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Formulation and Evaluation of Herbal Sunscreen Lotion by Using Moringa Oleifera and Curcuma Longa Extract

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Abstract: The increasing awareness of the harmful effects of UV radiation has driven the demand for safer and more effective sun protection products. This study focuses on the formulation and evaluation of herbal sunscreen lotions using natural ingredients such as Moringa oleifera, Curcuma longa, Aloe vera, and other plant-based components. These formulations were developed using maceration and emulsification techniques, followed by a comprehensive evaluation of physical parameters, pH, viscosity, spreadability, homogeneity, stability, irritancy, and Sun Protection Factor (SPF). Among the three formulations (F1, F2, and F3), F3 demonstrated superior properties, including the highest SPF value of 39.65, indicating excellent photoprotective potential. All formulations were found to be non-irritant, thermally stable, and cosmetically acceptable. The results support the potential of herbal-based sunscreens, in combination with safe mineral agents like zinc oxide, as effective alternatives to chemical products, providing broad-spectrum UV protection with minimal side effects.

Keywords: Herbal sunscreen, Moringa oleifera, Curcuma longa, SPF, UV protection, photoprotection, natural formulation, skin care.

1. Introduction:

Sunscreens are substances that block, scatter, or absorb ultraviolet light. It regulates harmful consequences such as accelerated aging, which can result in wrinkles, sagging, and UV-induced hyperplasia. Sunscreen is increasingly being used as a photoprotective agent to defend against UV rays. A formulation that prevents sunburn on the treated region when applied topically is called a sunscreen preparation. The purpose of sunscreens is to support the body's resistance against the sun's damaging UV rays.[1]

• UVA: With the longest wavelength (320–400 nm), UVA damages the skin's dermis and internal cells, causing sunburn and tanning immediately.

• UVB: This medium wavelength (290–320 nm) causes blisters, sunburned skin, and prolonged darkening by harming the cells in the epidermis.

•UVC: its shortest wavelength, which ranges from 100 to 290 nm, harms the epidermis' outermost cells, causing inflammation, infections, and lesions.[2]

Sunscreen formulations including antioxidant-active ingredients help prevent skin conditions brought on by ultraviolet light. By absorbing UV rays, flavonoids, one of the many active antioxidant chemicals, can combat UV-induced radicals and offer protection from UV radiation. Because flavonoid compounds include chromophores, or conjugated double bonds, which may absorb UV A and UV B rays and lessen their intensity on the skin, they have the potential to be used as sunscreens.[3]

Sunscreen Ideal Properties:

- Needs to absorb a wide spectrum of UV radiation to prevent sunburn
- Resistance against UVB and UVA rays
- It must be able to provide protection for the entire skin
- It must remain steady when exposed to sunlight
- The active compound's stability and safety
- It should be chemically inert, safe, and effective at low concentrations
- Must not result in toxicity, sensitization, or irritation
- Filtering shouldn't be stained
- Antioxidant and scavenging of reactive oxygen species
- The ability to prevent mutations
- The anticancer property [2]

Mechanism of Photoprotection:

Sunscreens work by blocking and reducing the harmful effects of UV radiation after exposure to the sun. It has been shown that sunscreens improve the skin's resistance to UV rays. They mainly function via two processes, which are explained below. A visual representation of the mentioned mechanisms of action is provided in Fig. 01.

(a) UV radiation is reflected and scattered off the skin's surface. This is how mineral-based (inorganic) sunscreens mostly function. They offer a protective layer that prevents sunlight from reaching the skin.

(b) Absorption of the UV energy by transforming it into thermal energy, which lessens the damage it causes and the depth at which it can enter the skin. This is the main way that organic sunscreen function.

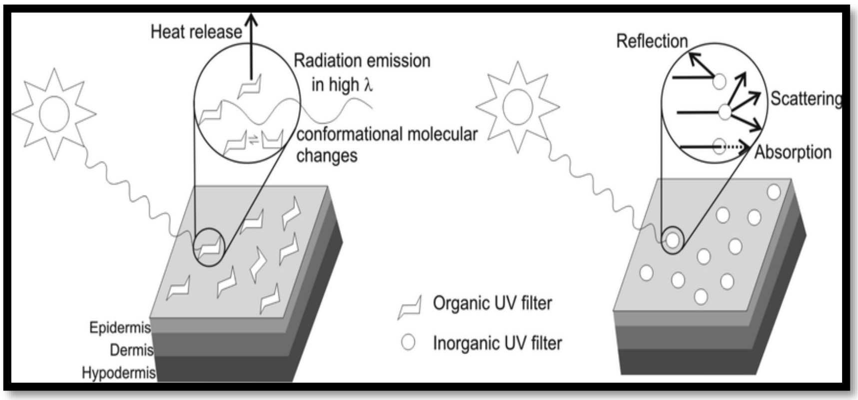

Fig no. 01: Mechanism of action of organic and inorganic sunscreens.

To provide protection against a variety of UV rays, chemical sunscreen products often contain a number of organic components. The compound's high effectiveness can be attributed to inorganic particles scattering the microparticles in the top layers of skin, which increases the optical route of photons. This increases the absorption of photons and improves the sun protection factor (SPF). [4]

2. Material and Methods:

Instruments: Analytical balance (Wensar), Digital pH meter (Denwar), Brookfield Viscometer (Labman), UV spectrophotometer (Labman).

Plant Material: The plant material used in the formulation was collected from the medicinal garden of PCOP Dighanchi, Maharashtra

Method of Preparation:

• Preparation of Crude Extract of Curcuma Longa and Moringa Oleifera:

Ethanol, a widely used solvent because of its capacity to dissolve a variety of bioactive chemicals and its relative safety for pharmacological use, is used to soak dried and powdered Moringa oleifera leaves and dried and powdered rhizomes of Curcuma Longa.[5] The mixture is allowed to naturally steep for approximately three days at room temperature without mechanical agitation or stirring, while a standard solvent-to solid ratio of 10:1 is maintained.[6]

The mixture is filtered to remove the liquid extract from the plant material following the threeday maceration. Because it effectively removes polar and semi-polar substances, such as flavonoids and phenolic acids, while preserving the compounds' integrity, ethanol is utilized.[5][7]

Fig no. 02: Extract of A. Moringa Oleifera and B. Curcuma Longa

Phytochemical Screening of Different Qualitative Chemical Tests:
It may be used to determine the chemical composition of ethanol and aqueous extract profiles. To find out which phytoconstituents were present in the extracts, the following tests were conducted on them.[2]

• Tests For Curcuma Longa and Moringa Oliefera:

1) Detection of Curcuminoid (only for Curcuma Longa)
Hydrochloric Acid Test
To 2ml of the extract, add a few drops of strong hydrochloric acid. The presence of curcuminoids is indicated by a red coloring.[8]

2) Detection of Alkaloids
Dragondroff's Test
Add 1-2ml of Dragendorff's reagent to a few ml of the extract. Alkaloids are confirmed to be present when an orange or reddish-brown precipitate forms.[9]

3) Detection of Flavonoids
Lead Acetate Test
To 2 ml of the extract, add a few drops of a 10% lead acetate solution. When flavonoids are present, a yellow precipitate forms.[10]

4) Detection of Tannins
Ferric Chloride Test
To two ml of the extract, add two to three drops of a 5% ferric chloride solution. Tannins are indicated by a blue-black or green coloration.[11]

5) Detection of Saponins
Foam Test
In a cylinder, shake 50 mg of the extract for 15 minutes with 20 ml of purified water. When saponins are present, a stable foam layer of around 2 cm is present.[9]

6) Detection of Phenols
Ferric Chloride Test
To two ml of the extract, add two to three drops of a 5% ferric chloride solution. Tannins are indicated by a blue-black or green coloration.[10]

7) Detection of Steroids

Libermann-Burchard Test
Add 2 ml of chloroform, 1 ml of acetic anhydride, and 1 ml of concentrated sulfuric acid to 2ml of the extract. green or bluish-green ring at the junction of the two layers shows the presence of steroids.[11]

8) Detection of Glycosides
Keller-Killiani Test
Layer 1 ml of concentrated sulfuric acid on top of 2 ml of extract after adding 1 ml of glacial acetic acid containing ferric chloride. Glycosides are shown at the contact by a reddish-brown ring.[10]

Fig no. 03: Phytochemical tests of Curcuma Longa.

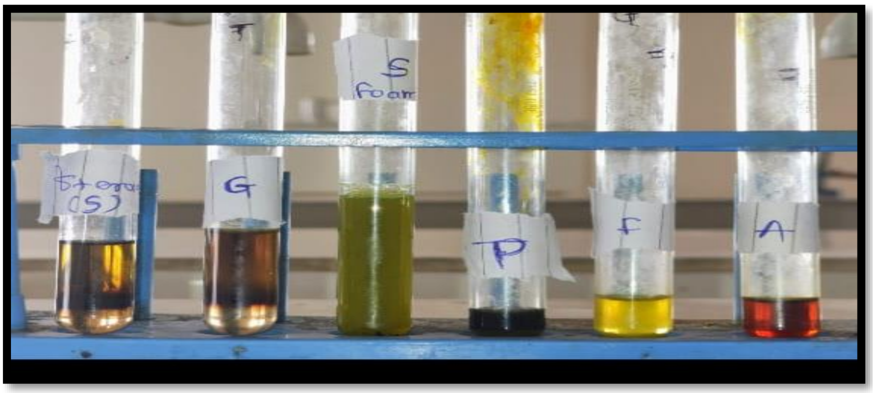

Fig no. 04: Phytochemical tests of Moringa Oliefera.

3. Preparation of sunscreen lotion:

Table no. 01: List of Ingredients

Ingredients	**F1**	**F2**	**F3**
Moringa Oliefera extract	2ml	2ml	2.5ml
Curcuma Longa extract	2ml	2.5ml	2ml
Stearic Acid	2 gm	2gm	2gm
Cetyl Alcohol	2 gm	2gm	2gm
Zinc Oxide	3 gm	4gm	5gm
Carbopol 940	0.02 gm	0.02gm	0.02gm
Olive Oil	8 ml	5ml	5ml
Coconut Oil	2 ml	5ml	5ml
Glycerin	5 ml	5ml	5ml
Rose Water	1 ml	1ml	1ml
Rose Oil	0.25 ml	0.25ml	0.25ml
TEA	2ml	2ml	2ml
Propyl Paraben	0.25 gm	0.25ml	0.25ml
Aloe Vera Gel	1 gm	2gm	2gm
Distilled Water	20 ml	20ml	20ml
Total	50gm	50gm	50gm

• Preparation Method:

1. Preparation of the Oil Phase

In a beaker set over a water bath, cetyl alcohol and stearic acid were precisely weighed and melted. After melting, propyl paraben and zinc oxide were added, and the liquid was heated further while being gently stirred to guarantee even dispersion. After that, glycerin, coconut oil, and olive oil were added to the liquefied mixture and heated until it melted completely.

2. Preparation of Carbopol Gel (two hours before treatment)

In order to create a gel-like structure, 0.02 g of Carbopol 940 was separately added to 10 ml of distilled water and left to hydrate and swell for two hours without being disturbed.

3. Formation of Emulsions

To create a homogenous emulsion, the oil phase (previously prepared) was gradually added to the carbopol gel foundation while being constantly stirred with a mechanical stirrer.

4. Using TEA to Prepare the Aqueous Phase

Two ml of triethanolamine (TEA) were added to 20 ml of distilled water that had been heated to 70 to 75 degrees Celsius in a different beaker. This combination was kept at the same temperature while being agitated.

5. Emulsification and Combination

To help neutralize the carbopol and stabilize the emulsion, the TEA-containing aqueous phase was gradually added while being constantly stirred.

6. Cooling and Adding Active Ingredients

The mixture was allowed to cool to below 40°C after being well mixed. At this point, aloe vera gel, moringa extract, and Curcuma longa extract were added after rose water and rose oil. To guarantee that the active ingredients were distributed evenly, the resultant mixture was completely homogenized using a stirrer.[12]

Fig no. 05: Formulations F1,F2,F3.

4. Herbal Sunscreen Lotion Evaluation:

4.1 Physical parameters:

In order to evaluate fragrance and consistency, the sunscreen formulation's color, odour, and look were carefully examined through eye inspection and hand application. [24]13

4.2 Determination of pH:

pH was determined using a digital pH meter (Denwar). After calibration, readings were obtained.[13]

4.3 Determination of Viscosity:

A Brookfield viscometer (Labman) was used to measure viscosity. The rpm was set to 5 and spindle number 4 was utilized. A 50 ml beaker was filled with about 50 g of the sample. The dial reading was used to determine viscosity. [13]

4.4 Spreadability:

By sandwiching 1 g of formulation between two glass slides and applying a specified weight, spreadability was evaluated. It was noted how long it took the upper slide to travel a certain distance.

The formula
$S = M \times L$ S = T M×L

Where:
S stands for spreadability.
M = The upper slide's weight

L is the glass slide's length.
T = Slide separation time in seconds.[13]

4.5 Washability:

A tiny bit of the formulation was applied to the skin, and as it dried, it was rinsed off with ordinary water. A visual assessment was made on the ease of removal.[13]

4.6 Homogeneity:

Through visual inspection, homogeneity was assessed for smoothness, uniform distribution, and uniformity throughout application.[13]

4.7 Irritancy Test:

The volunteers' left dorsal surface was marked in an area of one square centimeter. Erythema, redness, or edema symptoms were monitored for up to 24 hours after lotion was applied.[13]

4.8 Determination of SPF:

20 ml of ethanol and 0.20 g of the herbal lotion were combined, filtered, and used as a stock solution. The blank was made of ethanol. A UV-Vis spectrophotometer (Labman) was used to measure absorbance at 5-nm intervals between 290 and 320 nm. The Mansur formula was used to determine SPF:

SPF=CF×290∑320EE(λ)×I(λ)×Abs(λ)[14]

4.9 Stability Testing:

For 20 days, the formulation was kept at room temperature and at 45 ± 1°C. The 0th, 5th, 10th, 15th, and 20th days were evaluated for variations in color, smell, phase separation, and consistency.[13]

5. Result And Discussion:

The herbal sunscreen lotions (F1, F2, F3) were formulated using various natural ingredients and evaluated for key physicochemical and performance parameters. The findings are summarized and discussed below.

5.1 Phytochemical Screening Test:

Table no. 02: Phytochemical screening test

Sr. No.	Phytoconstituent	Test Name	Present In
1	Curcuminoids	Hydrochloric Acid Test	Curcuma longa only
2	Alkaloids	Dragendorff's Test	Moringa Oleifera and Curcuma Longa
3	Flavonoids	Lead Acetate Test	Moringa Oleifera and Curcuma Longa
4	Tannins	Ferric Chloride Test	Moringa Oleifera and Curcuma Longa
5	Saponins	Foam Test	Moringa Oleifera and Curcuma Longa
6	Phenols	Ferric Chloride Test	Moringa Oleifera and Curcuma Longa
7	Steroids	Libermann-Burchard Test	Moringa Oleifera and Curcuma Longa
8	Glycosides	Keller-Killiani Test	Moringa Oleifera and Curcuma Longa

The Phytochemical analysis of the selected herbal extracts revealed the presence of various bioactive compounds that contribute significantly to the sunscreen properties and overall efficacy of the formulations.

5.2 Determination of Evaluation Parameters of Herbal Sunscreen Lotion

Table no. 03: Determination of Evaluation Parameters of Herbal Sunscreen Lotion

Parameter	F1	F2	F3
Colour	Beige	Light Yellow	Light beige
Odour	Rose like	Rose like	Rose like

Appearance	Good	Good	Good
Washability	Washable	Washable	Washable
State	Semisolid	Semisolid	Semisolid
Texture	Smooth	Smooth	Smooth
pH	5.34	5.17	5.25
Viscosity (cP)	11,520	12,919	10,300
Spreadability (mm)	28	22	24
Irritancy Test	No irritation	No irritation	No irritation
Homogeneity	Homogenous	Homogenous	Homogenous

All three formulations appeared semisolid, smooth, and were easy to wash off. Their pleasant rose-like odour and uniform appearance reflected successful formulation. The result of pH of prepared lotion was found to be around 6 which was suitable for topical application. F2 had the highest viscosity (12,919 cP), while F3 had the lowest (10,300 cP). F1 exhibited a balanced viscosity (11,520 cP), making it easy to spread while still maintaining a stable structure on the skin. These values suggest that all formulations are suitable in consistency for sunscreen application. Spreadability is a critical factor for ease of application. F1 had the highest spreadability (28 mm), followed by F3 (24 mm) and F2 (22 mm). F1 was the easiest to apply evenly, which is favorable for consumer use. All formulations were homogeneous, with no visible lumps or separation. Each lotion was also easily washable, indicating that the base formulation and emulsification were effective and user-friendly. None of the formulations caused redness, swelling, or irritation in the skin irritation test. This confirms that the herbal ingredients used are non-irritant and safe for regular topical application.

- **Determination of SPF**

Table no. 04: Determination of SPF

Wavelength (nm)	**EE × I**	**Absorbance F1**	**EE×I×Abs F1**	**Absorbance F2**	**EE×I×Abs F2**	**Absorbance F3**	**EE×I×Abs F3**
290	0.015	3.5081	0.05262	3.161	0.04742	4.0229	0.06034
295	0.0817	3.5828	0.29279	3.1849	0.26029	3.1732	0.25934

300	0.2874	3.7194	1.06912	3.2001	0.91933	2.7307	0.78470
305	0.3278	3.9683	1.30041	3.1367	1.02846	2.426	0.79503
310	0.1864	4.3141	0.80412	2.8398	0.52921	2.1594	0.40231
315	0.0839	4.3685	0.36651	2.2268	0.18678	1.9644	0.16476
320	0.018	4.3955	0.07912	1.5727	0.02831	1.8357	0.03304
Σ Products			3.96469		2.99980		2.49952
SPF Value			**39.65**		**30**		**25**

SPF values were calculated using the Mansur equation based on UV absorbance:

- F1: SPF 39.65
- F2: SPF 30.00
- F3: SPF 25.00

These values place all three formulations in the high-protection category, with F1 providing the most effective sun protection. The high SPF values are attributed to the presence of flavonoids, phenolics, and curcuminoids, along with zinc oxide which enhances UV blocking.

- **Determination of Thermal Stability**

Table no. 05: Determination of Thermal Stability

Formulation	**After 5 days**	**After 10 days**	**After 15 days**
F1	Stable	Stable	Stable
F2	Stable	Stable	Stable
F3	Stable	Stable	Stable

The lotions remained stable during storage under room and elevated temperatures. No oil separation, color change, or texture change was observed over 15 days, indicating excellent thermal stability.

6. Conclusion:

The study successfully formulated and evaluated three herbal sunscreen lotions using natural plant-based ingredients. Among them, Formulation F1 emerged as the most effective, showing high SPF, good spreadability, ideal viscosity, and no adverse effects on skin. The findings support the feasibility of using herbal extracts, supported by mineral agents like zinc oxide, as safer alternatives to synthetic sunscreen agents. Further long-term and in vivo testing is recommended to validate these results and expand their application in the cosmeceutical industry

7. Acknowledgement:

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8. Summary:

- Herbal sunscreens were formulated using Moringa, Turmeric, Aloe vera, and other natural ingredients.
- All three formulations were skin-compatible, stable, and non-irritant.
- F1 exhibited the best overall performance with SPF 39.65, ideal for high UV protection.
- Zinc oxide, though not a herbal ingredient, contributed to broad-spectrum protection as a safe mineral UV filter.

Results highlight the potential of plant-based sunscreens as safe, effective skincare solutions.

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