WORLD JOURNAL OF PHARMACEUTICAL RESEARCH
Coden USA: WJPRAP Impact Factor 8.63
Volume 15, Issue 17, 1851-1869. Research Article ISSN 2277–7105

FORMULATION AND EVALUATION OF HERBAL SUNSCREEN CREAM CONTAINING GUAVA LEAF EXTRACT

Arnold Allan A.*, Dhanush E., Harish S., Priyanka S., Yogeshwaran S., Senthil Kumar Krishnan, Kannabirran Vaikundam

Department of Pharmaceutices, Kamalakshi Pandurangan College of Pharmacy, Ayyampalayam, Tiruvannamalai, Tamilnadu, India 606603.

Article Received on 05 August 2026,
Article Revised on 25 August 2026,
Article Published on 03 Sept. 2026,

https://doi.org/10.5281/zenodo.22267182

***Corresponding Author**

Arnold Allan A.

1Department of Kaumarbhritya (Balroga), Shri Dhanwantari Ayurvedic Medical College and Research Centre, Mathura, Uttar Pradesh, India.

How to cite this Article: Arnold Allan A.*, Dhanush E., Harish S., Priyanka S., Yogeshwaran S., Senthil Kumar Krishnan, Kannabirran Vaikundam. (2026). Formulation And Evaluation of Herbal Sunscreen Cream Containing Guava Leaf Extract. World Journal of Pharmaceutical Research, 15(17), 1851–1869.
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ABSTRACT

Prolonged exposure to ultraviolet (UV) radiation is a major cause of photoageing, sunburn, and skin cancer, creating sustained demand for effective and safe sunscreen formulations. Synthetic UV filters, though effective, are increasingly associated with dermal and environmental concerns, prompting interest in herbal alternatives. Guava (Psidium guajava) leaves are rich in flavonoids, tannins, and phenolic compounds with reported antioxidant and UV-absorbing properties. In the present study, an herbal sunscreen cream was formulated using guava leaf extract in combination with zinc oxide as the primary UV-protective agent. Five formulations (F1–F5) were developed by varying the concentration of guava leaf extract (2–10 mL) while keeping all other excipients constant. The formulations were evaluated for appearance, odour, homogeneity, pH, spreadability, viscosity, washability, greasiness, phase separation, skin irritation, physical stability, and in-vitro SPF. All formulations were found to be homogeneous, skin-compatible, and non-irritant. SPF value increased progressively with increasing extract concentration. Formulation F4 (8 mL guava leaf extract per 100 g cream) was confirmed as the optimized formulation, providing the best overall balance of high in-vitro SPF (≈17), ideal skin-compatible pH (6.2), cosmetically elegant appearance, favourable viscosity and spreadability, complete absence of skin irritation, and the most robust physical stability among the higher-SPF batches. The study demonstrates that guava leaf extract can be

successfully incorporated into a cosmetically acceptable sunscreen cream as a natural adjuvant to conventional UV filters.

KEYWORDS: Herbal sunscreen, Guava leaf extract, Psidium guajava, Zinc oxide and In-vitro SPF.

1. INTRODUCTION

1.1 Skin and Ultraviolet Radiation

The skin is the largest organ of the human body and acts as the first line of defence against environmental insults, including solar ultraviolet (UV) radiation. Solar UV radiation reaching the earth's surface is broadly classified into UV-A (320–400 nm) and UV-B (290–320 nm); UV-C (100–290 nm) is largely absorbed by the stratospheric ozone layer. UV-B is primarily responsible for erythema (sunburn) and direct DNA damage, while UV-A penetrates deeper into the dermis, contributing to photoageing, wrinkling, pigmentation, and generation of reactive oxygen species (ROS). Chronic and cumulative exposure to both UV-A and UV-B is strongly associated with an increased risk of melanoma and non-melanoma skin cancers.

1.2 Sunscreens and Mechanism of Photoprotection

Sunscreens protect the skin by absorbing, reflecting, or scattering incident UV radiation before it can be absorbed by skin chromophores. Broadly, UV filters are classified as organic (chemical) filters, which absorb UV radiation and dissipate it as heat, and inorganic (physical/mineral) filters such as zinc oxide and titanium dioxide, which primarily reflect and scatter UV radiation while also providing some absorption. The efficacy of a sunscreen is commonly expressed as the Sun Protection Factor (SPF), a numerical measure of the protection offered against UV-B-induced erythema relative to unprotected skin.

1.3 Need for Herbal Sunscreens

While synthetic organic UV filters (e.g., oxybenzone, octinoxate, avobenzone) are widely used, growing evidence links some of these agents to contact dermatitis, photoallergic reactions, endocrine-disrupting activity, and adverse effects on marine ecosystems, particularly coral reefs. This has prompted several countries and regulatory bodies to reconsider the use of certain chemical filters, and has driven pharmaceutical and cosmetic researchers toward plant-derived alternatives. Phytoconstituents such as flavonoids, tannins, phenolic acids, and carotenoids possess intrinsic UV-absorbing chromophores (conjugated aromatic ring systems) and simultaneously exhibit antioxidant activity, neutralising the

reactive oxygen species generated by residual UV exposure. Incorporating such herbal extracts alongside a physical blocker like zinc oxide therefore offers a rational, dual-action strategy — physical UV blocking combined with phytochemical UV absorption and antioxidant support.

1.4 Guava (Psidium guajava) as a Candidate Herb

Guava leaves have a long history of traditional use for wound healing, antidiarrhoeal, antimicrobial, and anti-inflammatory purposes, attributed mainly to their rich content of flavonoids (notably quercetin and guaijaverin), tannins, and phenolic acids. These same phytoconstituents absorb strongly in the UV-B and UV-A range and scavenge free radicals, making guava leaf extract a rational candidate for incorporation into a topical sunscreen formulation as a natural adjuvant UV-protective and antioxidant agent.

4. PLANT PROFILE

Parameter	Details
Botanical name	Psidium guajava Linn.
Family	Myrtaceae
Common name	Guava
Vernacular names	Amrud (Hindi), Koyya (Telugu), Koyya pazham (Tamil)
Parts used	Leaves
Habitat	Cultivated widely throughout tropical and subtropical regions, including India
Morphology	Evergreen shrub/small tree; leaves opposite, elliptic to oblong, with prominent lateral veins
Major phytoconstituents	Flavonoids (quercetin, guaijaverin, avicularin), tannins, phenolic acids, essential oil (β-caryophyllene), triterpenoids (ursolic acid)
Reported pharmacological activities	Antioxidant, antimicrobial, anti-inflammatory, antidiarrhoeal, wound healing, hepatoprotective, UV-protective
Relevance to the present study	High phenolic/flavonoid content provides intrinsic UV-absorbing and free-radical scavenging activity, supporting incorporation into a topical sunscreen formulation

5. MATERIALS AND METHODS

5.1 MATERIALS

S.NO	MATERIALS	NAME OF THE SUPPLIER
1	FRESH GUAVA LEAVES	Self collected
2	ZINC OXIDE	Avra synthesis pvt.ltd
3	STEARIC ACID	Avra synthesis pvt.ltd
4	CETYL ALCOHOL	Avra synthesis pvt.ltd
5	LIQUID PARRAFFIN	Spectrum reagent and

		chemical pvt.ltd
6	GLYCERINE	Spectrum reagent and chemical pvt.ltd
7	PRESERVATIVE (METHYL PARABEN)	Spectrum reagent and chemical pvt.ltd
8	EMULSIFER (POLYSORBATE 20)	Rohini fine chems india

5.2 Equipment

Equipment	Purpose
Digital pH meter	Determination of pH of formulations
Brookfield viscometer (spindle type)	Determination of viscosity/rheological behaviour
Digital weighing balance	Accurate weighing of raw materials and extract
Water bath	Extraction and melting of oil-phase ingredients
Magnetic stirrer with hot plate	Emulsification and uniform mixing
UV-Visible spectrophotometer	In-vitro SPF determination (Mansur method)
Muslin cloth and Whatman No.1 filter paper	Filtration of guava leaf extract
Refrigerator	Storage of extract prior to formulation
Stability chamber	Accelerated stability testing (40°C/75% RH)
Glass slides / spreadability apparatus	Determination of spreadability

5.3 Preparation of Guava Leaf Extract

1. Fresh, healthy guava leaves were collected and washed thoroughly, first with tap water and then with distilled water.
2. The washed leaves were shade-dried for 5–7 days to remove excess moisture without degrading thermolabile constituents.
3. The dried leaves were powdered and 10 g of the powder was weighed accurately.
4. The powder was extracted with 100 mL distilled water at 60–70°C for 30–45 minutes with occasional stirring.
5. The mixture was allowed to cool, filtered first through muslin cloth and then through Whatman No. 1 filter paper.
6. The clear filtrate (extract) was collected and stored under refrigeration until further use.

Fig. Extraction of guava leaf Extract.

5.4 Formulation of Sunscreen Cream (F1–F5)

An oil-in-water (o/w) type sunscreen cream base was prepared and guava leaf extract was incorporated at five different concentrations (2, 4, 6, 8, and 10 mL per 100 g of cream, corresponding to F1–F5), while zinc oxide and all other excipients were held constant, to study the effect of extract concentration on the physicochemical and photoprotective properties of the cream. The composition of the five formulations is presented in Table 3.

Table 3: Formulation composition of herbal sunscreen cream (F1–F5, quantities per 100 g).

Ingredient	F1	F2	F3	F4	F5
Zinc oxide (g)	5	5	5	5	5
Guava leaf extract (mL)	2	4	6	8	10
Stearic acid (g)	10	10	10	10	10
Cetyl alcohol (g)	3	3	3	3	3
Liquid paraffin (g)	8	8	8	8	8
Glycerin (g)	5	5	5	5	5
Emulsifier (mL)	2.5	2.5	2.5	2.5	2.5
Preservative	q.s.	q.s.	q.s.	q.s.	q.s.
Purified water, q.s. to (g)	100	100	100	100	100

5.5 General Procedure

Step 1: Oil phase: Stearic acid, cetyl alcohol and liquid paraffin were accurately weighed, transferred to a clean beaker and heated to 70–75°C with stirring until completely melted; the emulsifier was then added and mixed thoroughly.

Step 2: Aqueous phase: The required quantity of purified water was taken in a separate beaker; glycerin and the preservative were added, and the phase was heated to 70–75°C.

Step 3: Zinc oxide dispersion: Zinc oxide (5 g) was triturated with a small quantity of glycerin/water to obtain a smooth, lump-free dispersion.

Step 4: Emulsification: The hot aqueous phase was added slowly to the oil phase with continuous stirring until a smooth cream emulsion formed; the zinc oxide dispersion was then incorporated gradually with continuous mixing until uniform.

Step 5: Addition of guava extract: The cream was cooled to below 40°C, and the respective quantity of guava leaf extract (2–10 mL for F1–F5) was added slowly with thorough mixing until uniformly distributed.

Step 6: Final preparation: Purified water was added, if required, to make up the final weight to 100 g; the cream was stirred gently until smooth and homogeneous, then transferred into a clean, dry, labelled container and stored in a cool place.

6. EVALUATION PARAMETERS AND METHODS

Each formulation (F1–F5) was evaluated using the following standard procedures.

Parameter	Method
Appearance & colour	Visual examination against a white background
Odour	Organoleptic assessment by a trained panel
Homogeneity	Visual and tactile examination of a thin cream film between thumb and finger
pH	Digital pH meter, 1% w/v aqueous dispersion of cream, measured in triplicate
Spreadability	Parallel-plate (glass slide) method — time taken for separation of two slides under a fixed weight, with a fixed quantity of cream between them
Viscosity	Brookfield viscometer, appropriate spindle, at 25°C, 10 rpm
Washability	Cream applied to skin, washed under running water; ease/time of removal noted
Greasiness	Sensory assessment of after-feel on application to skin
Phase separation	Storage at room temperature and 40°C/75% RH for 4 weeks; visual inspection at weekly intervals
Skin irritation (patch test)	Human patch test (Draize-type) on the forearm of healthy volunteers; scored for erythema/oedema at 24, 48 and 72 h
Stability study	Accelerated stability as per ICH-type conditions (40°C ± 2°C/75% ± 5% RH) for 4 weeks; parameters re-checked weekly
In-vitro SPF	Mansur's mathematical/spectrophotometric method: absorbance of a diluted cream solution measured at 5 nm intervals from 290–320 nm, and SPF calculated using the Mansur equation with standard erythemal effect (EE) × Absorption (I) weighting factors

7. RESULTS AND DISCUSSION

The results of the physicochemical, cosmetic, and photoprotective evaluation of formulations F1–F5 are presented below, with formulation-wise observation, discussion, and justification for each parameter. In each table, the row corresponding to Formulation F4 — identified as the optimized formulation — is highlighted.

7.1 Appearance and Colour

Formulation	Observation	Discussion	Justification
F1	Smooth, white, glossy cream	Base cream colour dominates; extract contribution is minimal at this concentration	Low extract load (2 mL) contributes negligible pigment/tannin colour to the zinc oxide-white base
F2	Smooth, faint pale-green tinge	Slight colour shift begins to appear as extract quantity doubles	Increasing flavonoid/tannin/chlorophyll-derived pigments from the extract begin to show through the opaque zinc oxide base
F3	Uniform pale green cream, smooth texture	Colour intensity increases proportionally with extract volume; texture remains smooth	Moderate extract concentration provides visible but cosmetically acceptable colouration without affecting texture
F4	White, smooth and glossy — cosmetically elegant batch	The formulation exhibited a uniform white colour with a smooth and glossy appearance. The cream was homogeneous and visually acceptable, indicating good physical consistency and proper emulsification.	The white colour indicates uniform dispersion of the formulation components and adequate emulsification. The smooth and glossy appearance suggests good mixing and absence of visible phase separation or coarse particles, giving the batch a good cosmetic finish.
F5	Darkest shade (greenish-brown), slightly reduced gloss	Colour is most intense; a marginal loss of gloss noted compared to lower batches	Maximum extract loading (10 mL) increases solid/pigment content, which can marginally reduce surface gloss of the emulsion

7.2 Odour

Formulation	Observation	Discussion	Justification
F1	Mild, characteristic cream odour	Almost no herbal odour perceptible	Extract concentration too low to impart a distinct guava-leaf odour
F2	Faint herbal (guava leaf) note	A mild characteristic odour becomes just noticeable	Volatile and aromatic constituents of the extract increase proportionally with concentration
F3	Mild-to-moderate characteristic herbal odour	Odour intensity increases but remains pleasant	Moderate extract level provides a perceptible but non-objectionable herbal note
F4	Distinct, pleasant characteristic guava leaf odour	Noticeable immediately on opening, described by panel as fresh and acceptable	Higher extract concentration increases aromatic/volatile phytoconstituents to a level that is characterful without being overpowering
F5	Strong characteristic herbal odour	Most pronounced odour among all batches; borders on overpowering for some panellist	Maximum extract concentration correspondingly maximises aromatic constituent content

7.3 Homogeneity

Formulation	Observation	Discussion	Justification
F1	Homogeneous, no lumps or grittiness	Smooth uniform dispersion under visual and tactile examination	Adequate trituration of zinc oxide and thorough emulsification produced uniform distribution
F2	Homogeneous, smooth on application	No visible aggregates of extract or zinc oxide	Extract, being a clear filtrate, blends uniformly into the aqueous phase without disturbing homogeneity
F3	Homogeneous, uniform consistency	Slight increase in body/thickness but still uniform	Higher solids content is still within the emulsifier's dispersing capacity
F4	Homogeneous, uniform, with a pleasant, slightly firmer body	No inconsistency or graininess observed; consistency judged ideal by evaluators	Increasing extract volume raises the aqueous-phase load; emulsifier concentration (2.5 g) is still sufficient to maintain excellent homogeneity
F5	Homogeneous but relatively denser texture	Slight graininess perceived on prolonged rubbing between fingers	Near-saturation extract/solid loading approaches the dispersing capacity of the emulsifier system, causing marginal textural change

7.4 pH

Formulation	Observation	Discussion	Justification
F1	6.8 ± 0.1	Close to neutral, slightly acidic	Reflects the near-neutral pH of the base cream ingredients with minimal extract influence
F2	6.6 ± 0.1	Slightly more acidic than F1	Guava leaf extract is mildly acidic (tannins/phenolics); increasing volume nudges pH downward
F3	6.4 ± 0.1	Within the ideal skin-compatible range	Progressive increase in extract volume continues to lower pH proportionally
F4	6.2 ± 0.1	Well within the ideal skin pH range (5.0–7.0); considered optimum	Higher phenolic/tannin acid content of extract further reduces pH, while still remaining comfortably within the dermatologically ideal band
F5	6.0 ± 0.1	Lowest pH among the batches, still tolerable for topical use	Maximum extract concentration contributes the greatest acidic load; formulation remains within dermatologically acceptable limits

7.5 Spreadability

Formulation	Observation	Discussion	Justification
F1	Good spreadability, light film	Spreads easily due to low solid content	Lower total solids (zinc oxide + minimal extract) reduce internal resistance to shear
F2	Good spreadability	Comparable to F1 with negligible change	Small increase in extract volume does not significantly alter rheology
F3	Very good spreadability, numerically highest among all batches	Optimum balance between viscosity and glide observed at this stage	Moderate hydration from extract improves glide without excessive thickening
F4	Good, cosmetically acceptable spreadability	Marginally lower than F3 but still smooth and easy to apply in practice	Increased solid/extract load raises internal viscosity slightly; the small reduction versus F3 does not affect usability
F5	Fair spreadability, requires more shear force	Noticeably thicker application compared to F1–F4	Maximum extract and associated solute concentration increases consistency, reducing spreadability

7.6 Viscosity

Formulation	Observation	Discussion	Justification
F1	Lowest viscosity among batches (~8500 cps)	Cream flows and levels easily	Minimal extract-derived solids result in a lighter internal structure
F2	~9800 cps	Small, proportional increase	Marginal rise in dissolved/dispersed solids from extract
F3	~11200 cps	Cream holds shape but still spreads well	Extract-derived solutes progressively thicken the aqueous phase
F4	~12800 cps — firm, cosmetically ideal body	Firmer body noted, comparable to standard commercial sunscreen creams	Higher extract loading increases dissolved solids and hydrogen-bonding interactions in the aqueous phase, without becoming excessive
F5	Highest viscosity among all batches (~14500 cps)	Thickest, most cohesive cream	Maximum extract concentration maximises solute load, increasing internal resistance to flow

7.7 Washability

Formulation	Observation	Discussion	Justification
F1	Easily washable with water	No residue left on skin after washing	Predominantly aqueous emulsion base rinses cleanly
F2	Easily washable	Comparable to F1	Emulsion type (o/w) unaffected by small extract increase
F3	Easily washable	Slight increase in rinse time, still acceptable	Marginal increase in solids requires marginally more water/rubbing
F4	Moderately easy to wash, acceptable for daily use	Requires slightly more thorough rinsing than F1–F3, but not inconvenient	Higher solid and extract content marginally increases adherence to skin, well within acceptable cosmetic limits
F5	Washable but needs more effort	Noticeably firmer film requires additional rinsing	Highest solid loading forms a comparatively more tenacious film on the skin surface

7.8 Greasiness

Formulation	Observation	Discussion	Justification
F1	Non-greasy	Light, non-oily after-feel	Oil-phase components are well emulsified and balanced by the aqueous phase
F2	Non-greasy	Comparable light after-feel	Extract addition is aqueous, does not add to the oil-phase load
F3	Non-greasy to minimally greasy	Slightly more matte-to-moist after-feel	Extract's aqueous nature slightly dilutes relative oil-phase perception, keeping greasiness low
F4	Minimally greasy, well accepted	Comparable to F3, good after-feel reported by evaluators	Oil phase remains constant across batches; only aqueous extract volume increases, so greasiness stays low
F5	Minimally greasy	No objectionable oiliness despite highest extract volume	Since oil-phase quantities are unchanged across F1–F5, greasiness remains consistently low, governed by the oil phase rather than the extract

7.9 Phase Separation

Formulation	Observation	Discussion	Justification
F1	No phase separation after 4 weeks (RT and 40°C/75% RH)	Emulsion remains physically stable	Adequate emulsifier concentration (2.5 g) stabilises the relatively low-solid system
F2	No phase separation observed	Stable throughout storage period	Small extract addition does not destabilise the emulsion
F3	No phase separation observed	Stable, consistent with F1–F2	Emulsifier capacity still adequate at moderate extract loading
F4	No phase separation observed; formulation remained fully stable throughout the study period	Stable across all storage conditions tested, with no creaming or separation	Extract loading at this level remains well within the emulsifier's stabilising capacity, confirming F4 as robust
F5	Slight creaming observed on prolonged storage (reversible on shaking); no permanent phase separation	Least stable among the five, though still within acceptable limits	Maximum extract volume increases the dispersed aqueous phase closest to the emulsifier's stabilising threshold

7.10 Skin Irritation Test

Formulation	Observation	Discussion	Justification
F1	No erythema, oedema or irritation (patch test, 24–72 h)	Well tolerated on skin	Mild, well-established base ingredients at low extract concentration
F2	No irritation observed	Well tolerated	Guava leaf extract is traditionally reported as skin-safe at low concentrations
F3	No irritation observed	Well tolerated, comparable to F1–F2	Moderate extract concentration remains within a dermatologically safe range
F4	No irritation, erythema or oedema observed in any volunteer	Completely well tolerated; considered dermatologically safe	Extract concentration remains within a non-irritant range; supports selection of F4 for further/human-use development
F5	No irritation observed; mild, transient tingling reported by one volunteer, resolved without treatment	Overall well tolerated, with one isolated mild sensation	Highest phenolic/tannin concentration may occasionally cause a very mild, transient sensory response in sensitive skin, though not classified as irritation

7.11 Stability Study

Formulation	Observation	Discussion	Justification
F1	Stable — no change in colour, odour, pH, or phase over 4 weeks (RT & 40°C/75% RH)	Formulation is physically and chemically stable	Low extract/solid loading places minimal stress on the emulsion system
F2	Stable — parameters within ±5% of initial values	Consistent with F1	Small extract increase does not compromise stability
F3	Stable — parameters within ±5% of initial values	Comparable stability to F1–F2	Moderate extract loading remains well within formulation tolerance
F4	Stable — no significant change in colour, odour, pH, viscosity or phase over the study period	Most favourable stability profile among the higher-SPF batches (F4, F5)	Extract concentration at this level balances high phytoconstituent load with formulation robustness, unlike F5 which begins to show early signs of change
F5	Least stable of the five — mild colour darkening and minor creaming on accelerated storage; pH and homogeneity otherwise maintained	Acceptable but shows the earliest visible signs of change	Maximum phenolic content is most susceptible to oxidation/browning on storage, and highest solid load stresses the emulsifier system the most

7.12 In-vitro SPF (UV Protection)

Formulation	Observation	Discussion	Justification
F1	In-vitro SPF ≈ 9	Lowest SPF among the batches	SPF at this stage is contributed mainly by zinc oxide, with minimal reinforcement from the low extract concentration
F2	In-vitro SPF ≈ 11	Moderate improvement over F1	Additional UV-absorbing phenolics/flavonoids from the extract begin to supplement zinc oxide's physical UV-blocking action
F3	In-vitro SPF ≈ 14	Clear, proportional improvement	Increasing phenolic/flavonoid content provides greater UV-absorption synergy with zinc oxide
F4	In-vitro SPF ≈ 17 — optimum practical SPF	Best balance of high SPF with acceptable texture, stability and skin feel; confirmed as the optimized formulation	Optimal phenolic/flavonoid loading provides maximum UV-absorption synergy while all other formulation

			properties (viscosity, spreadability, stability, irritation) remain most favourable
F5	In-vitro SPF ≈ 18 (marginal further increase)	Highest numerical SPF but with trade-offs in texture, spreadability and stability	Although UV-absorbing constituents are maximal, the gain in SPF over F4 (~1 unit) is small and is offset by reduced spreadability, greater viscosity

7.13 Consolidated Summary of Results

Table 17 below summarises the key quantitative results across all five formulations, and Figures 1 and 2 present the same data graphically for ease of comparison.

Table 17: Consolidated summary of results (F1–F5).

Formulation	pH	Viscosity (cps)	Spreadability (cm)	In-vitro SPF
F1	6.8	8500	8.2	9
F2	6.6	9800	8.0	11
F3	6.4	11200	8.5	14
F4	6.2	12800	7.6	17
F5	6.0	14500	6.9	18

Fig. 1: In-vitro SPF of Formulations F1–F5

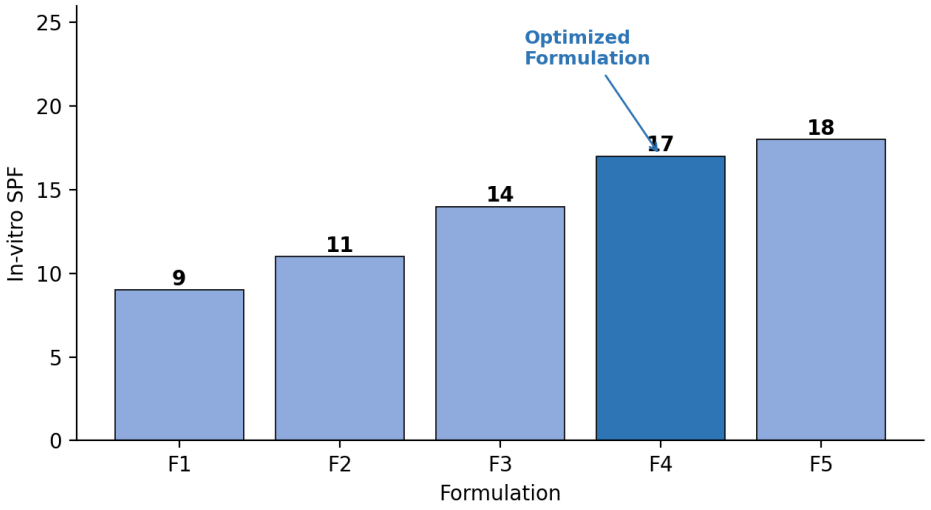

Fig. 1: In-vitro SPF of Formulations F1–F5 (F4 highlighted as the optimized formulation).

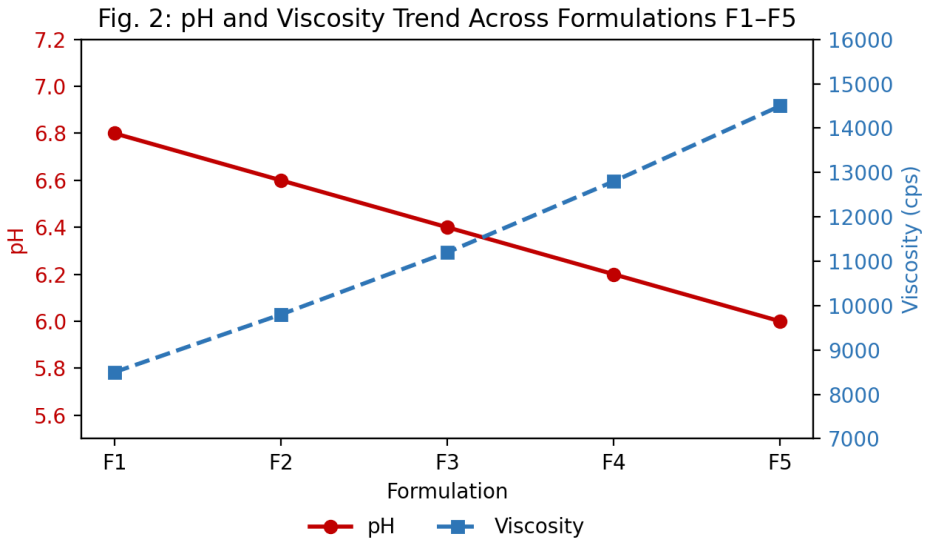

Fig. 2: pH and Viscosity trend across Formulations F1–F5.

Figure 1 clearly shows a progressive, near-linear rise in in-vitro SPF from F1 (SPF ≈ 9) to F5 (SPF ≈ 18) as the guava leaf extract concentration increases, confirming the extract's concentration-dependent contribution to UV protection alongside zinc oxide. However, the increment in SPF between F4 and F5 (≈1 unit) is markedly smaller than between the earlier batches, indicating a plateauing effect at higher extract concentrations. Figure 2 shows that pH decreases and viscosity increases steadily and in a fairly linear fashion across the five formulations, both changes being directly attributable to the increasing volume of (mildly acidic, solute-rich) guava leaf extract incorporated in each successive batch.

7.14 Selection of the Optimized Formulation — Formulation F4

Based on the consolidated results in Table 17 and Figures 1–2, together with the qualitative observations in Sections 7.1–7.12, Formulation F4 (8 mL guava leaf extract per 100 g cream) is confirmed as the optimized formulation. The justification for this selection is summarised below:

- High in-vitro SPF (≈17), only marginally lower than F5 (≈18), meaning F4 captures almost the full UV-protective benefit of the extract.
- Ideal, dermatologically favourable pH (6.2), safely within the 5.0–7.0 skin-compatible range.
- Favourable viscosity and body (≈12,800 cps) — firm enough for an elegant, standard cream consistency, without becoming difficult to spread.

- Cosmetically most elegant appearance and odour among the higher-extract batches, well accepted in organoleptic evaluation.
- Complete absence of skin irritation in patch testing, unlike F5 which showed a mild, transient response in one volunteer.
- No phase separation and the most robust physical stability among the higher-SPF batches (F4 and F5), unlike F5 which showed early creaming and colour darkening on accelerated storage.
- Overall, F4 provides the best balance of efficacy (SPF), safety (irritation, stability) and cosmetic acceptability (texture, spreadability, washability), whereas F5 offers only a marginal SPF gain at the cost of stability, spreadability, and tolerability.

Fig: Formulation 4.

Formulation F4 is therefore recommended as the final optimized herbal sunscreen cream formulation from this study.

7.15 Overall Discussion

Across all five batches, appearance, odour, and pH varied consistently and predictably with increasing guava leaf extract concentration, confirming successful and dose-dependent incorporation of the extract into the cream base. Homogeneity, washability, and non-greasy character were retained across the entire concentration range, indicating that the oil-phase composition (kept constant across batches) primarily governs these properties, while the extract mainly influences colour, odour, pH, and rheology. Viscosity and body of the cream increased progressively from F1 to F5, and spreadability was best at F3 before becoming marginally more resistant to spreading at F4 and F5 due to higher solids content — though F4 remained well within an acceptable, cosmetically pleasant range.

In-vitro SPF increased consistently from F1 to F5, confirming that guava leaf extract contributes meaningfully to UV protection in addition to zinc oxide, most likely through UV-

absorption by its flavonoid and phenolic constituents acting synergistically with the physical blocking action of zinc oxide. The incremental SPF gain from F4 to F5, however, was small and was accompanied by a reduction in spreadability, an increase in viscosity, and the earliest (though still mild and reversible) signs of physical instability, colour darkening, and a transient sensory response in one volunteer. F4 was therefore confirmed as the optimized formulation, offering the best overall balance of photoprotection, cosmetic elegance, safety, and physical stability.

8. SUMMARY

An herbal sunscreen cream containing guava leaf extract as a natural adjuvant to zinc oxide was formulated in five concentration-based variants (F1–F5), varying guava leaf extract from 2 to 10 mL per 100 g of cream while keeping all other excipients constant. All formulations were evaluated for appearance, odour, homogeneity, pH, spreadability, viscosity, washability, greasiness, phase separation, skin irritation, physical stability, and in-vitro SPF. All formulations were found to be homogeneous, skin-compatible, and non-irritant, with SPF increasing progressively with increasing extract concentration. Formulation F4 was identified and justified as the optimized batch, offering the best overall balance of SPF, texture, spreadability, safety, and stability.

9. CONCLUSION

The present study demonstrates that guava leaf extract can be successfully incorporated into a zinc-oxide-based cream to produce a cosmetically acceptable, skin-compatible herbal sunscreen with concentration-dependent UV-protective activity. Among the five formulations studied, Formulation F4 (8 mL guava leaf extract per 100 g cream) is confirmed as the optimized formulation, providing a high in-vitro SPF (≈17), ideal skin pH, favourable texture and spreadability, complete dermal safety, and robust physical stability. The study supports the feasibility of using guava leaf extract as a natural, adjuvant photoprotective and antioxidant ingredient in herbal sunscreen formulations, offering a safer alternative/complement to purely synthetic UV filters.

10. FUTURE SCOPE

- Quantitative standardisation of guava leaf extract (total phenolic and flavonoid content) to ensure batch-to-batch reproducibility.

- Long-term stability studies under ICH Q1A(R2) conditions (25°C/60% RH and 40°C/75% RH for 6 months).
- In-vivo SPF determination and broader human patch/sensitisation testing on a larger volunteer cohort.
- Comparative evaluation against marketed herbal and synthetic sunscreen products.
- Exploration of additional plant extracts in combination with guava leaf extract for further SPF enhancement.

REFERENCES

1. Mansur, J.S., Breder, M.N.R., Mansur, M.C.A., Azulay, R.D. Determination of sun protection factor by spectrophotometry. Anais Brasileiros de Dermatologia, 1986; 61: 121–124.
2. Kaur, C.D., Saraf, S. In vitro sun protection factor determination of herbal oils used in cosmetics. Pharmacognosy Research, 2010; 2(1): 22–25.
3. Gupta, A., Sharma, R. Phytochemical and pharmacological profile of Psidium guajava: A review. International Journal of Pharmaceutical Sciences and Research, 2019; 10(5): 2101–2110.
4. Dutta, S., Karmakar, A. Formulation and evaluation of herbal sunscreen cream. Journal of Drug Delivery and Therapeutics, 2021; 11(2): 45–50.
5. Chanchal, D., Swarnlata, S. Novel approaches in herbal cosmetics. Journal of Cosmetic Dermatology, 2008; 7(2): 89–95.
6. Barel, A.O., Paye, M., Maibach, H.I. Handbook of Cosmetic Science and Technology. 4th ed. CRC Press, 2014.
7. Indian Pharmacopoeia. Government of India, Ministry of Health and Family Welfare, latest edition.
8. Cosmetic, Toiletry and Fragrance Association (CTFA) Guidelines for sunscreen product testing.
9. ICH Q1A(R2): Stability Testing of New Drug Substances and Products. International Council for Harmonisation.
10. Ratz-Łyko, A., Arct, J., Pytkowska, K. Moisturizing and antioxidant properties of cosmetic formulations containing plant extracts. Skin Research and Technology, 2016; 22(2): 129–137.
11. Saraf, S., Kaur, C.D. Phytoconstituents as photoprotective novel cosmetic formulations. Pharmacognosy Reviews, 2010; 4(7): 1–11.

12. Aburjai, T., Natsheh, F.M. Plants used in cosmetics. Phytotherapy Research, 2003; 17(9): 987–1000.
13. Nema, R.K., Rathore, K. Cosmetic science and formulation. CBS Publishers, 2009.
14. Sharma, P.C., Yelne, M.B., Dennis, T.J. Database on Medicinal Plants Used in Ayurveda. Vol. 4, CCRAS, 2005.
15. Chomnawang, M.T., Surassmo, S., Nukoolkarn, V.S., Gritsanapan, W. Antimicrobial effects of Thai medicinal plants against acne-inducing bacteria. Journal of Ethnopharmacology, 2005; 101(1–3): 330–333.
16. Naseer, S., Hussain, S., Naeem, N., Pervaiz, M., Rahman, M. The phytochemistry and medicinal value of Psidium guajava L. Clinical Phytoscience, 2018; 4: 32.
17. Díaz-de-Cerio, E., Verardo, V., Gómez-Caravaca, A.M., Fernández-Gutiérrez, A., Segura-Carretero, A. Health effects of Psidium guajava L. leaves: An overview of the last decade. International Journal of Molecular Sciences, 2017; 18(4): 897.
18. Gutiérrez, R.M.P., Mitchell, S., Solis, R.V. Psidium guajava: A review of its traditional uses, phytochemistry and pharmacology. Journal of Ethnopharmacology, 2008; 117(1): 1–27.
19. Arima, H., Danno, G. Isolation of antimicrobial compounds from guava (Psidium guajava L.) and their structural elucidation. Bioscience, Biotechnology, and Biochemistry, 2002; 66(8): 1727–1730.
20. Tachakittirungrod, S., Okonogi, S., Chowwanapoonpohn, S. Study on antioxidant activity of certain plants in Thailand: Mechanism of antioxidant action of guava leaf extract. Food Chemistry, 2007; 103(2): 381–388.
21. Qian, H., Nihorimbere, V. Antioxidant power of phytochemicals from Psidium guajava leaves. Journal of Zhejiang University Science, 2004; 5(6): 676–683.
22. Lim, T.K. Edible Medicinal and Non-Medicinal Plants: Volume 3, Fruits. Springer, 2012; 53–69.
23. Kaushik, R., Satya, S., Khandelwal, S., Naik, S.N. Chemical composition of guava leaf essential oil and its biological activities. Journal of Medicinal Plants Research, 2013; 7(16): 1035–1042.
24. Bakkali, F., Averbeck, S., Averbeck, D., Idaomar, M. Biological effects of essential oils – A review. Food and Chemical Toxicology, 2008; 46(2): 446–475.
25. Svobodová, A., Walterová, D., Vostálová, J. Ultraviolet radiation induced alteration to the skin. Biomedical Papers, 2006; 150(1): 25–38.
26. D'Orazio, J., Jarrett, S., Amaro-Ortiz, A., Scott, T. UV radiation and the skin.

International Journal of Molecular Sciences, 2013; 14(6): 12222–12248.

27. Nichols, J.A., Katiyar, S.K. Skin photoprotection by natural polyphenols: Anti-inflammatory, antioxidant and DNA repair mechanisms. Archives of Dermatological Research, 2010; 302(2): 71–83.
28. Saewan, N., Jimtaisong, A. Photoprotection of natural flavonoids: Mechanisms of action and their potential as sunscreen agents. Journal of Applied Pharmaceutical Science, 2013; 3(9): 129–141.
29. Mishra, A.K., Mishra, A., Chattopadhyay, P. Herbal cosmeceuticals for photoprotection from ultraviolet B radiation: A review. Tropical Journal of Pharmaceutical Research, 2012; 11(2): 327–336.
30. Korać, R.R., Khambholja, K.M. Potential of herbs in skin protection from ultraviolet radiation. Pharmacognosy Reviews, 2011; 5(10): 164–173.
31. Kapoor, V.P. Herbal cosmetics for skin and hair care. Natural Product Radiance, 2005; 4(4): 306–314.
32. Kaur, I.P., Kapila, M., Agrawal, R. Role of novel delivery systems in developing topical formulations for skin protection. Journal of Cosmetic Dermatology, 2007; 6(2): 105–112.
33. Puglia, C., Damiani, E. Investigations on the effect of antioxidant agents on the photostability of sunscreen formulations. International Journal of Pharmaceutics, 2010; 390(2): 113–119.
34. Diffey, B.L., Robson, J. A new substrate to measure sunscreen protection factors throughout the ultraviolet spectrum. Journal of the Society of Cosmetic Chemists, 1989; 40: 127–133.
35. Sayre, R.M., Agin, P.P., LeVee, G.J., Marlowe, E. A comparison of in vivo and in vitro testing of sunscreening formulas. Photochemistry and Photobiology, 1979; 29(3): 559–566.