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Formulation and Evaluation of Sun Shielding Capabilities of Trianthema Species.

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ABSTRACT

This study investigates the sun-shielding capabilities of Trianthema species, a plant traditionally known for its medicinal properties. The research aims to formulate a sun-protective product, such as a cream or gel, using extracts from the leaves and stems of the plant. The first step involves extracting bioactive compounds, specifically flavonoids and phenolic acids, which are known to absorb UV radiation. The extracts are then incorporated into a suitable base to create a stable and effective formulation.

The sun-shielding efficacy of the final product is evaluated using both in vitro and in vivo methods. In vitro analysis involves measuring the UV absorbance of the formulation using a spectrophotometer to determine its Sun Protection Factor (SPF). The SPF is a numerical value that indicates the level of protection against UVB rays, which are the primary cause of sunburn. In vivo testing involves applying the product to the skin of volunteers and exposing them to controlled doses of UV radiation to measure its actual protective effect and any potential skin irritation. The results are compared with a commercially available sunscreen to assess its relative efficacy.

INTRODUCTION

Cosmetics have been an integral part of human culture for thousands of years, transcending time, geography, and social boundaries. From the elaborate kohl eyeliner of ancient Egypt to the sophisticated skincare routines of modern-day South Korea, cosmetics have not only served as a tool for beautification but have also held cultural, social, and even spiritual significance. Historically, they were symbols of status, health, and identity—worn by pharaohs, emperors, warriors, and commoners alike. Over time, cosmetics have evolved from rudimentary concoctions made from natural elements like charcoal, clay, and crushed berries into highly sophisticated products developed through advanced scientific research and technology.

The Structure and Function of Human Skin

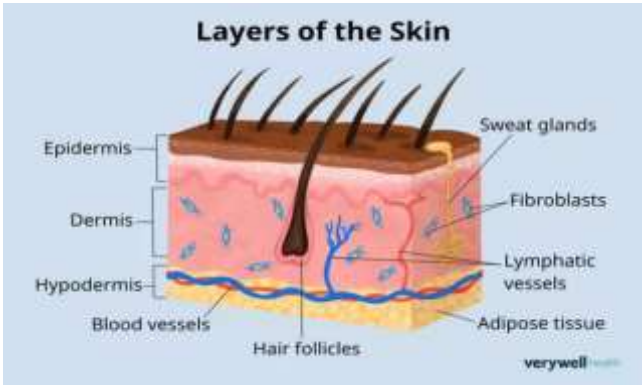

Figure 1.1: Structure of skin

The skin functions as a protective barrier, sensory organ, and a key component in thermoregulation and immune response. Its interaction with sunlight is most evident in the epidermal layer, where photoreceptors and pigment cells respond to ultraviolet (UV) radiation**.**

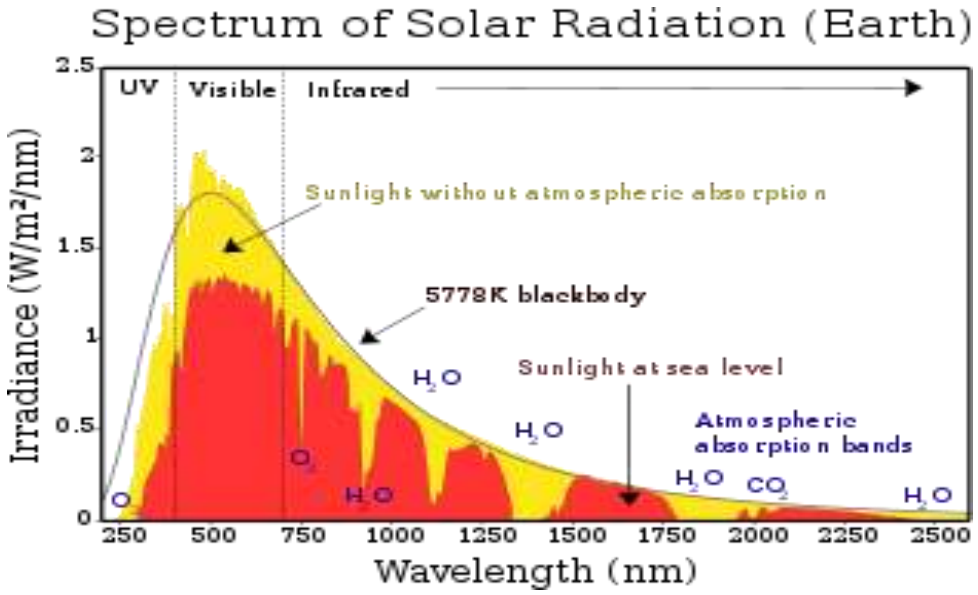

Figure 1.2 Solar spectral irradiance

Sunlight is composed of electromagnetic radiation, including:

- **Visible Light:** The portion we can see.
- **Infrared Radiation (IR):** Felt as heat.
- **Ultraviolet Radiation (UV):** Invisible but highly biologically active.

UV radiation is further divided into:

- **UVA (320–400 nm):** Penetrates deep into the skin, associated with aging and long- term skin damage.
- **UVB (290–320 nm):** Affects the surface of the skin and is responsible for sunburn and the synthesis of vitamin D.
- **UVC (100–290 nm):** Mostly absorbed by the ozone layer and does not reach the Earth's surface.

Plant Profile

Trianthema portulacastrum

Taxonomy

- **Family:** Aizoaceae
- **Genus:** *Trianthema*
- **Species:** *Trianthema portulacastrum* L.
- **Common Names:** Horse purslane, Desert horse purslane, Giant pigweed
- **Vernacular Name:**
- **Hindi:** Santhi, Sathiyo

Pharmacological Properties

1. **Antioxidant** – Free radical scavenging activity through DPPH and FRAP assays.
2. **Hepatoprotective** – Protects against chemically-induced liver damage.
3. **Anti-inflammatory** – Inhibits inflammatory mediators.
4. **Antimicrobial** – Effective against several bacterial and fungal strains.
5. **Antidiabetic** – Demonstrates hypoglycemic effects in experimental models.

6. **Wound healing** – Promotes tissue regeneration.

MATERIALS AND METHOD

Selection of the plant

On the ground of literature review and deep discussion with supervisor and co- supervisor *Trianthema portulacastrum* plant is selected for the formulation of sunscreen preparation.

Procurement

The plant material of *Trianthema portulacastrum* was collected in the month of June- July from botanical garden of Ashtang Ayurvedic College, Indore.

1.1 Preparation of crude drug for extraction

For extract preparation, leaves of selected plants were used. Leaves of selected plant were gathered and dehydrated in shade. After drying, leaves were powdered coarsely using mechanical grinder. This coarse powder of plant leaves was then screened through sieve No. 16. And after passing they were stored in an airtight container for the extraction (Ghuman S et al., 2011)**.**

1.2 Preparation of plant extract

The gathered, neat and grounded leaves of *Trianthema portulacastrum* was selected for the extraction method. 500 gm of powdered material was evenly packed in the soxhlet apparatus. It was then extracted with ethanol, water, chloroform, acetone and Hydroalcoholic solvent. These solvent was purified before use. The extraction strategy utilized was consistent hot percolation and done with different solvents, for 72 hrs. The extractwas concentrated by vacuum distillation to reduce the volume to 1/10; the transfer this concentrated extract to 100ml beaker and evaporate the remained solvent using water bath. Cooled it and placed in a dessicator to remove the excessive moisture. The dried extractwere packed in airtight containers and used for further studies.

1.3 *In-vitro* antioxidant activity

DPPH radical scavenging activity

DPPH i.e. 2,2-diphenyl-1-picrylhydrazyl, an organic chemical compound having stable free-radical molecules, used to monitor the reactions that involve radicals for antioxidant assay. To perform this assay, leaf extracts of plantwas evaluated for their free radical scavenging activities. This method is relying on reduction of a methanolic solution of the coloured DPPH radical. DPPH reacts with an antioxidant compound, that can donate hydrogen, DPPH is reduced and changes in color (from deep violet to light yellow) were read at 517 nm (Blois 1958). First prepared 0.1mM solution of DPPH reagent in methanol in a set of test tubes and measure their absorbance. To these test tubes (containing 1ml of solution), add 3ml methanolic solution of different extract in concentration of 10, 20, 30, 40, 50 and 100 µg and incubate for 30 min at 517nm and check the absorbance. Ascorbic acid was taken as reference drug. This test was performing in triplicate and the results averaged. The percentage reduction in absorbance was determined from the initial and final absorbance of each solution. (Gulcin İ et al., 2023)

Percentage scavenging of DPPH radical was calculated using the formula

$$\% \text{ Scavenging of DPPH} = \frac{[\text{Absorbance of Control} - \text{Absorbance of Test}]}{[\text{Absorbance of Control}]} \times 100$$

1.4 Formulation of gel

Firstly carbopol 934 was dispersed in distilled water and purified water kept the beaker aside to swell the carbopol 934 for half an hour. and then stirring should be done to mix the Carbopol 934 to form gel. In another beaker weight and transfer the required quantity of extracted drug powderand dissolved in polyethylene glycol the solution was added and mixed to the first solution. 5ml of distilled water was taken and required quantity of methyl paraben dissolved by heating on water bath and solution was cooled. Finally full mixed ingredients were mixed properly to the carbopol 934 gel with continuous stirring and lastly triethanolamine was added drop wise to the formulation for adjustment of required skin pH (6.8 -7) and to obtain the gel at required consistency.

Evaluation of Gel

Physical Parameters

Appearance, color and homogeneity are determined.(Ayalu R et al., 2016)

Determination of subjective Properties

Consistency, feel on application and irritation parameters are determined

Spreadability

Two glass slides of standard dimensions (20cm×5cm) were selected. The formulation was over one of the slide. The other slide placed on the top of the cream such a that the formulation sandwiched between the two slides in an area occupied by a distance of 7.5 cm, alongside 100 gm weight was placed uniformly to form a thin layer

The weight was removed and the excess of cream adhering to the slides was scrapped off. The two slides in a position were fixed to stand (45° angle) without slightest disturbance and in such a way that only the lower slide held firmly by the opposite fangs of the clamps allowing the upper slide to slip off freely by the force of weight tied to it. 60 gm of weight was tied to the upper slide carefully. The time taken for the upper slide to travel the distance of 5 cm and separate away from the lower slide under the

direction of weight was noted. The experiment repeated for 3 times and the mean taken for three such dimensions was calculated. (Boonme P, et al., 2016)

The spreadabilityis calculated by using formula: = - Where, S= Spreadability, L= Length of glass slide, M= Weight tied to the upper slide and T= Time. In present experiment M= 60 gm and L= 7.5 cm.

Extrudability

The formulation was filled in the standard capped collapsible aluminum tubes and sealed by crimping the ends. The weight of the tubes was recorded. The tube was placed between two glass slides and was clamped. A 500 gm gel was placed over the glass slides and then the cap was removed. The amount of cream extruded was collected and weighed. The percent of cream was calculated and graded as follow

90% Extrudability = + + + + Excellent 80% Extrudability = + + + Good

70% Extrudability = + + Fair 50% Extrudability = + Poor

pH Determination

Formulation might have variety of pH mostly ranging from 5 to 9. The gel 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 meter (Boonme P et al., 2016)

Viscocity

The correct spindle was selected for the given product then the operating condition was setup. Then the viscosity was measured directly at 6 rpm speed by keeping the torque constant. The mean was obtained.[Saraf S, et al., 2008]. The viscosity is determined by following formula:

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

In Vitro SPF determination

The in-vitro determination SPF of synthetic sunscreen agents (Oxybenzone and Avobenzone) was done by UVSpectrophotometer. These sunscreen agents are widely used in the sunscreen formulation. The results of oxybenzone and avobenzoneare shown in the table 4.50-4.51 respectively. SPF of active drugs, formulated creams, marketed sunscreen products and synthetic sunscreen agents were calculated by the application of equation:

320

SPF= CF Σ EE (λ) X I (λ) X Abs (λ)

290

The aliquot prepared were scanned between 290-320 nm and the obtained absorbance values were multiplied with the respective EE (λ) and I (λ) values. Then, their summation was taken and multiplied with the correction factor (10) (Mali SS et al., 2018)

Stability studies

Stability studies as per ICH guidelines For assessing the stability of formulated gel, the following parameters were taken into consideration like colour, liquefaction, phase separation, viscosity, extrudability, spreadability, pH and SPF of formulation. To ensure that the product is stable throughout its designated shelf life, the stability studies are essential. The stability was carried out instability chamber at 40 ±2 °C and 75 ± 5% humidity for 30 days. (Tolba MM et al., 2016)

RESULTS AND DISCUSSION

Selection of the plant

On the ground of literature review and deep discussion with medical practitioners of the Indore (M.P.) plant *Trianthema portulacastrum* is selected for evaluation of the antioxidant and Sunscreen activity.

Preliminary phytochemical evaluation of selected plants

Carbohydrates

Carbohydrates were detected in ethanol, acetone, and hydroalcoholic extracts via Molisch's test. Their absence in the aqueous extract is unusual and may be due to lower solubility or presence of interfering substances. Ethanol and hydroalcoholic solvents, being semi-polar, effectively extracted carbohydrate-rich fractions.

Glycosides

Legal's test indicated the presence of glycosides in water, acetone, and hydroalcoholic extracts. Glycosides are generally polar, hence their solubility in water and polar solvent combinations like hydroalcoholic extract is expected. Their absence in ethanol may reflect selectivity for other constituents.

Fixed Oils and Fats

The spot test confirmed fixed oils and fats in ethanol, chloroform, and hydroalcoholic extracts. These non-polar to semi-polar compounds were well extracted by ethanol and chloroform, aligning with their lipophilic nature. Water and acetone were less efficient in their extraction.

Proteins and Amino Acids

Millon's test showed positive results for ethanol, chloroform, and acetone extracts. The absence in water and hydroalcoholic extract might be due to denaturation or lower solubility in mixed solvents. Protein solubility can be highly pH and solvent-dependent.

Saponins

Saponins were present in all tested extracts as confirmed by the foam test. Their amphiphilic nature allows them to dissolve in both polar and non-polar solvents, explaining their widespread detection. This also supports their traditional use in skin and liver formulations.

Phenolic Compounds and Tannins

$FeCl_3$ test showed phenolics and tannins in ethanol, water, acetone, and hydroalcoholic extracts, but not in chloroform. Their polar nature explains their absence in the non- polar chloroform extract. These compounds are key contributors to the plant's antioxidant and anti-inflammatory activities.

Phytosterols

Detected in ethanol and chloroform extracts via the Salkowski test, phytosterols are lipophilic and are usually found in non-polar or semi-polar extracts. Their absence in water and hydroalcoholic solvents reflects their low water solubility.

Alkaloids

Alkaloids were present in ethanol, water, chloroform, and hydroalcoholic extracts. These basic nitrogenous compounds are often soluble in both polar and moderately polar solvents, which aligns with the findings. Their absence in acetone may reflect lower extractive efficiency or instability.

Gums and Mucilage

Insolubility tests confirmed gums and mucilage in all extracts except water. This is unexpected, as these hydrophilic substances usually dissolve well in water. The result may suggest limited solubility under the specific test conditions or loss during filtration.

Flavonoids

Flavonoids were widely distributed across all extracts except acetone, as shown by the sodium hydroxide test. Being polyphenolic in nature, flavonoids typically show high solubility in alcohols and hydroalcoholic mixtures. Their absence in acetone could be due to precipitation or degradation.

Table 5.1: Results of Preliminary phytochemical evaluation

S. No.	Constituents	Tests	Ethanol extract	Water extract	Chloroform extract	Acetone extract	Hydro- alcoholic extract
1	Carbohydrate	*Molisch's test*	+	-	-	+	+
2	Glycosides	*Legal's test*	-	+	-	+	+
3	Fixed oil and Fats	*Spot test*	+	-	+	-	+
4	Proteins and Amino Acids	*Millon's test*	+	-	+	+	-
5	Saponins	*Foam test*	+	+	+	+	+
6	Phenolic Comp. and Tannins	*FeCl3 test*	+	+	-	+	+
7	Phytosterols	*Salkowski test*	+	-	+	-	-

S. No.	Constituents	Tests	Ethanol extract	Water extract	Chloroform extract	Acetone extract	Hydro- alcoholic extract
8	Alkaloids	*Dragendorff's test*	+	+	+	-	+
9	Gums and Mucilage	*Insolubility test*	+	-	+	+	+
10	Flavonoids	*Sodium hydroxide solution test*	+	+	+	-	+

In-vitro antioxidant activity

DPPH radical scavenging activity

The antioxidant reacts with stable free radical DPPH and converts it to 1,1-diphenyl-2- picryl hydrazine. The ability to scavenge the free radical, DPPH was measured at an absorbance of 516 nm. The DPPH (2,2-diphenyl-1-picrylhydrazyl) radical scavenging assay is a standard method used to evaluate the antioxidant potential of plant extracts by measuring their ability to donate hydrogen and neutralize free radicals. The results of the assay for various extracts of *Trianthema portulacastrum* and ascorbic acid (used as the reference standard) are presented across increasing concentrations (10–100 µg/mL).

Standard Reference – Ascorbic Acid

As expected, ascorbic acid demonstrated strong and concentration-dependent radical scavenging activity, with 95.25% inhibition at 100 µg/mL. This establishes a benchmark for comparison.

Ethanol Extract

The ethanol extract exhibited the highest antioxidant activity among all plant extracts:

- Scavenging activity increased from 11.32% at 10 µg/mL to 44.15% at 100 µg/mL.
- This suggests that ethanol efficiently extracted a high concentration of antioxidant compounds, likely flavonoids, phenolics, and tannins, known for their radical scavenging properties.
- The activity was dose-dependent and nearly half that of ascorbic acid at the highest concentration.

Hydroalcoholic Extract

The hydroalcoholic extract also showed notable antioxidant activity, with:

- 11.16% inhibition at 10 µg/mL increasing to 42.15% at 100 µg/mL.
- Its performance was comparable to the ethanol extract, indicating that combining alcohol with water enhances the extraction of both polar and semi-polar antioxidants.

Water Extract

The aqueous extract exhibited moderate activity, ranging from 8.16% to 33.11% across the tested concentrations.

- The relatively lower activity may be due to water extracting mainly hydrophilic compounds, which may not be as potent as the flavonoids and phenolics extracted by ethanol.

Acetone Extract

The acetone extract showed increasing antioxidant activity (8.16% to 31.61%), which was slightly better than the chloroform extract.

- Acetone, being a semi-polar solvent, extracted compounds with moderate antioxidant potential.
- However, compared to ethanol and hydroalcoholic extracts, it was less effective, suggesting a lower yield of potent antioxidant compounds.

Chloroform Extract

The chloroform extract showed the lowest activity among all the extracts:

- From 6.85% at 10 µg/mL to 26.78% at 100 µg/mL.
- This can be attributed to chloroform's non-polar nature, which limits its ability to extract polar antioxidant compounds such as phenolics and flavonoids.

Table no. 5.2: Results of *In-vitro* antioxidant activity

Sample	Ascorbic acid	Ethanol extract	Water extract	Chloroform extract	Acetone extract	Hydro alcoholic extract
10 µg/mL	17.64±0.03	11.32±0.15	08.16±0.14	06.85±0.13	8.16±0.13	11.16±0.23
20 µg/mL	30.41±0.02	16.54±0.13	11.23±0.16	9.37±0.12	10.12±0.16	15.53±0.13
30 µg/mL	43.53±0.13	22.97±0.36	16.07±0.22	12.97±0.32	14.86±0.32	19.27±0.19
40 µg/mL	56.80±0.04	22.83±0.03	19.45±0.12	16.23±0.28	19.62±0.16	23.56±0.22
50 µg/mL	68.43±0.02	32.38±0.30	25.18±0.28	18.22±0.30	22.24±0.28	29.78±0.25
100 µg/mL	95.25±0.03	44.15±0.03	33.11±0.12	26.78±0.22	31.61±0.12	42.15±0.16

All readings are mean ± SD, n = 3, IC50 value reported as Conc. ± SEM, P < 0.01 Vs standard

Formulation of gel

Table 5.3: Formulation of herbal sunscreen gel

S.No.	Composition	Quantity (in gms)				Use
		F1	F2	F3	F4	
1	Ethanol extract	1	2	3	4	Antioxidant/SPP
2	Carbopol 934	1	1	1	1	Polymer
3	Propylene glycol	10	10	10	10	Penetration enhancer
4	Methyl paraben	0.2	0.2	0.2	0.2	Preservative
5	Propyl paraben	0.5	0.5	0.5	0.5	Preservative
6	Purified water	100	100	100	100	Vehicle
7	Triethanolamine	Q.S.	Q.S.	Q.S.	Q.S.	Neutralizer

Evaluation of gel

Physical parameter

The physical parameters of a topical gel—such as appearance, color, and homogeneity—are critical indicators of the product's aesthetic appeal, consumer acceptability, and formulation stability. Four different formulations (F1 to F4) were prepared containing increasing concentrations (1%, 2%, 3%, and 4%, respectively) of *Trianthema portulacastrum* extract, and evaluated accordingly.

Appearance

All four formulations were described as "clear and transparent," indicating:

- Proper incorporation of the plant extract without particulate matter.
- No phase separation, cloudiness, or turbidity.
- Compatibility of the extract with the gel base (likely a hydrophilic polymer such as Carbopol).

Even with increasing concentrations from 1% to 4%, there was no visible compromise in clarity, suggesting good solubility or dispersion of the extract in the gel matrix.

Colour

Each formulation exhibited a greenish tint, which is expected due to the natural chlorophyll and phytochemical content of *Trianthema portulacastrum*.

- The uniform green coloration across all concentrations implies consistent dispersion of the extract.
- The color may deepen slightly with increasing concentration, although this wasn't reported as visually distinct, indicating minimal color variation even at 4%.

The greenish hue can also serve as a visual indicator of herbal content, which can enhance consumer appeal in natural cosmetic products.

Homogeneity

All formulations were described as homogenous, meaning:

- The extract was evenly distributed throughout the gel base.
- There was no phase separation, clumping, or sedimentation observed.
- The gelling agent and solvents used effectively maintained uniform consistency, even at the highest extract concentration (F4, 4%).

Homogeneity is crucial for dose consistency, efficacy, and user experience, especially in formulations with active herbal components.

Table 5.4: Results of Physical evaluation of gel

Parameter	Appearance	Colour	Homogenicity
F1	Clear and transparent	Greenish	Homogenous
F2	Clear and transparent	Greenish	Homogenous
F3	Clear and transparent	Greenish	Homogenous
F4	Clear and transparent	Greenish	Homogenous

Subjective Properties

All four formulations (F1–F4), containing increasing concentrations (1% to 4%) of *Trianthema portulacastrum* extract, were assessed for sensory parameters such as feel and irritation potential.

- Feel: All formulations were reported as smooth with no grittiness, indicating successful incorporation of the extract and excipients without undissolved particles or phase separation. This smooth texture enhances user comfort and spreadability, making the gel cosmetically acceptable.
- Irritation: None of the formulations caused skin irritation, suggesting that the extract and base components are non-irritant and skin-friendly, even at the highest concentration (4%). This supports the safety of the formulation for topical use.

Table 5.5: Results of subjective properties of gel

S.No.	**Parameter**	**F1**	**F2**	**F3**	**F4**
1	Feel	No grittiness, Smooth	No grittiness, Smooth	No grittiness, Smooth	No grittiness, Smooth
2	Irritation	No irritation	No irritation	No irritation	No irritation

Spreadibilty, Extrudability, pH, Viscocity and *In-Vitro* SPF determination

The gel formulations F1 to F4, containing increasing concentrations of *Trianthema portulacastrum* extract (1% to 4%), were evaluated for key physicochemical and functional parameters: spreadability, extrudability, pH, viscosity, and SPF.

- Spreadability values ranged from 18.36 to 18.62 gm·cm/sec, indicating all formulations had good spreadability, essential for ease of application. The slight increase in spreadability with higher extract concentration suggests the gel maintained a favorable texture.
- Extrudability remained above 90% in all cases, reflecting good tube dispensing behavior and consistent gel consistency. F3 (91.70%) showed the highest value, indicating optimal ease of extrusion.
- pH was stable at 6.8 for all formulations, within the ideal skin-compatible range (5.5–7), confirming safety for topical use without irritation.
- Viscosity ranged between 4134 and 4294 Cps, showing minimal variation. All values were within an acceptable range for gel-based products, ensuring good stability and consistency.
- SPF values increased with extract concentration, from 18.78 (F1) to 21.57 (F4), indicating a dose-dependent improvement in UV protection due to the presence of antioxidant and UV-absorbing compounds in the extract.

Table 5.6: Results of Spreadibilty, Extrudability, pH, Viscocity and *In-Vitro* SPF determination

S.No.	Spreadibility (gm.cm/sec)	Extrudability	pH	Viscocity (Cps)	SPF
F1	18.36	90.90%	6.8	4237±0. 11	18.7815
F2	18.5	91.10%	6.8	4294±0. 43	19.4494
F3	18.59	91.70%	6.8	4134±0. 24	20.1472
F4	18.62	91.30%	6.8	4224±0. 29	21.571

Stability studies

Formulation F4, containing 4% *Trianthema portulacastrum* extract, was subjected to accelerated stability testing at 40 ± 2 °C and 75 ± 5% relative humidity to assess its physical and functional stability.

- Spreadability showed a slight decrease from 18.62 to 18.58 gm·cm/sec, indicating minimal change in texture or consistency, which is not likely to affect user experience.
- Extrudability remained constant at 91.30%, suggesting the formulation maintained its tube dispensing ability and consistency over time.
- pH remained stable at 6.8, confirming that the gel retains its skin-friendly and non- irritating nature, with no signs of degradation or chemical instability.
- Viscosity showed a slight increase from 4224 to 4315 Cps, which is within acceptable limits. This may be due to minor solvent evaporation or polymer interaction over time, but it does not indicate any phase separation or instability.
- SPF value showed a negligible decline from 21.571 to 21.482, which indicates that the UV-protective activity of the formulation remains largely intact under stress conditions.

Table 5.6: Results of stability studies of gel

S.No.	40 ±2 °C and 75 ± 5% (F4)	
	Before	**After**
Spreadibility	18.62	18.58
Extrudability	91.30%	91.30%
pH	6.8	6.8
Viscocity	4224±0. 29	4315±0. 22
SPF	21.571	21.482

CONCLUSION

Trianthema portulacastrum was selected for preparation of sunscreen gel. Reserch work starts from collection and authentification of plant. Various solvents were used for extraction of phytosonstituents. The presence of flavonoids, phenolic compounds, saponins, and alkaloids — all of which exhibit UV-absorbing and antioxidant properties

— provides strong support for using *Trianthema portulacastrum* in photoprotective cosmeceutical products. This phytochemical diversity confirms the multipurpose therapeutic potential of the plant and validates its incorporation into herbal formulations for dermatological use.

The DPPH assay results demonstrate that *Trianthema portulacastrum* possesses significant antioxidant activity, especially in its ethanol and hydroalcoholic extracts. These findings validate the traditional use of the plant in herbal medicine and its potential incorporation into cosmeceutical products, such as herbal sunscreen gels, for providing natural photoprotection and free radical defense.

The physical evaluation of sunscreen gel formulations F1 to F4 shows that all concentrations of *Trianthema portulacastrum* extract (1% to 4%) were successfully incorporated into a clear, homogenous, and aesthetically acceptable gel. This suggests that the formulation base is suitable for holding herbal extracts without compromising physical stability or appearance.

These favorable physical characteristics support further evaluation of the gels for functional properties such as SPF, antioxidant activity, skin compatibility, and shelf stability.

Results of subjective evaluation confirm that the formulations are safe, comfortable to use, and suitable for further dermatological or cosmetic application.

All formulations exhibited acceptable physical properties and enhanced SPF with increased extract concentration, making them suitable candidates for herbal sunscreen applications. Formulation F4 (4% extract) showed the highest SPF without compromising other quality parameters.

Stability studies performed on F4 formulation and result revealed that Formulation F4 is physically and functionally stable under accelerated conditions. There were no significant changes in spreadability, extrudability, pH, viscosity, or SPF, demonstrating that the formulation is robust, shelf-stable, and suitable for long-term storage in cosmetic applications.

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