

Formulation and SPF Evaluation of Gel Preparations Containing Ethanol Extract of Guava Leaves (*Psidium guajava* L.)

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ABSTRACT

UV rays are electromagnetic waves that can cause skin damage such as sunburn, premature aging, eye damage, and skin cancer. Guava leaf (*Psidium guajava* L.) contains flavonoid compounds that can absorb UV light. This research was conducted to develop and evaluate a sunscreen gel from guava leaf extract and determine its SPF value using a UV-Vis spectrophotometer. Guava leaf extract was obtained through maceration using 96% ethanol as the solvent. Three sunscreen gel formulations were prepared with extract concentrations of 0.5% (F1), 1% (F2), and 1.5% (F3). Evaluation included SPF value determination, stability testing, organoleptic properties, homogeneity, viscosity, pH, adhesion, and spreadability. The results showed SPF values of 14.73 for F1, 19.66 for F2, and 60.11 for F3, indicating strong sunscreen potential. Stability evaluation demonstrated homogeneous preparations without phase separation, pH values within the skin-compatible range (6.30–6.56), and viscosity values that met gel requirements (50–1000 cPs). Adhesion values increased from 2.41 seconds in F0 to 5.1 seconds in F3, while all formulations showed spreadability within the ideal range for topical preparations (5–7 cm). These findings demonstrate the scientific potential of guava leaf extract as a stable natural sunscreen agent and support its development in herbal-based topical formulations

Keywords: gel; guava leaves; *Psidium guajava* L; SPF

INTRODUCTION

UV (Ultraviolet) rays are electromagnetic wave radiation originating from the sun and can be transmitted at various wavelengths and frequencies (1). Excessive exposure to ultraviolet radiation (UVR) is associated with various skin disorders, including erythema, premature aging, hyperpigmentation, and skin cancer. The World Health Organization (WHO) reported that globally more than 1.5 million skin cancer cases and over 120.000 skin cancer-related deaths occurred in 2020 due to UV exposure (2). Furthermore, prolonged exposure to UV radiation is recognized as the primary cause of melanoma and non-melanoma skin cancer (3).

Sunscreen, a skincare product, may block the sun's harmful ultraviolet (UV) rays and keep skin from being damaged. Natural and synthetic active ingredients in sunscreen are able to absorb, reflect, or scatter UV radiation. The Sun Protection Factor (SPF) number is a measure of a sunscreen's efficacy in protecting skin from ultraviolet (UV) radiation (3). The higher the sunscreen's SPF number, the better it protects the skin from the sun (4).

Natural ingredients known to be used for sunscreen are guava leaves (*Psidium guajava* L.). The flavonoid content within them has antioxidant activity (5) that can neutralize free radicals from UV light and provide protection against UV radiation (6). Previous studies have reported the sunscreen activity of guava leaf (*Psidium guajava* L.) extract, particularly in powder preparations, with SPF values still varying among formulations. However, the development of guava leaf extract into a gel-based sunscreen preparation has not been widely investigated. Gel formulations are considered advantageous for topical sunscreen delivery because they are non-greasy, easily spread on the skin, provide better user comfort, and enhance the release and stability of active compounds

compared to several conventional semisolid preparations (7,8). In addition, information regarding the physical stability and suitability of guava leaf extract in sunscreen gel formulations remains limited, particularly concerning pH, viscosity, adhesion, and spreadability characteristics required for topical preparations.

Based on research conducted by (9) on an ethanol extract of guava leaves in powder form, the SPF values for formula 1 were 9.88, formula 2 was 9.70, and formula 3 was 15. However, there is no sunscreen gel based on guava leaves. Therefore, the purpose of this experiment is to formulate a gel-based sunscreen preparation from guava leaves.

METHODS

Tool

The equipment used includes an analytical balance, water bath, rotary evaporator, UV-Vis spectrophotometer, viscometer, evaporating dishes, Erlenmeyer flasks, funnels, watch glasses, a set of spreadability and adhesiveness testing equipment, a pH meter, a mortar and pestle, filter paper, mesh no. 60, object glass, stirring rod, deck glass, gel pot, and ruler.

Materials

The required materials include guava leaves obtained from the Cipaku area, Ciamis, 96% ethanol, and triethanolamine (TEA). Carbopol 940, glycerol, methyl paraben, distilled water, Mg powder, concentrated HCl, 1% FeCl₃, Dragendorff's reagent, Mayer's reagent, Wagner's reagent, 2N HCl, amyl alcohol, Liebermann-Buchard reagent, and a positive control sunscreen brand Wardah SPF30 PA +++.

Detailed Procedure

Extraction

The extraction method chosen was maceration, using 96% ethanol as the solvent with a 1:10 ratio of crude drug to solvent, macerated for 3 days. 500 g of crude drug and 5L of solvent were required. Then the macerate was filtered and remacerated. When the macerate reached a viscous extract yield, it was subjected to rotary evaporation at 50°C and 45 rpm in order to determine the total macerate yield (8).

Phytochemical Screening

Screening of sample powders and extracts is aimed at observing the chemical compounds they contain. Compound testing includes flavonoids, alkaloids, saponins, phenols, tannins, and steroids.

Formulation of Guava Leaf Extract Gel (*Psidium guajava* L.)

The ethanol extract of guava leaves was formulated into a gel preparation, with the basic formula referring to previous studies. The concentration of the extract in each formula varied, namely 0.5%, 1%, 1.5%. In a mortar, 1 g of carbopol 940 was developed using hot distilled water, then glycerin and propylene glycol were added and ground until homogeneous, and methyl paraben was added. Then, the final step is to add the guava leaf extract and tea.

Table 1. Formula for guava leaf extract gel (*Psidium guajava* L.)

Ingredients	Function	F0 (%)	F1 (%)	F2 (%)	F3 (%)
Guava leaf extract	Active substance	-	0.5	1	1.5
Carbopol 940	Gelling agent	1	1	1	1
Methyl Paraben	Antimicrobial	0.2	0.2	0.2	0.2
Propyl Paraben	Antimicrobial	0.03	0.03	0.03	0.03
Propylene Glycol	Humectant	5	5	5	5
TEA	Emulsifier	1	1	1	1
Glycerin	Humectant	25	25	25	25

Distilled water	Solvent	Ad 100	Ad 100	Ad 100	Ad 100
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Evaluation of the sunscreen

The sunscreen gel preparation was evaluated based on organoleptic evaluation, homogeneity, viscosity, pH, spreadability, stickiness, and SPF value.

Data Analysis

The research data obtained were analyzed using Excel software to obtain the mean and standard deviation results for evaluating the sunscreen gel preparations of guava leaf ethanol extract and to determine the SPF value. The data are presented in tables and graphs and described narratively. Data processing was done theoretically, meaning the results of the serum spray preparation evaluation tests were compared with existing literature.

RESULT AND DISCUSSION

Results Subsection

The guava leaves used were obtained from Ciamis Regency, West Java. The results of the determination that has been tested at the Plant Taxonomy Laboratory, Department of Biology, Faculty of Mathematics and Natural Sciences, Padjadjaran University. Based on the identification results, it was stated that the sample plant is indeed guava leaf (*Psidium guajava* L.). The extraction method used in this experiment was cold maceration using 96% ethanol as the solvent. The yield of guava leaf extract obtained was 90.15 g, resulting in a yield of 18.03%.

Table 2. Yield of Extract

Sample	Weight of Powdered Simplicia (g)	Weight of Extract (g)	Yield (%)
Guava leaf extract	500	90.15	18.03

The extraction process of guava leaves using the cold maceration method with 96% ethanol produced 90.15 g of thick extract with a yield value of 18.03%. This result indicates that 96% ethanol was able to extract secondary metabolites from guava leaves effectively, particularly flavonoid and phenolic compounds that are known to possess antioxidant and photoprotective activities. Ethanol is widely used as an extraction solvent because of its ability to dissolve both polar and semi-polar bioactive compounds while maintaining compound stability during extraction (10).

The results of phytochemical screening are shown in Table 3. The results for the simplicia powder and guava leaf extract indicate that the secondary metabolites present are alkaloids, flavonoids, saponins, phenolics, tannins, and flavonoids, and steroids.

Table 3. Phytochemical Screening Result

No	Identification	Reactant	Observation Data			
			Powdered Simplicia		Thick Extract	
			Result	Observation	Result	Observation
1	Alkaloid	Dragendorff	+	Orange	+	Orange
		Mayer	+	Deposit White	+	Deposit White

		Wagner	+	Deposit brown sediment	+	Deposit brown sediment
		Concentrated HCl + magnesium metal powder + amyl alcohol	+	Red colored solution and layer of amyl alcohol	+	Red colored solution and layer of amyl alcohol
2	Flavonoid					
3	Saponin	Ethanol + 2N HCl	+	Foam formed	+	Foam formed
4	Phenol	Ethanol + FeCl ₃ 1%	+	Black and blue sediment	+	Black and blue sediment
5	Tannin	FeCl ₃ 1%	+	Dark blue solution	+	Dark blue solution
6	Steroid	Ether + Lieberman's Reagent	+	Green	+	Green

The phytochemical screening results showed that both powdered simplicia and thick extract of guava leaves contained alkaloids, flavonoids, saponins, phenols, tannins, and steroids. The presence of flavonoids and phenolic compounds is particularly important because these secondary metabolites are known to possess antioxidant and photoprotective activities that contribute to sunscreen effectiveness. Flavonoids contain conjugated aromatic structures and chromophore groups that can absorb ultraviolet (UV) radiation, especially in the UV-A and UV-B regions, thereby reducing UV penetration into the skin and minimizing oxidative stress caused by free radicals. In addition, phenolic compounds can donate hydrogen atoms or electrons to stabilize reactive oxygen species generated by UV exposure, which enhances skin photoprotection (11). The phytochemical profile obtained in this study is consistent with previous reports showing that *Psidium guajava* leaf extract contains flavonoids, tannins, saponins, and phenolic compounds as dominant bioactive constituents with antioxidant and UV-protective potential. Polyphenolic compounds have been widely investigated as active ingredients in cosmetic and sunscreen formulations due to their antioxidant, anti-inflammatory, and photoprotective mechanisms (12).

Sunscreen gel preparations were evaluated to determine whether the formulations met the required quality standards for topical products. The evaluations included organoleptic testing, homogeneity, viscosity, pH, spreadability, and adhesiveness tests. Based on Table 4, the organoleptic test results showed differences in color intensity among the formulas, which were influenced by the concentration of guava leaf extract added, ranging from 0% (F0), 0.5% (F1), 1% (F2), to 1.5% (F3). The higher the extract concentration, the darker the color and the stronger the characteristic herbal aroma of the preparation. However, all formulations maintained a semisolid gel texture with homogeneous characteristics, indicating that the addition of guava leaf extract did not adversely affect the physical stability of the gel preparations.

Table 4. Organoleptic Test Result

Formula	Texture	Color	Odor
0	Semisolid	Clear	Odorless
1	Semisolid	Light brown	Guava leaf specialties
2	Semisolid	Dark brown	Guava leaf specialties
3	Semisolid	Blackish brown	Guava leaf specialties

The homogeneity test produced the data shown in table 5, which indicates that the gel of guava leaf (*Psidium guajava* L.) ethanol extract meets the quality standards for gels, being homogeneous and free of coarse particles. Variations in extract concentration throughout the formula did not affect the homogeneity of the gel preparation.

Table 5. Homogeneity Test Result

Formula	Homogeneity
0	Homogeneous
1	Homogeneous
2	Homogeneous
3	Homogeneous

The viscosity test results presented in Table 6 showed that all formulations met the acceptable viscosity requirements for topical gel preparations, namely 50–1000 dPas. The average viscosity values obtained were 64.19 ± 0.07 dPas for F0, 100.85 ± 0 dPas for F1, 96.46 ± 0 dPas for F2, and 96.85 ± 0.30 dPas for F3. The increase in viscosity observed after the addition of guava leaf extract indicated that the extract contributed to strengthening the gel matrix through interactions between phytochemical compounds and the polymer base. However, increasing the extract concentration from 1% to 1.5% did not significantly increase viscosity, suggesting that excessive extract concentration may reduce the effectiveness of polymer interactions and limit further gel network formation.

Table 6. Viscosity Test Result

Formulation	Viscosity (dPas)			Average
	1	2	3	
0	64.15	64.15	64.28	64.19 ± 0.07
1	100.85	100.85	100.85	100.85 ± 0.00
2	96.46	96.46	96.46	96.46 ± 0.00
3	96.68	96.68	97.20	$96.85 \pm 0,30$

These findings are in agreement with previous studies reporting that the incorporation of herbal extracts into gel formulations can influence rheological properties, particularly viscosity, depending on extract concentration and polymer compatibility. A study by (13) reported that bioactive compounds in herbal gels affected the rheological and mechanical characteristics of Carbopol-based formulations through interactions within the polymeric network, resulting in changes in viscosity and gel stability. Furthermore, (14) demonstrated that variations in extract and Carbopol concentration significantly affected gel viscosity, spreadability, and physical stability of topical herbal formulations. Overall, the viscosity values obtained in this study indicate that all formulations possessed suitable consistency and good physical stability for topical sunscreen application.

Based on the pH test results presented in Table 7, all formulations showed pH values within the acceptable range for topical gel preparations, namely 4.5–6.5, indicating that the formulations were safe and suitable for skin application. The average pH values obtained were 6.56 ± 0.02 for F0, 6.36 ± 0.01 for F1, 6.33 ± 0.03 for F2, and 6.30 ± 0.06 for F3. The decrease in pH with increasing guava leaf extract concentration was likely caused by the presence of phenolic compounds, flavonoids, and tannins contained in the extract, which possess weak acidic properties due to hydroxyl (-OH) functional groups within their chemical structures. These compounds are capable of donating hydrogen ions (H⁺) into the system, thereby lowering the pH of the preparation (9).

Table 7. pH Test Result

Replication	F0	F1	F2	F3
1	6.55	6.35	6.30	6.25
2	6.56	6.36	6.34	6.28
3	6.58	6.37	6.35	6.36
Average	6.56 ± 0.02	6.36 ± 0.01	6.33 ± 0.03	6.30 ± 0.06

In addition to their effect on pH, flavonoids also contribute to sunscreen activity through their conjugated aromatic rings and chromophore groups, which can absorb ultraviolet (UV) radiation, particularly within the UV-A and UV-B regions. Furthermore, flavonoids and phenolic compounds exhibit antioxidant activity by scavenging free radicals generated by UV exposure, thereby enhancing photoprotective effects in topical sunscreen formulations. This mechanism has been widely reported in natural photoprotective agents derived from plant extracts. The pH results obtained in this study are consistent with previous studies on herbal gel formulations, where increasing extract concentration resulted in a slight decrease in pH due to the acidic nature of polyphenolic compounds. A study by Dos Santos (13) reported that the incorporation of phenolic-rich natural extracts into topical gel systems influenced the physicochemical properties of the formulations, including pH and rheological stability. Similarly, another study explained that polyphenols and flavonoids in cosmetic formulations contribute both antioxidant and UV-absorbing activities due to their chemical structures containing aromatic conjugated systems (12).

Based on the adhesion test results presented in Table 8, the addition of guava leaf ethanol extract increased the adhesiveness of the gel formulations. The average adhesion values obtained were 2.4 ± 0.1 seconds for F0, 3.7 ± 0.1 seconds for F1, 4.5 ± 0.1 seconds for F2, and 5.1 ± 0.1 seconds for F3. These results indicate that increasing the concentration of guava leaf extract enhanced the adhesion ability of the gel preparation. The improvement in adhesion may be attributed to the presence of polyphenolic compounds such as flavonoids and tannins, which can strengthen intermolecular interactions within the gel matrix and increase the consistency of the preparation.

Tabel 8. Adhesion test results

Formula	Replications			Average
	1	2	3	
F0	2.3	2.5	2.4	2.4 ± 0.1
F1	3.6	3.8	3.7	3.7 ± 0.1
F2	4.4	4.5	4.6	4.5 ± 0.1
F3	5.0	5.1	5.2	5.1 ± 0.1

Adequate adhesion is an important characteristic of topical sunscreen formulations because it prolongs the contact time of the preparation on the skin surface, thereby improving the effectiveness of active compounds in

protecting the skin against ultraviolet (UV) radiation. In addition, stronger adhesion can reduce the rate at which the preparation is removed from the skin during daily activities.

The results obtained in this study are in agreement with previous studies showing that increasing concentrations of plant extracts in gel systems can enhance adhesion properties due to interactions between bioactive compounds and polymer bases. A study reported that phenolic-rich herbal extracts improved the mechanical and bioadhesive properties of topical gel formulations through increased polymer–compound interactions (15). Similarly, another study demonstrated that the incorporation of flavonoid-containing botanical extracts into Carbopol-based gels increased adhesiveness and improved topical retention characteristics (16). Overall, all formulations exhibited acceptable adhesion properties for topical gel preparations, with F3 showing the highest adhesion value, indicating better retention ability on the skin surface.

Based on the spreadability test results presented in Table 9, all formulations showed spreadability values within the ideal range for topical gel preparations, namely 5–7 cm. The average spreadability values obtained were 6.9 ± 0.10 cm for F0, 5.7 ± 0.10 cm for F1, 6.2 ± 0.10 cm for F2, and 6.3 ± 0.10 cm for F3. Formula F0 exhibited the highest spreadability value, which was associated with its lowest viscosity value (64.19 dPas), allowing the gel to spread more easily across the surface. In contrast, formula F1 showed a decrease in spreadability corresponding to an increase in viscosity (100.85 dPas), resulting in a thicker gel consistency that required greater force to spread. Meanwhile, the spreadability values of F2 and F3 increased again, which was consistent with the slight decrease in viscosity observed in both formulations.

Table 9. Spreadability Test Result

Formula	Replications			Average
	1	2	3	
F0	6.9	7.0	6.8	6.9 ± 0.10
F1	5.7	5.6	5.8	5.7 ± 0.10
F2	6.2	6.1	6.3	6.2 ± 0.10
F3	6.3	6.4	6.2	6.3 ± 0.10

From Table 9, there is also an inverse relationship between viscosity and spreadability, indicating that the concentration of guava leaf extract influenced the internal structure of the gel matrix. Higher viscosity generally reduces the mobility of the gel system, thereby decreasing spreadability. However, excessive extract concentration may interfere with polymer interactions within the gel network, causing slight reductions in viscosity and consequently increasing spreadability. Adequate spreadability is important in sunscreen gel formulations because it ensures uniform distribution of active compounds on the skin surface, which may improve photoprotective effectiveness and user comfort during application. The results of this study are consistent with previous reports on herbal gel formulations. A study demonstrated that increasing the concentration of plant extract in Carbopol-based gels affected viscosity and spreadability properties, where higher viscosity resulted in lower spreading ability. Another study reported that topical antioxidant gel formulations with appropriate spreadability values provided better ease of application and more uniform distribution on the skin surface (17,18).

The SPF test results presented in Table 10 showed that all formulations possessed sunscreen activity with different levels of photoprotective effectiveness. Based on UV-Vis spectrophotometric analysis, Formula F0 showed an SPF value of 13.99 ± 0.0081 , categorized as maximum protection. Formula F1 containing 0.5% guava leaf extract exhibited an SPF value of 14.73 ± 1.0009 , which also fell within the maximum protection

category. Meanwhile, Formula F2 containing 1% extract showed an SPF value of 19.66 ± 0.0063 , categorized as ultra protection, and Formula F3 containing 1.5% extract demonstrated the highest SPF value of 60.11 ± 0.0075 , indicating very high photoprotective potential. These results indicate that increasing the concentration of guava leaf ethanol extract significantly enhanced the SPF value of the gel formulations.

Table 10. SPF Test Results

Formula	SPF Value	Category
F0	13.9979 ± 0.0081	Maximum protection
F1	14.7387 ± 1.0009	Maximum protection
F2	19.6625 ± 0.0063	Ultra protection
F3	60.1108 ± 0.0075	Ultra protection

The increase in SPF value is closely related to the presence of flavonoids and phenolic compounds in guava leaf extract. Flavonoids contain conjugated double bonds, aromatic rings, and chromophore groups capable of absorbing ultraviolet radiation, particularly within the UV-A and UV-B wavelength regions. In addition, phenolic compounds act as antioxidants by scavenging reactive oxygen species generated by UV exposure, thereby reducing oxidative stress and skin damage. This dual mechanism contributes to the photoprotective activity observed in the sunscreen gel formulations. Previous studies have also reported that plant-derived polyphenolic compounds exhibit natural sunscreen activity due to their UV absorption and antioxidant capacities (12).

The SPF values obtained in this study were higher than those reported in previous research on guava leaf extract formulations. A previous study (10) evaluating guava leaf ethanol extract in powder form reported SPF values ranging from 9.70 to 15, whereas the present study achieved SPF values up to 60.11 in gel formulations. This difference may be influenced by formulation type, extract concentration, solvent system, and the interaction between active compounds and the gel base, which may improve the uniform distribution of UV-absorbing compounds on the skin surface (19).

However, this study still has several limitations. The SPF evaluation was performed only using an in vitro UV-Vis spectrophotometric method and did not include in vivo testing on human skin. In addition, environmental factors, extract composition variability, and potential degradation of phenolic compounds during storage were not extensively evaluated. Therefore, further studies involving photostability testing, in vivo SPF analysis, and identification of specific active compounds are necessary to confirm the effectiveness and stability of guava leaf sunscreen gel formulations.

CONCLUSION

Based on the research results obtained, guava leaf (*Psidium guajava* L.) ethanol extract can be formulated into a sunscreen gel and has SPF values of F0 13.99, F1 14.73, F2 19.66, F3 60.11. The SPF value of the sunscreen gel preparation from guava leaf ethanol extract increased with increasing extract concentration.

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