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Development and Evaluation of *Andrographis paniculata* Root Extract Cream: Effects of Stearic Acid and Triethanolamine on Stability and Antioxidant Activity

Nur Khairi, **Maulita Indrisari**, **Andi Nur Aisyah**, **Marwati Marwati**

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Abstract: Oxidative stress contributes to skin damage, highlighting the need for plant-derived topical antioxidants. This study aimed to evaluate antioxidant activity of *Andrographis paniculata* root extract and develop a stable antioxidant cream. Dried roots were macerated with 70% ethanol, and antioxidant activity was assessed using the DPPH scavenging assay with vitamin C as control. Three oil-in-water cream formulations containing 0.25% extract were prepared with different stearic acid and triethanolamine concentrations and evaluated after accelerated storage for organoleptic properties, pH, homogeneity, viscosity, spreadability, adhesion, emulsion type, and antioxidant activity. Extraction yielded 6.66% blackish-brown extract. The extract showed concentration-dependent antioxidant activity, with an IC_{50} of 16.55 ppm, while vitamin C showed activity with an IC_{50} of 4.72 ppm. All creams remained homogeneous, retained oil-in-water emulsion type, and showed no visible phase separation. Accelerated storage significantly increased pH in all formulations, significantly reduced viscosity only in Formula I, significantly increased spreadability only in Formula III, and did not significantly affect adhesion time. Higher stearic acid and triethanolamine concentrations increased viscosity and adhesion but reduced spreadability. The cream retained antioxidant activity, with an IC_{50} of 69.61 ppm. Overall, Formula II showed the most stable physical profile and is a promising candidate for herbal antioxidant development.

Introduction

Oxidative stress is a major biological process involved in skin aging, inflammation, barrier dysfunction, pigmentation disorders, and several dermatological conditions. Excessive production of reactive oxygen species may damage lipids, proteins, and cellular structures, thereby accelerating cutaneous degeneration and reducing the skin's ability to maintain physiological homeostasis (1, 2). It may therefore be suggested that antioxidants play an important role as active agents in topical pharmaceutical and cosmeceutical preparations. Plant-derived antioxidants are particularly attractive because they commonly contain diverse bioactive compounds, including phenolics, flavonoids, tannins, terpenoids, carotenoids, and other secondary metabolites that may act through radical scavenging, reducing power, metal chelation, and anti-inflammatory mechanisms (3–5). Among medicinal plants with promising pharmacological potential, *Andrographis paniculata* has received considerable scientific attention. This plant is widely reported to contain polyphenols, flavonoids, phenolic acids, tannins, alkaloids, glycosides, terpenoids, and diterpenoid lactones, particularly andrographolide, which is frequently discussed as a characteristic marker compound of the species (6–9). Previous investigations have demonstrated the antioxidant capacity of *A. paniculata* extracts using several *in vitro* assays, including DPPH, ABTS, FRAP, ORAC, nitric oxide scavenging, and reducing power assays (10–12). These findings support the relevance of *A. paniculata* as a botanical source of antioxidant compounds for further pharmaceutical development.

Despite the growing evidence on the antioxidant potential of *A. paniculata*, several formulation-related challenges remain. Antioxidant activity observed in crude extracts does not necessarily remain unchanged after incorporation into a semisolid dosage form. Herbal extracts are chemically complex and may undergo degradation, oxidation, color alteration, or interaction with excipients during formulation and storage. In topical systems, antioxidant performance is influenced not only by the chemical profile of the extract but also by the type of

vehicle, emulsion structure, pH, viscosity, spreadability, adhesion, storage conditions, and compatibility between active compounds and excipients (13 – 15). Therefore, the development of antioxidant herbal creams requires evaluation of both biological activity and physical stability. A cream dosage form offers practical advantages for topical antioxidant delivery because it can increase contact time with the skin, improve user acceptability, facilitate uniform application, and provide a suitable matrix for incorporating plant extracts. Oil-in-water and water-in-oil emulsions are widely used in topical preparations because they can accommodate both hydrophilic and lipophilic constituents. However, the stability and performance of cream formulations depend strongly on the emulsifier system and the balance between aqueous and oil phases. Previous studies have emphasized that topical herbal creams must be evaluated for organoleptic properties, homogeneity, pH, spreadability, adhesion, viscosity, emulsion type, and stability under accelerated conditions to ensure acceptable pharmaceutical quality (16, 17). Triethanolamine and stearic acid are commonly used in topical cream formulations because they contribute to emulsification, pH adjustment, interfacial stabilization, texture, and rheological characteristics. Triethanolamine can act as an alkalizing agent and supports the formation of oil-in-water emulsions when combined with fatty acids, while stearic acid functions as a lipophilic structuring agent that improves cream consistency, viscosity, and emulsion stability (18 – 20). Variations in their concentrations may significantly alter the physical properties of cream preparations, including viscosity, spreadability, adhesion, and stability. Previous studies have shown that stearic acid contributes to cream viscosity and structural consistency, whereas triethanolamine plays an important role in emulsification through the formation of a stearic acid–triethanolamine system (21). Therefore, this emulsifier system is considered relevant for optimizing herbal cream formulations containing antioxidant extracts.

The antioxidant activity of botanical extracts is commonly assessed using the DPPH radical scavenging method because it is simple, rapid, reproducible, and suitable for comparing plant extracts with standard antioxidants such as Vitamin C. In this assay, antioxidant compounds donate hydrogen atoms or electrons to reduce the stable DPPH radical, resulting in a measurable decrease in absorbance at approximately 517 nm (22, 23). The use of DPPH is especially appropriate in preliminary screening of herbal materials, although interpretation should consider that antioxidant capacity may be affected by solvent type, phytochemical composition, concentration range, and matrix effects after formulation (24–26). Existing literature has extensively documented antioxidant activity in *A. paniculata*, particularly in leaf extracts, and has shown that phenolic and flavonoid contents often correlate with radical scavenging activity (27, 28). However, fewer studies have focused specifically on the root extract of *A. paniculata* and its incorporation into a topical cream system. Moreover, limited evidence is available on how variations in triethanolamine and stearic acid concentrations influence the physical stability and antioxidant effectiveness of *A. paniculata* root extract cream. This gap is important because formulation variables may alter both the pharmaceutical characteristics and measurable antioxidant activity of the final dosage form.

Therefore, this study aimed to evaluate the antioxidant activity of *A. paniculata* root extract and to formulate it into topical creams using variations of triethanolamine and stearic acid as emulsifying components. The study further assessed the physical stability of the cream formulations, including organoleptic characteristics, pH, homogeneity, spreadability, adhesion, viscosity, and emulsion type, before and after accelerated storage. The antioxidant effectiveness of the formulated cream was also evaluated using the DPPH method. The novelty of this study lies in integrating antioxidant evaluation of *A. paniculata* root extract with formulation optimization using a stearic acid–triethanolamine emulsifier system and subsequent assessment of antioxidant activity in the final cream dosage form.

Methodology

Plant Material and Authentication

The roots of *A. paniculata* were collected from Pomalaa, Southeast Sulawesi, Indonesia. Taxonomic authentication of the plant material was performed at the Research Center for Biology, Indonesian Institute of Sciences (LIPI), with the determination certificate number 165/IPH.1.01/If.07/I/2017. The collected roots were thoroughly cleaned to remove soil residues and other impurities, dried to constant weight, and ground into a fine homogeneous powder. The powdered material was kept in airtight containers at room temperature and protected from direct light and moisture prior to extraction.

Preparation of *Andrographis paniculata* Root Extract

The root extract of *A. paniculata* was prepared by maceration. Briefly, 500 g of dried powdered roots was extracted with 5 L of 70% ethanol for 3–4 days at room temperature with occasional agitation. The macerate was filtered through filter paper, and the plant residue was remacerated with another 5 L of 70% ethanol under the same conditions. The collected filtrates were combined and concentrated under reduced pressure using a rotary evaporator at 40 °C for approximately 4 h under a vacuum pressure of 40 mbar to obtain a thick extract. The viscous extract was further air-dried at room temperature until a dry extract was obtained. The dried extract was stored in an airtight container and protected from light and moisture until use (29, 30).

DPPH Antioxidant Activity Assay of *Andrographis paniculata* Root Extract

The antioxidant activity of *A. paniculata* root extract was evaluated using the DPPH radical scavenging method, with Vitamin C as the positive control. The DPPH assay was selected because it is a widely used spectrophotometric method for determining the free-radical scavenging capacity of plant extracts and antioxidant compounds. A DPPH solution was prepared by dissolving DPPH reagent in ethanol to obtain a working solution with suitable absorbance at the measurement wavelength. The solution was protected from light by covering the container with aluminum foil and was freshly prepared before analysis.

Stock solutions of *A. paniculata* root extract and Vitamin C were prepared separately using the same solvent. The extract solution was diluted to obtain concentrations of 5, 15, 25, 35, and 45 ppm. Vitamin C solution was prepared at concentrations of 2, 4, 6, 8, and 10 ppm. Each sample solution was mixed with DPPH solution at a predetermined ratio and incubated in the dark at room temperature for the required reaction time. After incubation, the absorbance was measured using a UV-Vis spectrophotometer at 517 nm. The blank solution contained DPPH solution without sample, while the sample solution contained DPPH and the tested extract or Vitamin C. Each concentration was tested in triplicate (21).

Preparation of *A. paniculata* Root Extract Cream

All ingredients used can be seen in **Table 1**. The ingredients were accurately weighed according to the calculated formula composition. The cream components were divided into two phases: the oil phase and the aqueous phase. The oil phase, consisting of stearic acid, liquid paraffin, adeps lanae, and propylparaben, was placed in a porcelain dish and melted on a hot plate at approximately 70 °C. Separately, the aqueous phase, consisting of triethanolamine, methylparaben, and distilled water, was heated on a hot plate at the same temperature until all components were completely dissolved. After both phases reached a similar temperature, the oil phase was slowly incorporated into the aqueous phase with continuous stirring to form a uniform cream base. Stirring was maintained until a homogeneous semisolid mass was obtained. The *A. paniculata* root extract was then gradually added to the cream base and triturated gently until evenly dispersed. Rose oil was subsequently incorporated as a fragrance, and the mixture was further stirred until a homogeneous cream preparation was obtained (31).

Stability Evaluation of the Cream Formulations

The physical stability of the cream formulations was evaluated before and after accelerated storage. The cream formulations were placed in tightly closed containers and stored in a climatic chamber (Memmert, Germany) at 40 ± 2 °C and 75 ± 2% relative humidity (RH) for 6 weeks. The temperature and relative humidity were controlled using the climatic chamber system and monitored periodically throughout the storage period to ensure that the conditions remained within the specified range. The evaluated parameters included organoleptic characteristics, pH, homogeneity, spreadability, adhesion time, viscosity, and emulsion type.

Organoleptic evaluation was performed by observing the physical appearance, color, and odor of each formulation. The cream was examined visually to determine whether phase separation, discoloration, unpleasant odor, or changes in consistency occurred after storage.

The pH test was conducted using a calibrated pH meter. A suitable amount of cream was dispersed in distilled water and mixed until uniform. The pH value was measured in triplicate, and the results were expressed as mean ± standard deviation. This test was performed to determine the suitability of the cream for topical application (32).

Homogeneity was evaluated by spreading a small amount of cream on a clean glass slide. The preparation was observed visually for the presence of coarse particles, aggregates, or uneven distribution of extract. A homogeneous cream was indicated by a smooth and uniform appearance (33).

Spreadability was determined by placing 0.5 g of cream at the center of a glass plate. A s glass plate was placed on top, and weights of 50 g and then 100 g were applied sequentially. The diameter of the spread cream was measured. A spreading diameter of 5–7 cm was considered indicative of a semi-solid consistency suitable for comfortable topical application. The adhesion test was performed by placing the cream between two glass slides and applying a standard load for a fixed period. After the load was removed, the time required for the slides to separate was recorded in s. The adhesion time indicated the ability of the cream to remain in contact with the application surface (34).

Viscosity was measured using a rotational viscometer (Brookfield), which is commonly used for measuring the flow resistance of semi-solid materials such as creams. To ensure accuracy, spindle number 3 was selected, as recommended by the manufacturer for testing creams, and the rotational speed was set to 3 rpm. Before starting the measurement, a sufficient amount of the cream was carefully placed into the sample container of the viscometer. The sample was allowed to stabilize for a few min to ensure that no air bubbles were present and that the cream temperature was uniform. The instrument was then operated, and the viscosity value (in centipoise, cP) was recorded once the reading became stable (35).

The emulsion type was determined by dispersing a

Table 1. Composition of *Andrographis paniculata* root extract cream formulations.

Ingredient	Formula (% w/w)			Function
	I	II	III	
Andrographis paniculata root extract	0.25	0.25	0.25	Active ingredient
Stearic acid	10	15	20	Emulsifying agent
Triethanolamine	2	3	4	Emulsifying agent
Adeps lanae	3	3	3	Emollient
Liquid paraffin	5	5	5	Occllusive
Methylparaben	0.15	0.15	0.15	Preservative
Propylparaben	0.5	0.5	0.5	Preservative
Rose oil	0.5	0.5	0.5	Fragrance
Distilled water	q.s to 100	q.s to 100	q.s to 100	Vehicle

small amount of cream in water. Formulations that dispersed easily in water were classified as oil-in-water emulsions. The emulsion type was observed before and after accelerated storage to determine whether the system remained stable (36).

DPPH Antioxidant Activity Assay of *Andrographis paniculata* Root Extract Cream

The antioxidant activity of the cream formulations containing *A. paniculata* root extract was also evaluated using the DPPH radical scavenging method. Each cream formulation was accurately weighed and dissolved or dispersed in a suitable solvent to extract the antioxidant compounds from the cream base. The mixture was homogenized and filtered or centrifuged to obtain a clear sample solution suitable for spectrophotometric analysis. The prepared cream sample solution was mixed with DPPH solution and incubated in the dark at room temperature for the required reaction time. After incubation, the absorbance was measured using a UV-Vis spectrophotometer at the maximum wavelength of DPPH. A blank solution and control solution were prepared under the same conditions. Each measurement was performed in triplicate. The % inhibition of DPPH radicals was calculated using the same equation used for the extract and Vitamin C assay. The antioxidant activity of the cream formulations was compared among Formula I, Formula II, and Formula III to evaluate the influence of different emulsifying agent compositions on the radical scavenging activity of cream formulations containing a fixed concentration of *A. paniculata* root extract. The results were expressed as mean inhibition ± standard deviation (37).

Statistical Analysis

All quantitative data were obtained from triplicate measurements and expressed as mean ± standard deviation (SD). The antioxidant activity of *A. paniculata* root extract, Vitamin C, and the cream formulation was evaluated based on the % of DPPH radical inhibition, and the IC_{50} values were estimated from the relationship between log concentration and probit values using linear regression analysis. For physical stability evaluation, pH, viscosity, spreadability, and adhesion time were analyzed using Two-way Analysis of Variance (Two-way ANOVA), with formulation batch and storage condition as the independent factors and the physicochemical parameters as the dependent variables. When significant differences were detected, Tukey's HSD *post-hoc* test was applied to determine pairwise differences among groups. A p-value of less than 0.05 was considered statistically significant.

Results and Discussion

Extraction Yield and Physical Characteristics of *Andrographis paniculata* Root Extract

Extraction of *A. paniculata* roots using 70% ethanol produced a thick-to-dry extract with a blackish-brown color and a characteristic odor. The extraction yield was 6.66%, corresponding to approximately 33.3 g of extract obtained from 500 g of dried powdered root material. The dark color of the extract may be associated with the concentration of phenolic compounds, flavonoids, tannins, diterpenoid lactones, and other secondary metabolites present in *A. paniculata*. The extraction procedure, involving maceration and remaceration with 70% ethanol followed by concentration using a rotary evaporator at 40°C, was considered appropriate for extracting polar and semi-polar bioactive constituents while minimizing excessive thermal degradation of thermolabile compounds.

The use of 70% ethanol was specifically chosen as entirely relevant to the primary antioxidant objective of this study because such hydroethanolic solvent systems are thoroughly capable of effectively extracting essential phenolic compounds, flavonoids, glycosides, and terpenoids, which are widely recognized as potent radical-scavenging constituents. Previous scientific studies have thoroughly reported that these phenolic-and flavonoid-rich extracts function as major contributors to the robust antioxidant activity of *Andrographis paniculata* (38, 39). Therefore, the resulting extraction yield of 6.66% not only accurately reflects the quantitative efficiency of the entire extraction process but also importantly provides a solid foundation for accurately interpreting the antioxidant activity observed in both the crude extract and the

Table 2. Antioxidant activity of *Andrographis paniculata* root extract.

Concentration (ppm)	Log concentration	Replicate	Blank absorbance	Sample absorbance	Inhibition (%)	Mean inhibition ± SD (%)	Probit
5	0.69	1	0.83	0.59	29.51	29.66 ± 0.18	4.45
		2	0.83	0.58	29.86		
		3	0.83	0.58	29.62		
15	1.17	1	0.83	0.49	40.74	40.46 ± 0.24	4.76
		2	0.83	0.50	40.26		
		3	0.83	0.49	40.38		
25	1.39	1	0.83	0.38	54.36	53.20 ± 1.19	5.09
		2	0.83	0.40	51.97		
		3	0.83	0.39	53.28		
35	1.54	1	0.83	0.27	67.14	66.94 ± 0.18	5.41
		2	0.83	0.27	66.90		
		3	0.83	0.27	66.78		
45	1.65	1	0.83	0.20	75.98	76.06 ± 0.13	5.73
		2	0.83	0.19	76.22		
		3	0.83	0.20	75.98		



Figure 1. *Andrographis paniculata* root extract cream.

subsequently formulated topical cream.

Antioxidant Activity of *Andrographis paniculata* Root Extract

The antioxidant activity of *A. paniculata* root extract was evaluated using the DPPH radical scavenging method. As shown in **Table 2**, the extract demonstrated a concentration-dependent increase in radical scavenging activity. The mean % inhibition increased from 29.66 ± 0.18% at 5 ppm to 40.46 ± 0.24% at 15 ppm, 53.20 ± 1.19% at 25 ppm, 66.94 ± 0.18% at 35 ppm, and 76.06 ± 0.13% at 45 ppm. The probit values also increased from 4.45 to 5.73, indicating a systematic dose-response relationship between extract concentration and DPPH radical inhibition.

Based on the relationship between probit values and log concentration presented in **Table 2**, the IC_{50} value of the root extract was estimated to be approximately 16.55 ppm, indicating strong antioxidant activity. This finding is consistent with previous reports showing that *A. paniculata* contains polyphenols, flavonoids, tannins, phenolic acids, terpenoids, alkaloids, glycosides, and diterpenoid lactones such as andrographolide, all of which may contribute to antioxidant activity (7, 28). The DPPH method is suitable for this evaluation because antioxidant compounds reduce the stable DPPH radical through hydrogen atom or electron donation, resulting in decreased absorbance at approximately 517 nm (22, 23).

Vitamin C was used as the positive control to validate the antioxidant assay. As presented in **Table 3**, Vitamin C exhibited stronger DPPH radical scavenging activity at lower concentrations than the *A. paniculata* root extract. The % inhibition increased from 10.55 ± 1.03% at 2 ppm to 34.16 ± 2.55% at 4 ppm, 59.25 ± 1.48% at 6 ppm, 77.58 ± 0.76% at 8 ppm, and 92.74 ± 0.49% at 10 ppm. The probit values also increased from 3.74 to 6.42, confirming a clear dose-response pattern. Based on the data in **Table 3**, the IC_{50} value of Vitamin C was estimated to be approximately 4.72 ppm, which was lower than the IC_{50} value of the *A. paniculata* root extract shown in **Table 2**. This indicates that Vitamin C, as a pure antioxidant compound, had stronger antioxidant capacity than the crude extract. This difference is expected because plant extracts consist of complex phytochemical matrices containing compounds with different solubility, reactivity, and radical scavenging efficiencies. Nevertheless, the antioxidant activity of *A. paniculata* root extract remains pharmacologically relevant because botanical antioxidant effects are often mediated by the combined and potentially synergistic actions of multiple constituents. Low *et al.* (2015) emphasized that DPPH scavenging activity in *A. paniculata* may be more strongly correlated with phenolic and flavonoid constituents than with andrographolide alone (40).

Physical Stability of *Andrographis paniculata* Root Extract Cream

The cream formulations were prepared using a fixed concentration of *A. paniculata* root extract, namely 0.25%, with variations in stearic acid and triethanolamine concentrations, as shown in **Table 1**. Formula I contained 10% stearic acid and 2% triethanolamine, Formula II contained 15% stearic acid and 3% triethanolamine, and Formula III contained 20% stearic acid and 4% triethanolamine. These variations were designed to evaluate the influence of the emulsifier system on the physical characteristics and stability of the cream. Visually, the three cream formulations are shown in **Figure 1**, indicating that all formulations had a semisolid form and appeared visually homogeneous.

The organoleptic evaluation presented in **Table 4** showed that, before accelerated storage, all formulations were cream-like in appearance, brown in color, and had a

Table 3. Antioxidant activity of Vitamin C as the positive control.

Concentration (ppm)	Log concentration	Replicate	Blank absorbance	Sample absorbance	Inhibition (%)	Mean inhibition ± SD (%)	Probit
2	0.30	1	0.84	0.74	11.70	10.55 ± 1.03	3.74
		2	0.84	0.76	9.69		
		3	0.84	0.75	10.28		
4	0.60	1	0.84	0.53	36.99	34.16 ± 2.55	4.60
		2	0.84	0.57	32.03		
		3	0.84	0.56	33.45		
6	0.77	1	0.84	0.33	60.63	59.25 ± 1.48	5.24
		2	0.84	0.35	57.68		
		3	0.84	0.34	59.45		
8	0.90	1	0.84	0.18	78.13	77.58 ± 0.76	5.75
		2	0.84	0.19	76.71		
		3	0.84	0.18	77.89		
10	1.00	1	0.84	0.06	92.90	92.74 ± 0.49	6.42
		2	0.84	0.05	93.14		
		3	0.84	0.06	92.19		

Table 4. Organoleptic characteristic of *Andrographis paniculata* root extract cream.

Formula	Before accelerated storage			After accelerated storage		
	Appearance	Color	Odor	Appearance	Color	Odor
I	Cream	Brown	Rose	Cream	Light brown	Rose
II	Cream	Brown	Rose	Cream	Light brown	Rose
III	Cream	Brown	Rose	Cream	Light brown	Rose

rose-like odor. After accelerated storage, all formulations retained their cream form and rose-like odor; however, the color changed from brown to light brown. This color change may indicate slight alteration or oxidation of extract-derived pigments and polyphenolic compounds during accelerated storage. Herbal formulations frequently undergo color changes during stability testing because plant extracts contain chemically diverse constituents that may be sensitive to heat, oxygen, pH, and light exposure (13, 16). However, since no phase separation or undesirable odor was observed, the results in **Table 4** indicate that the emulsifier system was able to maintain acceptable organoleptic stability.

The pH values of the cream formulations are presented in **Table 5**. Before accelerated storage, all formulations had pH values of approximately 4.32. After accelerated storage, the pH increased to 5.04 ± 0.05 in Formula I, 5.07 ± 0.02 in Formula II, and 5.30 ± 0.27 in Formula III. **Table 5** indicates that the differences in pH among the formulations were not statistically significant. The increase in pH may be associated with the presence of triethanolamine and its interaction with stearic acid, aqueous-phase components, and extract constituents during storage. From a topical formulation perspective, the final pH values remained within a range generally considered suitable for skin application. Previous literature emphasizes that pH compatibility is essential for maintaining skin tolerability, minimizing irritation risk, and supporting skin barrier function. The pH values of the cream formulations are presented in **Table 5**. Before accelerated storage, all formulations showed comparable pH values of approximately 4.32, indicating that the initial acid–base condition of the cream system was relatively uniform among Formula I, II, and III. This similarity may be attributed to the proportional composition of stearic acid and triethanolamine in the three formulations. In topical cream systems, stearic acid and triethanolamine interact to form triethanolamine stearate, an anionic type emulsifying system that contributes to emulsion formation, interfacial film stabilization, and the consistency of the semisolid base. Since the ratio between stearic acid and triethanolamine was maintained proportionally across the formulations, the initial neutralization balance and pH profile remained relatively similar despite the different total concentrations of these emulsifying agents.

After accelerated storage, the pH values increased to 5.04 ± 0.05 in Formula I, 5.07 ± 0.02 in Formula II, and 5.30 ± 0.27 in Formula III. Based on Two-way ANOVA followed by Tukey's HSD *post-hoc* test, the pH values after accelerated storage were significantly higher than those before storage ($p < 0.05$), as indicated by different superscript letters. This finding demonstrates that storage time and thermal stress significantly affected the acid–base characteristics of the cream formulations. The increase in pH may be associated with gradual physicochemical changes in the emulsion system during storage, including further interaction or redistribution between triethanolamine and stearic acid, changes in the aqueous phase, and possible ionization or degradation-related changes involving the extract-containing components of the formulation. Although the pH increased significantly after storage, the pH values among Formula I, II, and III within the same storage condition were not statistically different. This suggests that the variation in the concentration of stearic acid and triethanolamine did not produce a significant difference in pH among formulations as long as their proportional ratio was maintained. However, Formula III showed the highest numerical pH value after storage, which may be related to its higher total content of stearic acid and triethanolamine. A higher concentration of the emulsifying system may provide a larger reservoir of ionizable and neutralizable components, thereby contributing to a greater tendency toward pH alteration under thermal stress, even though this difference was not statistically significant among the formulations.

From a physicochemical perspective, the pH shift after accelerated storage indicates that the internal microenvironment of the cream base was affected by elevated temperature. Thermal stress may alter the distribution of aqueous and oil-phase components, influence the interfacial film formed by triethanolamine stearate, and modify the equilibrium between the emulsifying agents and other excipients. Adeps lanae and liquid paraffin contribute to the oil phase and emollient characteristics of the cream, while the aqueous phase serves as the main medium in which pH-related changes are detected. Therefore, the observed pH alteration should be interpreted as part of the overall stability behavior of the emulsion system rather than as an isolated chemical

Table 5. pH Value of *Andrographis paniculata* root extract cream.

Formula	Before accelerated storage	After accelerated storage
I	4.32 ± 0.02^{a}	5.04 ± 0.05^{b}
II	4.32 ± 0.02^{a}	5.07 ± 0.02^{b}
III	4.32 ± 0.05^{a}	5.30 ± 0.27^{b}

Note: Different superscript letters indicate statistically significant differences among groups based on Two-way ANOVA followed by Tukey's HSD *post-hoc* test ($p < 0.05$). Values with the same superscript letter are not significantly different.

change (41).

From a topical formulation perspective, the final pH values after accelerated storage remained within a range generally considered acceptable for skin application. However, the statistically significant increase in pH indicates that accelerated storage can influence the acid–base stability of the cream formulations and should be considered in product stability evaluation. Maintaining pH compatibility is important because pH is closely associated with skin tolerability, irritation potential, preservative performance, and preservation of the skin barrier function (16, 42). These findings indicate that although the formulations retained a skin-compatible pH range after storage, the significant pH shift demonstrates the need to monitor storage-induced physicochemical changes in the developed *A. paniculata* root extract cream.

The homogeneity test results presented in **Table 6** showed that all cream formulations remained homogeneous before and after accelerated storage. No visible aggregation, coarse particle formation, grittiness, or phase separation was observed in Formula I, II, or III. This finding indicates that *A. paniculata* root extract was evenly dispersed within the cream base and that the semisolid system was able to maintain macroscopic uniformity under accelerated storage conditions.

From a physicochemical perspective, the maintained homogeneity may be attributed to the emulsifying system formed by stearic acid and triethanolamine. In the aqueous phase, triethanolamine can partially neutralize stearic acid to form triethanolamine stearate, an anionic type emulsifier that reduces interfacial tension between the oil and aqueous phases. This interfacial film helps stabilize dispersed droplets and supports the formation of a uniform semisolid cream matrix (43). The gradual increase in stearic acid and triethanolamine concentrations from Formula I to Formula III may also contribute to the structural consistency of the cream base by strengthening the internal emulsion network. The presence of adeps lanae and liquid paraffin may further support the homogeneity of the formulations by contributing to the oil phase and improving the emollient characteristics of the cream. Adeps lanae has amphiphilic properties that may assist in stabilizing the oil–water interface, while liquid paraffin helps form a continuous lipophilic environment that supports smooth texture and uniform distribution of dispersed components (44). In addition, methylparaben and propylparaben were incorporated as preservatives, while rose oil was added as fragrance; these components were present at fixed concentrations across all formulations and did not appear to interfere with the macroscopic uniformity of the cream.

The viscosity values of the cream formulations are presented in **Table 7**. Before accelerated storage, the viscosity increased progressively from Formula I to Formula III, with values of 33.386 ± 4.69 cP, 42.053 ± 3.48 cP, and 66.346 ± 5.32 cP, respectively. This trend indicates that increasing the concentrations of stearic acid and triethanolamine contributed to the formation of a stronger semisolid structure. In classical topical cream technology, stearic acid acts not only as an emulsifying component but also as a consistency-enhancing fatty acid, while triethanolamine partially neutralizes stearic acid to form triethanolamine stearate. This type emulsifying system reduces interfacial tension and supports the formation of an interfacial film around the dispersed phase, thereby strengthening the internal emulsion network and increasing viscosity. After accelerated storage, the viscosity values decreased to 22.800 ± 6.92 cP in Formula I, 31.866 ± 6.11 cP in Formula II, and 59.866 ± 2.30 cP in Formula III. Based on Two-way ANOVA followed by Tukey's HSD *post-hoc* test, Formula I showed a statistically significant reduction in viscosity after accelerated storage ($p < 0.05$). In contrast, the viscosity reductions observed in Formula II and Formula III were not statistically significant according to the same superscript letters before and after storage. These findings indicate that accelerated storage affected the viscosity profile of the formulations differently, with Formula I being more susceptible to storage-induced viscosity loss.

The decrease in viscosity after accelerated storage may be explained by structural relaxation of the cream matrix, partial rearrangement of the emulsifier–lipid network, and redistribution of water within the aqueous phase. Thermal stress can weaken the internal organization of the semisolid system by disturbing the interfacial film formed by triethanolamine stearate and reducing the resistance of the cream matrix to flow (34). Formula I, which contained the lowest concentrations of stearic acid and triethanolamine, likely had a weaker internal network and lower structural resistance; therefore, it exhibited a significant viscosity reduction after storage. Conversely, Formula III maintained the highest viscosity

Table 6. Homogeneity of *Andrographis paniculata* root extract cream.

Formula	Before accelerated storage	After accelerated storage
I	Homogeneous	Homogeneous
II	Homogeneous	Homogeneous
III	Homogeneous	Homogeneous

Table 7. Viscosity *Andrographis paniculata* root extract cream.

Formula	Viscosity (cP)	
	Before accelerated storage	After accelerated storage
I	33386 ± 4.69[a]	22800 ± 6.92[b]
II	42053 ± 3.48[a]	31866 ± 6.11[a]
III	66346 ± 5.32[c]	59866 ± 2.30[c]

Note: Different superscript letters indicate statistically significant differences among groups based on Two-way ANOVA followed by Tukey's HSD *post-hoc* test ($p < 0.05$). Values with the same superscript letter are not significantly different.

both before and after accelerated storage, suggesting that the higher concentrations of stearic acid and triethanolamine produced a denser and more resistant emulsifier–lipid network.

The spreadability values of the cream formulations are presented in **Table 8**. Before accelerated storage, Formula I showed the highest spreadability value of 7.03 ± 0.15 cm, followed by Formula II at 6.21 ± 0.10 cm and Formula III at 5.00 ± 0.10 cm. Based on Two-way ANOVA followed by Tukey's HSD *post-hoc* test, these values were statistically different among the formulations, as indicated by different superscript letters. This result demonstrates that the variation in stearic acid and triethanolamine concentrations significantly influenced the spreading behavior of the cream formulations. The progressive decrease in spreadability from Formula I to Formula III can be explained by the increasing concentrations of stearic acid and triethanolamine. In the cream system, stearic acid acts as a fatty acid consistency agent, while triethanolamine partially neutralizes stearic acid to form triethanolamine stearate, an anionic soap-type emulsifier. This emulsifying system contributes to the formation of a stronger interfacial film and a more structured semisolid matrix. As the concentrations of stearic acid and triethanolamine increased, the internal emulsion network became denser, resulting in higher viscosity and greater resistance to flow. Consequently, Formula III, which contained the highest levels of stearic acid and triethanolamine, exhibited the lowest spreadability.

After accelerated storage, the spreadability values increased numerically to 7.46 ± 0.30 cm in Formula I, 6.66 ± 0.30 cm in Formula II, and 5.26 ± 0.11 cm in Formula III. The *post-hoc* analysis showed that the increase in spreadability of Formula I and Formula II after storage was not statistically significant because the superscript letters remained the same before and after storage. However, Formula III showed a statistically significant increase in spreadability after accelerated storage. This finding suggests that the most viscous formulation experienced measurable changes in its spreading behavior after exposure to thermal stress.

The increase in spreadability after accelerated storage may be associated with partial structural relaxation of the cream matrix, rearrangement of the emulsifier–lipid network, and redistribution of the aqueous and oil phases. Thermal stress can weaken the internal organization of the semisolid system, reduce matrix rigidity, and facilitate deformation of the cream under an applied load (18, 45). This effect was particularly evident in Formula III, which initially had the highest viscosity and the most compact internal structure. Although Formula III retained a relatively high viscosity after storage, the significant increase in spreadability indicates that thermal stress may have reduced its yield stress sufficiently to allow greater spreading under the constant weight used in the test. The spreadability results should be interpreted together with the viscosity data because both parameters are rheologically interrelated. A formulation with high initial viscosity generally possesses greater internal resistance and higher yield stress. Under a constant applied weight, this higher yield stress restricts the deformation and flow of the cream, resulting in a smaller spreading diameter (44). This explains why Formula III, which had the highest viscosity, showed the lowest spreadability before and after accelerated storage. Conversely, a reduction in viscosity or partial weakening of the semisolid matrix after storage may decrease internal resistance, allowing the cream to spread more easily and produce a larger spreading diameter (43).

The adhesion time of the cream formulations is presented in **Table 9**. Before accelerated storage, the adhesion time increased progressively from Formula I to Formula III, with values of 13.51 ± 0.12 s, 15.60 ± 0.41 s, and 17.70 ± 0.30 s, respectively. Based on Two-way ANOVA followed by Tukey's HSD *post-hoc* test, the adhesion time differed significantly among the formulations, as indicated by different superscript letters. This result demonstrates that the variation in stearic acid and triethanolamine concentrations significantly influenced the adhesive behavior of the cream formulations. The increase in adhesion time from Formula I to Formula III can be explained by the higher concentrations of stearic acid and triethanolamine in the formulation. In classical semisolid cream systems, stearic acid contributes to the formation of a more structured lipid matrix and improves the consistency of the cream.

Table 8. Spreadability of *Andrographis paniculata* root extract cream.

Formula	Spreadability (cm)	
	Before accelerated storage	**After accelerated storage**
I	7.03 ± 0.15[a]	7.46 ± 0.30[a]
II	6.21 ± 0.10[b]	6.66 ± 0.30[b]
III	5.00 ± 0.10[c]	5.26 ± 0.11[b]

Note: Different superscript letters indicate statistically significant differences among groups based on Two-way ANOVA followed by Tukey's HSD *post-hoc* test ($p < 0.05$). Values with the same superscript letter are not significantly different.

Table 9. Adhesion time *Andrographis paniculata* root extract cream.

Formula	Adhesion Time (s)	
	Before accelerated storage	**After accelerated storage**
I	13.51 ± 0.12[a]	12.48 ± 0.22[a]
II	15.60 ± 0.41[b]	15.41 ± 0.35[b]
III	17.70 ± 0.30[c]	16.74 ± 0.63[c]

Note: Different superscript letters indicate statistically significant differences among groups based on Two-way ANOVA followed by Tukey's HSD *post-hoc* test ($p < 0.05$). Values with the same superscript letter are not significantly different.

Triethanolamine partially neutralizes stearic acid to form triethanolamine stearate, an anionic type emulsifier that stabilizes the oil–water interface and strengthens the internal emulsion network. As the concentrations of stearic acid and triethanolamine increased, the cream matrix became denser and more resistant to separation from the test surface, thereby increasing the adhesion time (32).

After accelerated storage, the adhesion time decreased numerically to 12.48 ± 0.22 s in Formula I, 15.41 ± 0.35 s in Formula II, and 16.74 ± 0.63 s in Formula III. However, the *post-hoc* analysis showed that these decreases were not statistically. This finding suggests that accelerated storage did not significantly reduce the adhesive performance of the cream formulations, although a slight numerical decline was observed. The slight decrease in adhesion time after accelerated storage may be associated with partial structural relaxation of the semisolid matrix, rearrangement of the emulsifier–lipid network, or redistribution of water and oil phases within the cream system. Thermal stress may reduce the compactness of the internal structure, thereby slightly lowering the resistance of the cream to detachment from the test surface. Nevertheless, the absence of statistically significant changes indicates that the emulsifying system and lipid components were able to maintain the adhesive integrity of the formulations under accelerated storage conditions (18).

Formula III maintained the highest adhesion time both before and after accelerated storage. This result is consistent with its higher viscosity and lower spreadability, indicating that the stronger internal matrix formed by higher concentrations of stearic acid and triethanolamine contributed to better adhesion. A cream with higher viscosity generally has greater internal resistance and stronger cohesive forces, allowing it to remain attached to the application surface for a longer period. Conversely, formulations with lower viscosity, such as Formula I, tend to spread more easily but show shorter adhesion time due to weaker structural resistance. From a topical formulation perspective, adhesion time is important because it reflects the ability of the cream to remain in contact with the skin surface after application. Adequate adhesion may improve residence time and support prolonged contact between the active ingredient and the target area. However, excessively high adhesion may reduce user comfort and ease of spreading. Therefore, adhesion time should be interpreted together with viscosity and spreadability to determine the most balanced formulation (36). These results indicate that the stearic acid–triethanolamine emulsifying system plays an important role not only in maintaining cream consistency and viscosity, but also in controlling the adhesive performance of the developed *A. paniculata* root extract cream.

The emulsion type of the cream formulations is presented in **Table 10**. All formulations consistently maintained an oil-in-water (O/W) emulsion system both before and after accelerated storage testing. The structural stability of this system indicates that observed changes in pH, spreadability, adhesion, and viscosity did not trigger phase inversion. The O/W system is particularly suitable for topical preparations because its water-continuous phase makes it easily washable, comfortable to apply, and non-greasy, offering a lighter skin feel and superior cosmetic acceptability compared to water-in-oil systems.

Antioxidant Activity of *Andrographis paniculata* Root Extract Cream

The antioxidant activity of *A. paniculata* root extract cream is presented in **Table 11**. The cream showed concentration-dependent DPPH inhibition, increasing from

Table 10. Emulsion type *Andrographis paniculata* root extract cream.

Formula	Emulsion Type	
	Before accelerated storage	After accelerated storage
I	O/W	O/W
II	O/W	O/W
III	O/W	O/W

Table 11. Antioxidant activity of *Andrographis paniculata* root extract cream.

Concentration (ppm)	Log concentration	Replicate	Blank absorbance	Sample absorbance	Inhibition (%)	Mean inhibition ± SD (%)	Probit
50	1.69	1	0.83	0.43	47.78	44.88 ± 0.18	4.85
		2	0.83	0.47	43.36		
		3	0.83	0.47	43.48		
100	2	1	0.83	0.39	53.28	55.55 ± 0.24	5.13
		2	0.83	0.36	56.63		
		3	0.83	0.36	56.75		
150	2.17	1	0.83	0.28	66.30	66.62 ± 1.19	5.42
		2	0.83	0.28	66.18		
		3	0.83	0.27	67.38		
200	2.30	1	0.83	0.17	79.21	79.56 ± 0.18	5.82
		2	0.83	0.16	79.80		
		3	0.83	0.17	79.68		
250	2.39	1	0.83	0.13	84.46	84.86 ± 0.13	5.99
		2	0.83	0.12	84.70		
		3	0.83	0.12	85.42		

44.88 ± 0.18% at 50 ppm to 55.55 ± 0.24% at 100 ppm, 66.62 ± 1.19% at 150 ppm, 79.56 ± 0.18% at 200 ppm, and 84.86 ± 0.13% at 250 ppm. The increase in probit values from 4.85 to 5.99 in **Table 11** confirms a consistent dose-response pattern in the cream formulation.

The IC_{50} value of the cream was estimated to be approximately 69.61 ppm, which was higher than the IC_{50} value of the crude extract shown in **Table 2**. This indicates that incorporation of the extract into the semisolid cream base reduced the apparent radical scavenging potency. This reduction may be attributed to matrix effects, limited diffusion of antioxidant compounds from the cream base, or interactions between extract constituents and excipients. Previous studies have similarly reported that the antioxidant activity of topical formulations is strongly influenced by emulsion architecture, active localization within the formulation system, pH, rheology, excipient compatibility, and storage conditions (14, 46).

Although the IC_{50} value of the cream was higher than that of the extract, the data in **Table 11** show that the cream retained strong antioxidant activity at concentrations of 200–250 ppm, with inhibition values of 79.56 ± 0.18% and 84.86 ± 0.13%, respectively. These findings indicate that *A. paniculata* root extract retained measurable radical scavenging activity after incorporation into the cream base.

Conclusion

This study demonstrated that *A. paniculata* root extract has strong antioxidant activity and can be incorporated into topical cream formulations using stearic acid and triethanolamine as emulsifiers. Extraction with 70% ethanol yielded 6.66% extract with concentration-dependent DPPH radical scavenging activity (IC_{50} 16.55 ppm). The formulated creams maintained acceptable physical characteristics after accelerated storage, including homogeneous appearance and oil-in-water emulsion type. Accelerated storage significantly increased pH values, though they remained suitable for topical application. Viscosity decreased significantly only in Formula I, spreadability increased significantly in Formula III, and adhesion time remained unchanged. Variations in emulsifier concentrations significantly affected physical properties, with higher concentrations producing stronger semisolid matrices, higher viscosity, longer adhesion time, and lower spreadability. The cream retained measurable antioxidant activity (IC_{50} 69.61 ppm). Formula II showed the most stable physical profile after accelerated storage.

Declaration

Author Information

Nur Khairi *(*Corresponding author)*, Departement of Pharmaceutical and Technology, Universitas Almarisah Madani, Makassar, Indonesia, 90242. **Contribution:** Writing – Original Draft, Conceptualization.

Maulita Indrisari, Departement Pharmacotherapy Faculty of Medicine, Palangkaraya University, Palangkaraya, Indonesia. **Contribution:** Methodology, Software.

Andi Nur Aisyah, Departement of Pharmaceutical and Technology, Universitas Almarisah Madani, Makassar, Indonesia, 90242. **Contribution:** Visualization, Supervision.

Marwati Marwati, Departement of Pharmaceutical Biology, Univeritas Almarisah Madani, Makassar, Indonesia, 90242. **Contribution:** Data Curation.

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During the preparation of this manuscript, the authors used ChatGPT-4 solely as an assistant for language editing, grammar correction, and improving readability. No data, figures, or original research concepts were generated using artificial intelligence. The authors thoroughly reviewed and edited all AI-assisted text, take full responsibility for the contents of the published article, and approved the final manuscript prior to submission.

Conflict of Interest

The authors declare no conflict of interest.

Data Availability

All data generated or analyzed during this study are included in this published article and its supplementary information files.

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References

1. Thiviya P, Gamage A, Piumali D, Merah O, Madhujith T. Apiaceae as an Important Source of Antioxidants and Their Applications. Cosmetics. 2021;8(4):111. doi: https://doi.org/10.3390/cosmetics8040111

2. Khairi N, Nursamsiar, Utami NF, Marwati, Nur S. Mapping the composition–activity landscape of *Sterculia populifolia* DC: Antioxidant mechanisms, UV transmission attenuation, and enzymatic targets for skin aging. Biocatalysis and Agricultural Biotechnology. 2026;75:104105. doi: https://doi.org/10.1016/j.bcab.2026.104105

3. Hoffmann J, Gendrisch F, Schempp CM, Wölfle U. New Herbal Biomedicines for the Topical Treatment of Dermatological Disorders. Biomedicines. 2020;8(2):27. doi: https://doi.org/10.3390/biomedicines8020027

4. Napagoda M, Kumari M, Samaranayake U. *In vitro* evaluation of UV-filtering and anti-tyrosinase potential in selected medicinal plants in Sri Lanka for the development of herbal cosmetics. Prayogik Rasayan. 2021;5(2). doi: https://doi.org/10.53023/p.rasayan-20211102

5. Burlando B, Cornara L. Honey in dermatology and skin care: a review. J of Cosmetic Dermatology. 2013;12(4):306-313. doi: https://doi.org/10.1111/jocd.12058

6. Khatun R, Sengupta S, Bhattacharya M. Phytochemical analysis of *Andrographis paniculata* leaf for their antibacterial and antioxidant potential. Int. J. Eng. Sci. Tech. 2024;8(4). doi: https://doi.org/10.29121/ijoest.v8.i4.2024.623

7. Owoade AO. Phytochemical Characterization and Antioxidant Bioactivity of *Andrographis paniculata* (Nees). Pajols. 2021;5(2):246-256. doi: https://doi.org/10.36108/pajols/1202.50.0220

8. Shrivastava AK, Keshari M, Neupane M, Chaudhary S, Dhakal PK, Shrestha L, *et al*. Evaluation of Antioxidant and Anti-Inflammatory Activities, and Metabolite Profiling of Selected Medicinal Plants of Nepal. Journal of Tropical Medicine. 2023;2023:1-15. doi: https://doi.org/10.1155/2023/6641018

9. Karim MM, Fakir MF, Sagar A, Murshed HM, Ashrafuzzaman Md. Phytochemical Screening and Antioxidant Capacity of Some Selected Medicinal Plants of Bangladesh. Bangladesh J Bot. 2024;53(2):373–80. doi:10.3329/bjb.v53i2.74427

10. Kotha RR, Tareq FS, Yildiz E, Luthria DL. Oxidative Stress and Antioxidants—A Critical Review on *In Vitro* Antioxidant Assays. Antioxidants. 2022;11(12):2388. doi: https://doi.org/10.3390/antiox11122388

11. Pogorzelska-Nowicka E, Hanula MM, Brodowska-Trębacz M, Górska-Horczyczak E, Jankiewicz U, Mazur T, *et al*. The Effect of Cold Plasma Pretreatment on Water-Suspended Herbs Measured in the Content of Bioactive Compounds, Antioxidant Activity, Volatile Compounds and Microbial Count of Final Extracts. Antioxidants. 2021;10(11):1740. doi: https://doi.org/10.3390/antiox10111740

12. Rezvani-Kamran A, Salehi I, Shahidi S, Zarei M, Moradkhani S, Komaki A. Effects of the hydroalcoholic extract of *Rosa damascena* on learning and memory in male rats consuming a high-fat diet. Pharmaceutical Biology. 2017;55(1):2065-2073. doi: https://doi.org/10.1080/13880209.2017.1362010

13. Savić I, Savić-Gajić I. Physical, chemical, and antioxidant stability studies of a topical formulation containing pot marigold (*Calendula officinalis* L.) flowers extract. Adv Techol. 2021;10(1):11-19. doi: https://doi.org/10.5937/savteh2101011s

14. Bikiaris ND, Koumentakou I, Hatzistamatiou K, Lykidou S, Barmpalexis P, Nikolaidis N. Preparation and Investigation of the SPF and Antioxidant Properties of O/W and W/O Emulsions Containing Vitamins A, C and E for Cosmetic Applications. Cosmetics. 2023;10(3):76. doi: https://doi.org/10.3390/cosmetics10030076

15. Srilal TLI, Hettihewa SK. Development and Evaluation of a Novel Herbal Emulgel for Potential Anti-Inflammatory and Antioxidant Activities *in Vitro*. Cinec Academic Journal. 2021;5:46–53. doi:10.4038/caj.v5i1.73

16. Gyawali R, Narayan Paudel P. Herbal Remedies in Cosmeceuticals Formulation: A Review on Nepalese Perspectives. Annapurna J H Sci. 2022;2(1):59-65. doi: https://doi.org/10.52910/ajhs.66

17. Ilodibia CV, Ugwu RU, Nwokolo OL, Chukwuma MU, Akachukwu EE. Phytochemical Screening, Antifungal and Antibacterial Activity of Aqueous and Ethanolic Leaf and Stem Extracts of *Gnetum africanum* Welw. Research J. of Medicinal Plant. 2015;9(6):275-283. doi: https://doi.org/10.3923/rjmp.2015.275.283

18. BîRsan M. Development and evaluation of hydrophilic cream bases suitable for custom cosmetic skincare or compounding pharmaceutical dermal products. Farmacia. 2022;70(5):880-889. doi: https://doi.org/10.31925/farmacia.2022.5.13

19. Baptista S, Freitas F. Formulation of the polysaccharide fucopol into novel emulsified creams with improved physicochemical properties. Molecules. 2022;27(22):7759. doi:10.3390/molecules27227759

20. Djuris J, Vasiljevic D, Jokic S, Ibric S. Application of D -optimal experimental design method to optimize the formulation of O / W cosmetic emulsions. Intern J of Cosmetic Sci. 2013;36(1):79-87. doi: https://doi.org/10.1111/ics.12099

21. Khairi N, Khairuddin K, Marwati M, Maulita I, Michrun N, Fitria NI. Photoprotective Potential of Black Rice Extract: LC-MS/MS Profiling and Cram Optimization. Agricultural Biotechnology Journal. 2026;18(1):419–38. doi:10.22103/jab.2026.26478.1818

22. Rani KC, Ningrat KWC, Melinda S, Jayani NIE. Formulasi Chewable Gummy Daun Kelor (*Moringa oleifera*) dengan Gelling Agent Konjak Glukomanan dan Kappa Karagenan. Mpi. 2022;4(1):1-12. doi: https://doi.org/10.24123/mpi.v4i1.5032

23. Gashaye MB, Birhan YS. Phytochemical constituents, antioxidant and antibacterial activities of *Plectocephalus varians* (A. Rich.) C. Jeffrey ex Cufod root extracts. BMC Complement Med Ther. 2023;23(1). doi: https://doi.org/10.1186/s12906-023-03919-8

24. Naqbi KMAA, Karthishwaran K, Kurup SS, Abdul Muhsen Alyafei M, Jaleel A. Phytochemicals, Proximate Composition, Mineral Analysis and *In Vitro* Antioxidant Activity of *Calligonum crinitum* Boiss. Horticulturae. 2022;8(2):156. doi: https://doi.org/10.3390/horticulturae8020156

25. Nyalo P, Omwenga G, Ngugi M. Quantitative Phytochemical Profile and *In Vitro* Antioxidant Properties of Ethyl Acetate Extracts of *Xerophyta spekei* (Baker) and *Grewia tembensis* (Fresen). J Evid Based Complementary Altern Med. 2023;28. doi: https://doi.org/10.1177/2515690x231165096

26. Baldi A. Evaluation of *in vitro* antioxidant activity of *Eclipta alba*. Acta Hortic. 2013;2013(972):27-31. doi: https://doi.org/10.17660/actahortic.2013.972.3

27. Singh H, Singh N. Antioxidant and Antidiabetic Activity of *Berberis lycium*: The Possibilities of TLC-MS Bioautography and *in silico* Study. Ijper.

2022;56(1):207-214. doi: https://doi.org/10.5530/ijper.56.1.24

28. Ajayi OS, Balogun OS, Olawuni IJ, October N, Adigun R, Akinlade IG. Alpha Amylase Inhibition and Antioxidant Activities of Bicyclic Diterpenoid Lactones from *Andrographis paniculata*. Tjnpr. 2021;5(6):1110-1117. doi: https://doi.org/10.26538/tjnpr/v5i6.22

29. Therasa SA, Sobiya G, Parimala M. Leaves of *Andrographis paniculata* Is an Antioxidant and Anticancer Agent. Asian Journal of Pharmaceutical and Clinical Research. 2020;213–7. doi:10.22159/ajpcr.2020.v13i8.37014

30. Barata, D. M., Ruslan, N. A., Zawawi, N. A. A. M., Kub, T. N. T., Alojid, A. A. M. Comparative antibacterial activity and stability of *Andrographis paniculata* herbal mouthwash and commercial mouthwashes. Mjm. 2023;19(2):200-210. doi: https://doi.org/10.21161/mjm.220052

31. Ali SK, Makeen HA, Khuwaja G, Alhazmi HA, Sharma M, Koty A, *et al*. Assessment of the Phytochemical Profile, Antioxidant Capacity, and Hepatoprotective Effect of *Andrographis paniculata* against CCl4-Induced Liver Dysfunction in Wistar Albino Rats. Medicina. 2023;59(7):1260. doi: https://doi.org/10.3390/medicina59071260

32. Kartikasari ALN, Wibowo ADK, Kuncahyo I. Optimization of naringenin sunscreen cream formula using the simplex lattice design method. J. Halal Sci. Res. 2023;4(2):81-87. doi: https://doi.org/10.12928/jhsr.v4i2.7172

33. Jalil NK, Maulita Indrisari, Ikbal, Nurul Hikma. Pengaruh Emulgator Terhadap Stabilitas dan Aktivitas Tabir Surya Krim Ekstrak Mahkota Dewa dan Kencur. j. tumbuh. obat. indonesia. 2025;18(1):38-56. doi: https://doi.org/10.31002/jtoi.v18i1.2633

34. Petkova - Parlapanska K, Handzhiyski Y, Georgieva E, Nikolova G, Karamalakova Y. Antibacterial and antioxidant activity of cosmetic creams with extracts of dry flowers and fruits of *Sambucus nigra* l. - use of *Sambucus nigra* l. as a non-traditional chemical preservative. Jctm. 2024;59(3):549-557. doi: https://doi.org/10.59957/jctm.v59.i3.2024.7

35. Khairi N, Muslimin L, Mubarak F, Indrisari M, Fajriansyah F. Development and Evaluation of a Stable Topical Cream Formulated with *Annona squamosa* Seed Extract as a Natural Pediculosis Agent. Biology, Medicine, & Natural Product Chemistry. 14 Desember 2025;14(2):1355–63. doi:10.14421/biomedich.2025.142.1355-1363

36. Mungmai L, Wongwad E, Tanamatayarat P, Rungsang T, Vivattanaseth P, Aunsri N, *et al*. Stability, Bioactivity, and Skin Penetration of Prunus Leaf Extracts in Cream Formulations: A Clinical Study on Skin Irritation. Cosmetics. 2025;12(4):146. doi: https://doi.org/10.3390/cosmetics12040146

37. Swami P. Herbal sunscreen development: spf, antioxidants, comparative analysis. Ijhmp. 2024;5(1):64-71. doi: https://doi.org/10.59551/ijhmp/25832069/2024.5.1.90

38. Abd Samat NMA, Ahmad S, Awang Y, Bakar RAH, Hakiman M. Alterations in Herbage Yield, Antioxidant Activities, Phytochemical Contents, and Bioactive Compounds of Sabah Snake Grass (*Clinacanthus nutans* L.) with Regards to Harvesting Age and Harvesting Frequency. Molecules. 2020;25(12):2833. doi: https://doi.org/10.3390/molecules25122833

39. Jivaje K, Inamdar A, Gharge S, Kagwad P, Suryawanshi SS, Bhandurge P, *et al*. A Brief Review on Evaluation and Exploration of Antioxidant Activity of Mango Ginger. Ijam. 2022;13(2):321-327. doi: https://doi.org/10.47552/ijam.v13i2.1946

40. Low M, Khoo CS, Münch G, Govindaraghavan S, Sucher NJ. An *in vitro* study of anti-inflammatory activity of standardised *Andrographis paniculata* extracts and pure andrographolide. BMC Complement Altern Med. 2015;15(1). doi: https://doi.org/10.1186/s12906-015-0525-7

41. Gyawali R, Gupta RK, Shrestha S, Joshi R, Paudel PN. Formulation and Evaluation of Polyherbal Cream Containing *Cinnamomum zeylanicum* Blume, *Glycyrrhiza glabra* L and *Azadirachta indica* A. Juss. Extracts to Topical Use. J. Inst. Sci. Tech. 2020;25(2):61-71. doi: https://doi.org/10.3126/jist.v25i2.33738

42. Kulawik-Pióro A, Goździcka WJ. Plant and Herbal Extracts as Ingredients of Topical Agents in the Prevention and Treatment Radiodermatitis: A Systematic Literature Review. Cosmetics. 2022;9(3):63. doi: https://doi.org/10.3390/cosmetics9030063

43. Sarfraz M, Shabbir K, Adnan Q, Khan HMS, Shirazi JH, Sabir H, *et al*. Fabrication, organoleptic evaluation and in vitro characterization of cream loaded with *Carica papaya* seed extract. J of Cosmetic Dermatology. 2023;23(3):1045-1054. doi: https://doi.org/10.1111/jocd.16066

44. Sjahjadi FR, Febriyenti, Lucida H. Formula Optimization of a Sunscreen Cream of Tomato's Purified Extract. Advances in Health Sciences Research. 2021. doi: https://doi.org/10.2991/ahsr.k.211105.007

45. Cheong KL, Sabir A, Wang M, Zhong S, Tan K. Advancements in the Extraction, Characterization, and Bioactive Potential of Laminaran: A Review. Foods. 9 Mei 2025;14(10):1683. doi:10.3390/foods14101683

46. Cavalcanti GR, Duarte FI, Converti A, de Lima ÁA. Ferulic Acid Activity in Topical Formulations: Technological and Scientific Prospecting. Cpd. 2021;27(19):2289-2298. doi: https://doi.org/10.2174/1381612826666201020163331

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