an antioxidant with strong anti-inflammatory and antiproliferative activity [29].

Figure 8 Grape Seed Oil

1.8. Carrot Seed Oil (*Daucus carota*)

It is an essential oil and it renders a significant role of antioxidant, antiseptic, antifungal, and fragrant properties with high levels of vitamin A and also provides protection from the sun. According to a study, Carrot Seed Oil has a natural SPF of 38 and 40, which was published in "Pharmacognosy Magazine" in 2009 [7].

Figure 9 Carrot Seed Oil

1.9. Almond Oil

It is the richest source of polyphenolic compounds especially flavonoids and phenolic acids. Its potential is that the property of UVB protection of this plant's skin extract and its topical application has significant antioxidant, skin brightening, and anti-photo aging properties [30,31,32].

Figure 10 Almond Oil

1.10. Rosehip Seed Oil (*Rosa canina*)

It is the richest source of vitamin C, carotenoids, polyphenols, and different flavonoids that show antioxidant properties [33,34,35]. In addition, It has strong anti-inflammatory and antioxidant properties that stimulate the synthesis and restoration of collagen [36,37]. It has anti-aging properties and acts as a moisturizer.

Figure 11 Rosehip Seed Oil

1.11. Sesame Oil (*Sesamum indicum*)

It has been utilized as a healing oil for thousands of years. Sesame Oil has inhibited the growth of malignant melanoma (a skin cancer) prostaglandin and leukotrienes in *In-vitro* conditions. It acts as a potent antioxidant activity [38,39]. In the tissues, this oil will neutralize free oxygen radicals. Palmitic, palmitoleic acid, stearic, oleic, linoleic, eicosenoic acid are present in this oil. It is the richest source of vitamin E and Sesamol, sesamin is reported to restore moisture to the skin, keeping it soft and flexible [38,39,40,41].

Figure 12 Sesame Oil

1.12. Tea Tree Oil (*Melaleuca alternifolia*)

It acts as an effective antiseptic, fungicide, and germicide and it is a widely used ingredient of ample sunscreen formulations that relieve sunburn by increasing blood flow in capillaries, bringing nutrients to damaging skin.

Figure 13 Tea Tree Oil

2. Material and methods

Table 1 The weights of each ingredient of sunscreen preparation

Ingredients	Formulation I (50gm)	Formulation II (50gm)	Formulation III (50gm)
Raspberry Seed Oil	6 ml	6 ml	8 ml
Sesame Oil	5 ml	6 ml	-
Olive Oil	-	2 ml	5 ml
Coconut Oil	-	-	5 ml
Grape Seed Oil	6 ml	5 ml	5 ml
Carrot Seed Oil	6 ml	6 ml	5. 5 ml
Almond Oil	5 ml	5 ml	5 ml
Rosehip Seed Oil	5 ml	5 ml	0. 5 ml

Tea Tree Oil	2 ml	1 ml	2 ml
Shea Butter	2. 5 gm	2 gm	2 gm
Beeswax	2. 5 gm	2 gm	2 gm
Rose Water	5 ml	5 ml	5 ml
Gelatine	5 ml	5 ml	5 ml

2.1. 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:

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

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 [42,43].

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 (290-320 nm) were calculated spectrophotometrically by using the formula:

$$\text{SPF} = \text{CF} \times \sum_{290}^{320} \text{EE}(\lambda) \times \text{I}(\lambda) \times \text{Abs}(\lambda)$$

where,

- CF = Correction Factor (10)
- EE($\boldsymbol{\lambda}$) = Erythemal Effect Spectrum
- I($\boldsymbol{\lambda}$) = Solar Intensity of Radiation with wavelength $\boldsymbol{\lambda}$
- Abs($\boldsymbol{\lambda}$) = Absorbance of the sunscreen product at wavelength $\boldsymbol{\lambda}$
- EE × I = Constant Value

These values were determined by Sayre *et al*. (1979) and rendered in the table 2 [44].

Table 2 Relationship between erythemal effect (EE) and radiation intensity (I) at each wavelength ($\boldsymbol{\lambda}$)

Wavelength (nm)	**EE × I (Normalized)**
290	0. 0150
295	0. 0817
300	0. 2874
305	0. 3278
310	0. 1864
315	0. 0839
320	0. 0180
Total	1

3. Development of Formulation

3.1. STEP 1

Melt beeswax and Shea Butter in a china dish after that add Almond Oil, Coconut oil, Rosehip Seed Oil, Carrot Seed Oil, and Olive Oil in measured quantities and heat up to 75°C.

3.2. STEP 2

Add Rose Water and Gelatin in another china dish in measured quantity. Heat the mixture up to 75°C.

3.3. STEP 3

Mix both the mixture and stir gently until a smooth cream is formed at room temperature.

3.4. Evaluation Parameters

3.4.1. Physical Parameters

Appearance, color and homogeneity are determined.

4. Subjective Properties

4.1. *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 290-320 nm every 5 nm interval. The absorbance values and results of formulation I, II and III are shown in table 3.

4.2. Sun Protection Factor Determination

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

$$\mathrm{SPF} = \mathrm{CF} \times \sum_{290}^{320} \mathrm{EE}(\lambda) \times \mathrm{I}(\lambda) \times \mathrm{Abs}(\lambda)$$

The formulation prepared was scanned under UV Spectrometer and the obtained absorbance for 290 to 320 nm. These values are multiplied with EE × I values and the obtained values are multiplied by the correction factor 10.

4.3. Rancidity

Rancidification is the process of complete or incomplete oxidation or hydrolysis of fats and oils when exposed to air, light, or moisture or by bacterial action, resulting in an unpleasant taste and odor. Rancidity is performed by using the Phloroglucinol solution. The rancidity is due to the oxidation of the fats and oils; during oxidation free fatty acids are liberated. These free fatty acids react with the Phloroglucinol solution and give pink color indicating the rancidity of the product. 10 ml of cream was taken then added 10 ml of concentrated Hydrochloric acid and 10 ml of Phloroglucinol solution and shaken for one minute. The cream should have passed the test if no pink color develops.

4.4. pH Determination

P^H 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.

4.5. Procedure

All the formulations were water in oil emulsion. The pH of the cream is measured by making a 10% dilution of the cream and the pH is measured by the pH meter. The electrode must be washed and free from any residue of acid and alkali to ensure an accurate reading.

4.6. Viscosity

Viscosity is an important parameter in the evaluation of the cream. Viscosity governs many properties of the cream such as spreadability, pouring ability of the cream from the container, etc. The viscosity of formulation was determined by using Brookfield Viscometer and Viscosity was found to be in the range of 28000-32000 cp. The Viscosity is determined by using the following formula:

Viscosity = Dial Reading × Factor. For LV-4 at 6 RPM Factor is 1M (1000)

Table 2 Evaluation of herbal sunscreen

Parameters	Formulation I	Formulation II	Formulation III
Appearance	Smooth, Opaque	Smooth , Opaque	Smooth , Opaque
Color	Pale Yellow	Pale Yellow	Pale Yellow
Consistency	Good	Good	Good
Texture	Smooth	Smooth	Very Smooth
Irritation	Non	Non	Non
Spread ability	Good	Good	Good
Extrudability	Fair	Good	Good
pH	7. 3	7. 2	7. 1
Rancidity	No Pink color	No Pink color	No Pink color
Viscosity	28408	28540	30200
SPF by UV	21. 35	27	34

5. 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 34 SPF.

Figure 14 Final Product of Herbal Sunscreen

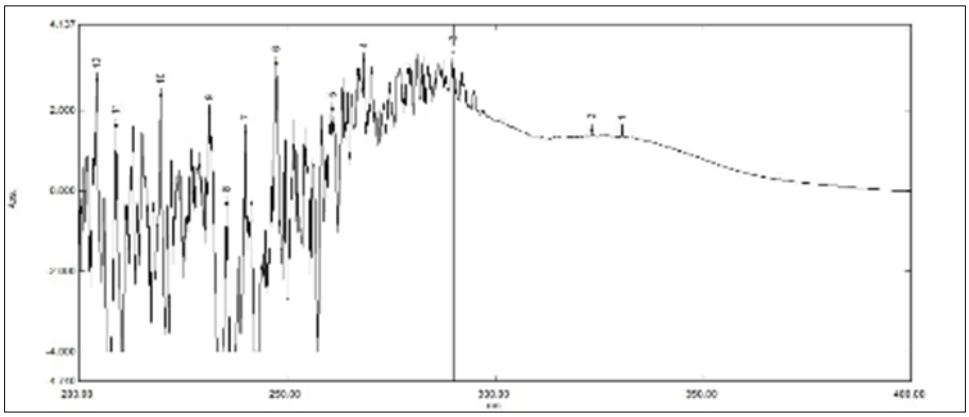

Figure 15 UV Spectrophotometer Graph

Table 3 Relationship between Erythemal Effect (EE) and Radiation Intensity (I) at each Wavelength (λ)

Wavelength (nm)	**EE × I (Normalized)**	**Absorbance()**	**EE × I × **
290	0. 0150	4. 001	0. 1260
295	0. 0817	3. 887	0. 3253
300	0. 2874	3. 509	0. 6450
305	0. 3278	3. 103	1. 0171
310	0. 1864	2. 943	0. 8458
315	0. 0839	2. 594	0. 4570
320	0. 0180	2. 015	0. 0302
Total	1		3. 4557 = 3. 4557 × 10 = 34. 557 SPF

6. Conclusion

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. Herbs are eco-friendly, compatible, and widespread compared to synthetic ones.

Compliance with ethical standards

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Disclosure of conflict of interest

No conflict of interest.

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