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Formulation and evaluation of poly-herbal UV protecting cream

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Abstract
UV radiations which constitutes of about 10% of total output of solar radiations, have known to cause various skin conditions such as erythema, sunburn, hyperplasia, immunosuppression, photo-aging, melano-genesis and DNA damage that can lead to skin cancer, on long term exposure. Sunscreens have expanded worldwide as an integral part of the photo-protection strategy based on its ability to reflect, absorb or scatter the sunlight. But majority of the marketed sunscreens containing synthetic agents, produce negative effects on the skin such as skin burning, dermatitis etc. Thus, the need for natural UV protecting agents arise. Numerous phyto-constituents that are present in herbal actives agents have been shown to prevent and treat various skin conditions. The present research work, to formulate poly-herbal UV protecting lotion includes herbal extracts like Aloe Vera, Turmeric, Orange, Green tea, Coconut oil as natural UV filter which consists of flavonoids, tannins, terpenoids, carotenoids, alkaloids, and phenolic compounds that have shown promising UV protecting ability. 5 trials batches of lotion base were prepared, individual SPF value of selected herbal actives was performed and based on it the concentration in final product was decided. The prepared lotion was found to be safe and was evaluated for various parameters and based on observations it was found to be of O/W type emulsion with pH, compatible with skin that gave homogeneous, emollient, non-greasy appearance after the application with significant antioxidant activity and SPF value. Thus, all selected extracts were good choice to use as ingredient in lotion that can provide significant action against UV.

Keywords: Herbal sunscreen cream, UV radiation, SPF

Introduction
The rapid growth of commercially available products containing sunscreens indicates that even though a suntan is still desired people are conscious of the possible dangers of photo-ageing and skin cancer, occurring as a result of sun overexposure. The harmful effects of solar radiation are caused predominantly by the ultraviolet (UV) region of electromagnetic spectrum, which can be divided into three regions: UVA, from 320 nm to 400nm, UVB, from 290 nm to 320 nm and UVC, from 200 nm to 290 nm. UVC radiation is filtered out by the ozone layer and is responsible for the damage due to sunburn 123. UVA radiation reaches the deeper layer of epidermis and dermis and provokes the premature ageing of the skin. Ultraviolet radiations have been implicated as a causative factor of skin cancer. The efficacy of sunscreen is usually expressed by the sun protection factor (SPF), which is defined as the UV energy required for producing a minimal erythema dose (MED) on protected skin, divided by the UV energy required for producing a MED on unprotected skin. The minimal erythema dose (MED) is defined as the lowest time interval or dosage of UV light radiation sufficient to produce a minimal, perceptible erythema on unprotected Skin 45
Nowadays because of the benefits of products containing natural compounds, acceptance of these products by the users, also the probability of the systemic absorption, using natural products that can absorb the ultraviolet radiation is of great interest. Natural substances extracted from plants have recently been considered as potential sunscreen resources because of their ultraviolet absorption in the UV region and their antioxidant activity. The photo protection afforded by topical sunscreen against solar ultraviolet radiation exposure can be determined *in vivo* or *in vitro* and it is ideally determined by photo testing in human volunteers. This type of determination has been used for many years and although useful and precise, is a time consuming process, complex and expensive, particularly when information concerning to the protection against long wavelength is required 67.

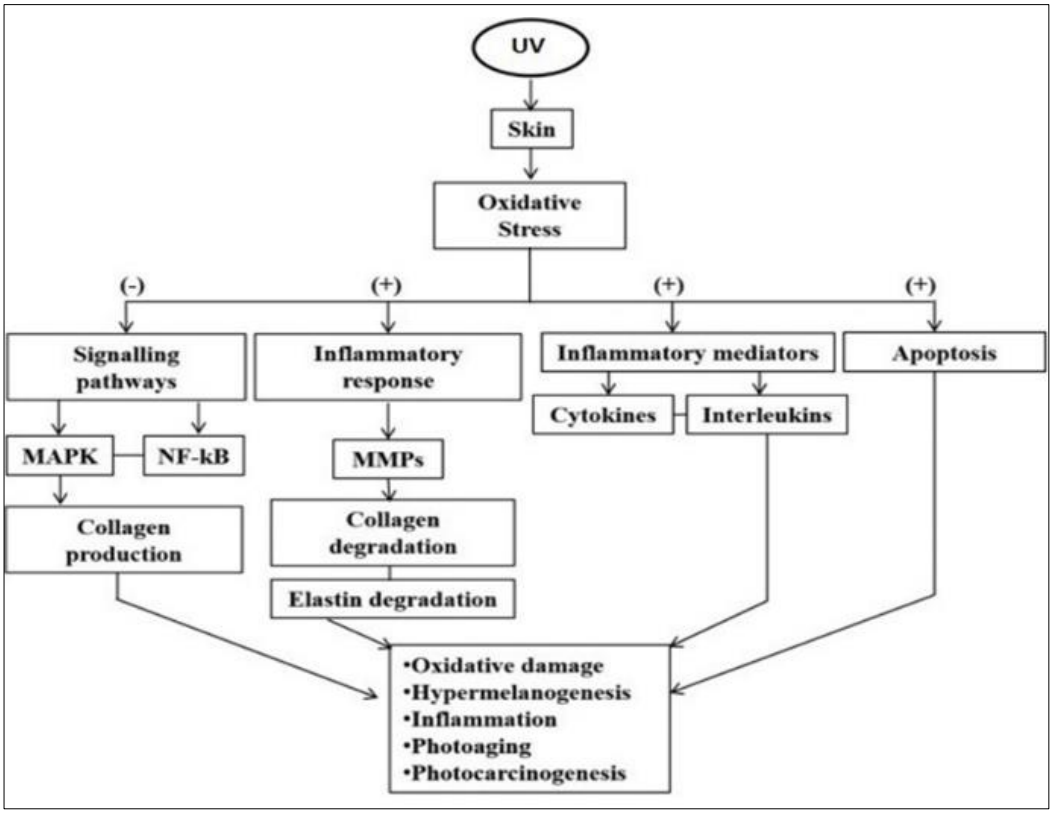

Fig 1: Effects caused by UV

As a consequence, much effort has been devoted to the development of *in vitro* techniques for assessing the photo-protection of sunscreen compounds. The methods *in vitro* are in general of two types. Methods which involve the measurement of absorption or the transmission of UV radiation through sunscreen product film in Quartz plates or Biomembrane and methods in which the absorption characteristics of the sunscreen agents are determine based on spectrophotometric analysis of dilute solution. Present herbal cosmeceuticals was a cream developed by using a variety of phytochemicals oils like red raspberry seed oil, tea tree oil, lavender oil, coriander oil, coconut oil, olive oil, which posess the properties like antioxidant, anti-aging, anti-wrinkling, lightning, hydration glow of the skin, pigmentation reducer and prevents skin from damage. Being rich in vitamins A and E formulations prepared using these essential oils protects from UV radiation by blocking sun effect and improving the skin beauty 8.

Materials and Methods

Table 1: List of ingredients

Sr. no	Name of ingredients	Category	reference
1	Turmeric powder	Active ingredient	Tonnesen *et al.*, 2002 [9] Leung, 1980 [10]
2	Orange Peel powder	Active ingredient	Kanaze *et al.*, 2009 [30]
3	Aloe vera gel	Active ingredient	Vogler BK *et al.*, 1999 West DP *et al.*, 2003 Rajpal V. 2000, Daud FS *et al.*, 2011 [12, 13, 14, 15]
4	Coconut oil	Active ingredient	Nevin KG *et al.*, 2004, Herzog B *et al.*, 2021 [16, 17]
5	Green tea	Active ingredient	Afaq F, Mukhtar H, 2006, Wang *et al.*, 1992 [18, 19]
6	Lavender oil	Active ingredient	R.V. Essentials

Preparation of plant extract [Mukherjee PK, 2002] [21]

Turmeric Powder Extraction

To extract the active compounds from turmeric powder, 20g of dried powder is taken. Ethanol (100ml x 3) should be used to extract the active compounds, and the mixture should be filtered to remove any solid particles. The resulting filtrate can be concentrated to dryness to obtain a concentrated extract of turmeric.

Orange Peel Powder Extraction

To extract the active compounds from orange peel powder, 20g of the dried powder is extracted with a suitable solvent, such as ethanol or methanol. Ethanol (100ml x 3) can be used to extract the active compounds, and the mixture should be filtered to remove any solid particles. The resulting filtrate can be concentrated to dryness to obtain a concentrated extract of orange peel.

Dried Green Tea Leaves Extraction

To extract the active compounds from dried green tea leaves, 20g of the leaves is taken and extracted with a suitable solvent, such as water or ethanol. Water (100ml x 3) can be used to extract the active compounds, and the mixture should be filtered to remove any solid particles. The resulting filtrate can be concentrated to dryness to obtain a concentrated extract of dried green tea leaves.

Collection of Aloe Vera gel

Fresh leaves were picked from a plant and washed thoroughly. After that upper layer of leaf was removed and

gel was scooped out. Furthermore, the gel was blended and filtered with a cheesecloth. Lastly clear gel was collected and stored in an air tight container.

Preparation of base for cream [22, 23]

A cream formulation was prepared and its ingredients are shown in Table 2. A small quantity of water was taken in processing vessel, heating up-to 85 ℃ and Carbopol-940 was added slowly with constant stirring till it completely dispersed. Heating was removed and added propylene glycol, glycerine and methyl paraben at 70-75 ℃. Side by side in another vessel given quantity of oil phase were melted at 70-75 ^{0}C. At same temperature (70-75 ℃) both phases water and oil were mixed slowly till homogeneous mass obtained

Table 2: Formulae for development of batches of Photo protective cream formulations

Sr. No.	Ingredients	B1	B2	B3
1	Carbopol-940	0.165g	0.3g	0.2g
2	Propylene Glycol	2ml	2ml	2ml
3	Methyl Paraben	0.25g	0.25g	0.25g
4	Glycerin	2ml	2ml	2ml
5	Propyl Paraben	0.15g	0.15g	0.15g
6	Triethanolamine	1.15ml	1.15ml	1.15ml
7	Liquid Paraffin	16ml	10ml	5ml
8	Stearic Acid	4g	4g	4g
9	Glycerol Monostearate	3.36g	3.36g	3.36g
10	Cetosteryl Alcohol	2.29g	2.29g	2.29g
11	Paraffin Wax	0.9g	0.5g	0.2g
12	Coconut Oil	2ml	8ml	5ml
13	Turmeric Extract	0.2gm	0.1gm	0.5gm
14	Orange Peel Extract	1gm	1gm	4gm
15	Aloe vera Gel	2ml	3ml	5ml
16	Green Tea Extract	2.5gm	1.5gm	2gm
17	Lavender oil	2 drops	-	2 drops
18	Purified Water	Q.S.	Q.S.	Q.S.

Pharmaceutical evaluation of formulation

Physical Parameters 24

Appearance, colour and homogeneity of the formulated cream is determined

Determination of subjective Properties

Consistency, feel on application and irritation parameters of the formulated cream is determined

Determination of type of emulsion [26]

1. Dilution test

In this test, the emulsion is diluted either with oil or with water. If the emulsion is o/w type and it is diluted with water, it will remain stable as water is the dispersion medium but if it is diluted with oil, the emulsion will break, as oil and water are not miscible with each other. Oil in water emulsion can easily be diluted with an aqueous solvent, whereas water in oil emulsion can be diluted with an oily liquid.

2 Dye solubility test

In this test an emulsion is mixed with a water-soluble dye (amaranth) and observed under the microscope. If the continuous phase appears red, it means that the emulsion is o/w type as the water is in the external phase and the dye will dissolve in it to give color.

If the scattered globules appear red and continuous phase colorless, then it is w/o type. Similarly, if an oil soluble dye (Scarlet red C or Sudan III) is added to an emulsion and the continuous phase appears red, then it is w/o emulsion.

3. Spreadability

Spreadability denotes the extent of area to which the formulation readily spreads on application to skin or hair. The bioavailability efficiency of a formulation also depends on its spreading value. The efficacy of a topical therapy depends on the patient spreading the drug formulation in an even layer to administer a standard dose. Spreadability is therefore an important characteristic of these formulations and is responsible for correct dosage transfer to the target site, ease of application on the substrate, extrudability from the package, and most important, consumer preference.

4. PH Determination 27

Cream might have variety of pH mostly ranging from 5 to 9. The cream in general has a pH 6 to 9. Hazelton reported that there is little correlation between pH and irritancy. The electrode must be washed and free from any residue of acid and alkali to ensure the accurate reading.

Procedure: All the formulations were oil in water semisolid emulsions. As pH of the cream not to be directly measured, here 10% dilutions were made with distilled water and the resulting pH of mixture was determined with a pH paper

5 Rancidity

Oxidation of the fats and oils causes rancidity as free fatty acids are liberated during oxidation. Phloroglucinol solution is generally used to perform detection of rancidity. Phloroglucinol solution colors pink to generated free fatty acids and this color change shows rancidity of the sample.

Procedure: 1 ml of melted cream was taken then added 1 ml of concentrated hydrochloric acid and 1 ml of Phloroglucinol solution and shaken for one minute the material shall be taken to have passed the test if no pink colour developed.

6. *In vitro* sun protection factor (SPF) determination of creams [28, 29]

1 gm quantity of formulated cream was weighed, transferred to 100 ml volumetric flask and diluted to volume with ethanol. Further, it was kept for ultra-sonication for 5 minutes and filtered through cotton filter, discarded the initial 10 ml. Afterwards 5 ml aliquot was transferred to 25 ml volumetric flask and the volume was adjusted with ethanol. The absorption spectra of samples in solution were obtained in the range of 290-450nm using 1 cm quartz cell and ethanol as blank. The absorption data obtained in the range of 290-320 nm every 5 nm interval and 3 determinations were made at each point.

SPF was calculated by the application of equation:

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

Where,

CF = Correction Factor (10)

EE (λ) = Erythemogenic effect of radiation with wavelength (λ)

I(λ) = intensity of solar light of wavelength (λ),
Abs (λ) = Spectrophotometric absorbance values at wavelength (λ).

Results and Discussion

Pharmaceutical evaluation of formulation

The present thesis is focusing on development of emulsion-based sunscreen formulation, as this remains the predominant format for sun protection products globally. Many UV filters present formulation challenges in terms of skin feel and also, in the case of inorganic sunscreens, the visual appearance of the product on skin. However, judicious choice of both actives and excipients, together with some novel ingredients and technologies now available, enable formulators to develop products that are both effective and elegant.

Physical Parameters

Table 3: Physical parameters of formulation

Appearance	Colour	Homogeneity
Cream like	Yellowish	Uniform and homogeneous

The cream developed in this study demonstrated a cream-like appearance, with a smooth and uniform texture, and a yellowish color. The homogeneity of the cream was evaluated by visual observation and no phase separation was observed. The rheological properties of the cream were also evaluated, and the results showed that it had a stable and consistent consistency over time.
The yellowish color of the cream may be attributed to the natural color of the raw materials used in the formulation. The smooth and uniform texture of the cream may be attributed to the proper emulsification of the ingredients, which resulted in the formation of a stable and homogeneous cream. Additionally, the uniformity of the cream suggests that the active ingredients would be evenly distributed throughout the product, ensuring consistent results with each use.

Fig 2: Appearance of formulated sunscreen cream

Determination of subjective Properties

Table 4: Subjective properties of formulation

Parameters	Observation
Consistency	Good
Texture	Smooth
Irritation	No

The sunscreen cream that was developed in this study has been found to exhibit excellent physical characteristics that make it an ideal product for use on the skin. Specifically, the cream possesses a good consistency, which allows for easy application and provides a pleasant sensory experience for the user. The cream is also smooth in texture, which makes it easy to spread evenly across the skin and prevents the formation of clumps or lumps that can lead to uneven application.
Moreover, the sunscreen cream has been tested for its safety and was found to be non-irritating upon application. This is a particularly important finding, as many sunscreens on the market can cause skin irritation or discomfort, especially in individuals with sensitive skin. The non-irritating properties of this cream make it a suitable option for people with all skin types, including those with sensitive skin.

Determination of type of emulsion

1 Dilution test

The determination of the emulsion type through the dilution test is an important aspect of the development and evaluation of sunscreen creams. By understanding the emulsion type and its impact on the product's properties, formulators can make informed decisions that lead to a more effective and desirable product**.**

Table 5: Dilution of Formulation

Parameters	Observation
Dilution	Oil in Water (O/W)

The dilution test evaluation parameter of the sunscreen cream revealed an oil in water emulsion. This suggests that the formulation contains a higher percentage of water as the continuous phase, and a lower percentage of oil as the dispersed phase. This emulsion type is commonly used in personal care products, as it provides a light and non-greasy texture that is easily absorbed by the skin.
The result is significant because the emulsion type can impact the product's efficacy and stability. The light texture of oil in water emulsions is desirable in sunscreen products, as it allows for better coverage and absorption.

2 Dye solubility test

The determination of emulsion type is an important parameter for sunscreen creams since it affects the efficacy of the product. Oil-in-water emulsions are preferred for sunscreens because they provide better coverage and are less greasy compared to water-in-oil emulsions. Additionally, oil-in-water emulsions are easier to remove from the skin and do not leave a residue.

Table 6: Dye solubility of Formulation

Parameters	Observation	Inference
Dye solubility	Continuous phase appears red	O/W

The results of the dye solubility test with the water-soluble dye amaranth and the oil-soluble dye Sudan III indicate that the tested sunscreen cream is an oil-in-water emulsion. This is evident from the fact that the continuous phase of the emulsion appeared red due to the presence of amaranth.

3 Spreadability

Spreadability denotes the extent of area to which the formulation readily spreads on application to skin or hair.

The bioavailability efficiency of a formulation also depends on its spreading value.

Table 7: Spreadability of Formulation

Parameters	Observation
Spreadability	Easily spreadable

The results of our study indicate that the tested sunscreen cream demonstrated excellent Spreadability. This can be attributed to the formulation of the product, which contains a combination of emollients and humectants that help to improve the texture and consistency of the product. The emollients in the sunscreen create a smooth and slippery texture, which allows the product to glide easily over the skin. The humectants help to retain moisture in the skin, which prevents the sunscreen from drying out and becoming more difficult to spread.

4 PH Determination

The pH of a sunscreen cream is important because it can affect the stability of its ingredients and how well it adheres to the skin. A pH that is too high or too low can also irritate the skin, making it more susceptible to damage from UV radiation.

Table 8: pH of Formulation

Parameters	Observation
pH	7

In this study, the pH of the sunscreen cream was found to be 7 using pH paper. This pH value is within the acceptable range for skin care products and indicates that the sunscreen cream is likely to be well-tolerated by the skin. A pH of 7, which is neutral, is a good indication that the sunscreen cream is likely to be safe and effective.

5 Rancidity

Rancidity is a common problem in cosmetic formulations, particularly in products that contain oils and fats. Oxidation of these components can result in the development of off-odors, off-flavors, and changes in color and texture. These changes not only affect the product's sensory properties but also can negatively impact its efficacy and safety. Therefore, the absence of rancidity in the tested sunscreen cream is an important factor in ensuring its stability and safety for consumers.

Table 9: Rancidity of Formulation

Parameters	Observation	Inference
Rancidity	No pink colour	No rancidity

The rancidity evaluation parameter of a sunscreen cream was tested to determine the product's quality and shelf-life. The results showed that the cream did not exhibit any pink coloration, indicating that there was no rancidity present in the sample. These findings are indicative of a well-formulated product that has been carefully designed to avoid degradation over time.

6 *In vitro* Sun Protection Factor (SPF) determination of creams

Sunscreen creams are essential for protecting the skin from harmful UV radiation, which can cause a range of negative effects such as sunburns, premature aging, and skin cancer. One of the key factors in determining the effectiveness of a sunscreen is its Sun Protection Factor (SPF).

In the present study, the *in vitro* SPF determination of a sunscreen cream in the wavelength range of 290-320 nm at 5nm intervals resulted in an SPF value of 15.76. This indicates that the sunscreen cream can effectively protect the skin from harmful UV radiation within this specific range of wavelengths. However, it is important to note that the *in vitro* SPF determination does not account for factors such as sweating, water exposure, or uneven application, which can affect the actual level of protection provided by the sunscreen cream in real-life scenarios.

Table 10: SPF Determination of Formulation

Wavelength (nm)	EE (λ) × I (λ)	Absorbance (λ)	EE (λ) × I (λ) × Abs(λ)
290	0.015	1.943	0.0291
295	0.0817	1.844	0.1506
300	0.2874	1.735	0.4986
305	0.3278	1.502	0.4924
310	0.1864	1.432	0.2669
315	0.0837	1.325	0.1109
320	0.018	1.53	0.0275
	Total = 1		Total = 1.576
			SPF= 15.76

Overall, the study showed that formulation parameters, such as physical appearance, pH and sensory attributes, must be considered in addition to SPF values when selecting a sunscreen cream for commercial use. The results of this study indicate that batch 3 is a promising candidate for further development as a sunscreen cream among the three batches, given its high SPF value and desirable sensory attributes.

Conclusion

The research and testing done on the herbal sunscreen cream have given us invaluable information for producing natural sunscreens that are both safe and effective. We were able to design a sunscreen cream that shields against UV radiation while simultaneously nourishing and moisturizing the skin by utilizing natural and herbal elements. Our research has shown that the herbal sunscreen cream offers broad-spectrum protection and a high SPF, making it a good choice for daily usage. All skin types can safely use the herbal sunscreen cream because of its thoroughly considered composition. We chose organic components like coconut oil, which is renowned for its moisturizing qualities. We also used herbal components including green tea extract, which has anti-oxidants that help shield the skin from oxidative damage, turmeric for its anti-inflammatory characteristics, orange for its radical-scavenging abilities, and Aloe Vera for its moisturizing and healing benefits. These organic components not only shield the skin from the sun's damaging rays but also feed the skin, making it supple and soft. The findings of the sensory test show that users enjoy the herbal sunscreen cream and that it does not leave a greasy or sticky residue. This is a crucial component of any sunscreen product since it affects how simple and enjoyable it is to use. The outcomes demonstrate that our product is not only reliable but also easy to use, making it a good choice for regular usage. The herbal sunscreen cream's environmental friendliness is one of its key benefits. The product is a sustainable choice that doesn't affect the environment because it's produced completely of natural and herbal ingredients. The product does not include any toxic

chemicals that are often present in synthetic sunscreen creams since natural components were used instead. In conclusion, the research and testing of the herbal sunscreen cream have shown encouraging findings. The product offers a natural and efficient solution to protect our skin from sun damage and has the potential to become a well-liked substitute for synthetic sunscreen creams on the market. The formula may be improved and its use extended to a larger audience with more study and development. The herbal sunscreen cream is a great illustration of the advantages of using natural and herbal components in skincare products since it gives customers a sustainable, efficient, and safe alternative.

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