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Optimization of the Red Chrysanthemum Flower Extract Cream Formula Using Simplex Lattice Design and *In Vitro* Evaluation

Nur Cholis Endriyatno, **Erin Efrilia**, **Sukma Sona**

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Abstract: Red chrysanthemum flower (*Chrysanthemum* × *morifolium*) is a plant that contains bioactive flavonoid compounds. These compounds are recognized for their effectiveness in reducing exposure to ultraviolet radiation. A formulation containing red chrysanthemum flower extract should be developed, and its photoprotective properties should be evaluated. The aim of this research is to determine the effect of stearic acid and triethanolamine on the physical properties of the cream and to identify the optimal formulation of the red chrysanthemum flower extract cream. This study used a simplex lattice design (SLD) with stearic acid and triethanolamine as factors. Response variables included pH, viscosity, adhesion, and spreadability. The formulation optimization involved 8 runs. The results showed that stearic acid and triethanolamine influence pH, viscosity, spreadability, and adhesion. The predicted optimal formula was obtained at a stearic acid (17.907%) and triethanolamine (2.093%), with a desirability value of 0.892. The prediction was verified, which showed no significant difference. The cream showed *in vitro* photoprotective activity (SPF 24.15 ± 0.78, %Te 0.37 ± 0.10, and %Tp 0.35 ± 0.03). The conclusion of this study is that the optimization using the SLD method can produce an optimal cream with *in vitro* sunscreen activity.

Introduction

Sunlight includes ultraviolet (UV) B rays that can damage the skin, leading to hyperpigmentation, erythema, wrinkles, and an increased risk of skin cancer (1–4). Active ingredients in sunscreens are potentially harmful, including Octyl Methoxycinnamate (OMC), benzophenone, 4-methylbenzilidene camphor, and octocrylene (5). Based on these potential side effects, alternative ingredients from natural sources are needed, one of which is the red *Chrysanthemum* flower. In previous research, red *Chrysanthemum* flower extract at a concentration of 300 ppm was found to have an average SPF value of 30.141 ± 0.487, which falls into the high category (6). Red *Chrysanthemum* flowers are known to contain flavonoids including apigenin and luteolin (7). Therefore, it is necessary to formulate to a cream.

Emulsifier components are essential in cream formulations for achieving desirable physical properties in the final product (8). Commonly used emulsifier combinations include stearic acid and triethanolamine (9). Stearic acid and triethanolamine form a stable oil-in-water (O/W) emulsion when combined with free fatty acids. Previous research has demonstrated that stearic acid and triethanolamine exert contrasting effects on the cream's physical properties. Specifically, stearic acid can reduce pH and spreadability, while increasing adhesion and viscosity (10). Conversely, triethanolamine elevates pH and enhances spreadability, yet diminishes adhesion and viscosity (11). Given their critical roles in the formulation and characteristics of the cream, it is essential to optimize the formulation to achieve the most suitable composition.

The Simplex lattice design (SLD) method can be employed to determine the relative proportions of ingredients that yield the most optimal formula based on predefined criteria. Previous research has proven that sunscreen creams can be optimised using the SLD method with factors (stearic acid and triethanolamine) as well as responses (pH, spreadability, adhesion, and viscosity) (12). The research gap identified is that no one has yet formulated red *Chrysanthemum* flower extract into a sunscreen cream, according to Google Scholar, although several studies involving stearic acid and triethanolamine have been reported. In addition, some chemical sunscreen ingredients may have harmful effects, so alternatives are needed. The novelty of this study lies in the use of *Chrysanthemum* flower extract as a photoprotective agent in a cream formulation optimised using SLD. Accordingly, this study aims to identify an optimal cream formulation containing *Chrysanthemum* flower extract that exhibits *in vitro* sun-protection activity.

Table 1. Formulation of red *Chrysanthemum* flower extract cream.

Materials	Run (%)							
	1	2	3	4	5	6	7	8
Extract	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
Stearic Acid	16	17.5	18	16.5	16	18	17	17
Triethanolamine	4	2.5	2	3.5	4	2	3	3
Propylene glycol	10	10	10	10	10	10	10	10
Paraffin wax	5	5	5	5	5	5	5	5
Cetyl alcohol	2	2	2	2	2	2	2	2
Methyl paraben	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Propyl paraben	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Distilled water	Ad 100	Ad 100	Ad 100	Ad 100	Ad 100	Ad 100	Ad 100	Ad 100

Methodology

Apparatus

Spectrophotometer (Shimadzu UV-1780, Japan), sonicator (Biobase UC-5 S, China), analytical balance (Ohaus MB95, USA), waterbath (Silver green DK-98-IIA, China), rotary evaporator (IKA RV8, Germany), pH meter (Smart Sensor AS218, China), stopwatch, moisture analyzer (Ohaus, USA), a set of viscometers (silver green BDV-9 s, China), adhesion tests, a set of spreading tests, mortar, stamper, and glassware.

Materials

Red *Chrysanthemum* flowers obtained in Semarang, Indonesia and other excipients consisting of 96% ethanol, distilled water, stearic acid, triethanolamine, propylene glycol, liquid paraffin, cetyl alcohol, methyl paraben, and propyl paraben.

Extraction

The extraction and characterisation process refers to previous research (6). The red *Chrysanthemum* was first identified. The red *Chrysanthemum* flower was then cleaned and dried in sunlight under a black cloth for 3 days, after which it was ground. The standardisation of the simplicia involved organoleptic, moisture content, and drying loss tests. Extraction of the red *Chrysanthemum* flower was carried out by maceration with 100 grams of powder and 1000 mL of 96% ethanol as the solvent at a 1:10 ratio for 2 x 24 h, followed by re-maceration for 1 x 24 h. After the maceration and re-maceration processes, the extract was evaporated using a rotary vacuum evaporator at 50 °C and 60 rpm. The extract was examined through organoleptic tests, yield determination, and moisture content tests. The red *Chrysanthemum* flower extract was identified as containing flavonoid compounds, as indicated by tests such as the Shibata, Pew's, and NaOH tests.

Cream Formulation

The cream formulation is based on previous research, with some modifications (11,13). The emulsifier limits (the concentration was adjusted to 20%, the total of the upper and lower limits for each emulsifier) are a stearic acid concentration of 16-18% and a triethanolamine concentration of 2-4%. The SLD was conducted in triplicate, resulting in eight recommendations, as listed in **Table 1**. The cream formulation begins by separately melting the oil phase (stearic acid, liquid paraffin, cetyl alcohol, and propyl paraben) and the water phase (triethanolamine and methyl paraben) in a porcelain dish and heating them on a hot plate at 60 °C while stirring until homogeneous. The red *Chrysanthemum* flower extract is dissolved with propylene glycol in a porcelain dish. The water phase is slowly added into the oil phase in a warm mortar and stirred until a cream mass forms. Distilled water is added gradually while continuously stirring. When the cream temperature reaches approximately 45 °C, the red *Chrysanthemum* flower extract is added into the mortar containing the mixture of oil and water phases, and ground until homogeneous.

Characterization

pH Test

The pH test used a pH meter to measure cream dissolved in water. Topical formulations should match skin pH 4.5-6.5 (14).

Viscosity Test

Viscosity testing is carried out by inserting the cream sample into a Viscotester Brookfield, then reading the viscosity according to the rotor used. The viscosity requirement for semi-solid formulation is 50–1000 dPas (15).

Spreadability test

Place 1 gram of cream on the glass, cover with another transparent glass slide, and leave it for 1 minute. Then, add weights of 50, 100, 150, and 250 g on top of the glass slide, observe, and measure the diameter formed. The spreadability requirement for topical preparations is 5–7 cm (11).

Adhesion Test

Apply 1 g of cream on a glass plate, then place another glass plate on top of the cream. Apply a 500 g load for 5 minutes, then remove it. Use a release weight of 80 g for testing. The adhesion requirement is > 4 seconds (15).

Simplex Lattice design Analysis

Data analysis used the simplex lattice design with Stat-Ease 360 (Trial). The factors were stearic acid and triethanolamine, and the responses were pH, viscosity, adhesion, and spreadability. Statistical criteria included, among others, the P-value (for the model and lack of fit), the response model form, R^2 (adjusted and predicted), and the equation. The software suggested the optimal

$$SPF = CF \times \sum_{290}^{320} EE \times I \times Abs \quad \textbf{(Eq. 1)}$$

$$\%Te = \frac{Ee}{\sum Fe} = \frac{\sum(T \times Fe)}{\sum Fe} \quad \textbf{(Eq. 2)}$$

$$\%Tp = \frac{Ee}{\sum Fp} = \frac{\sum(T \times Fp)}{\sum Fp} \quad \textbf{(Eq. 3)}$$

formulation, which was verified by comparing predicted and actual data (12). Physical tests included irritation, cream type, stability, and *in vitro* sunscreen evaluation.

Irritation Test

The irritation test is based on previous research, with some modifications (12,16). Irritation tests involved 10 respondents, who received 0.5 g of cream applied to the inner forearm skin. Observations focused on erythema and oedema at 24, 48, and 72 h. The safety parameters measured were erythema and oedema. Erythema was scored as follows: No erythema (0), Very slight erythema (almost invisible) (1), Clearly defined erythema (2), Moderate to severe erythema (3), and Severe erythema with doughy red colouring and slight crust formation (deep wound) (4). Oedema was scored as follows: No oedema (0), Very slight oedema (barely visible) (1), Small oedema (with clear boundaries) (2), Moderate oedema (edge approximately 1 mm) (3), and Oedema extending beyond (more than 1 mm and spreading outside the exposed area) (4). Written informed consent was obtained from all participants prior to testing. The irritation test has obtained ethical clearance from the Health Research Ethics Commission of Universitas Pekalongan, No. 150/B.02.01/KEPK/V/2026.

Inclusion criteria included subjects aged 18–55 years, willing to participate in the study, with healthy skin in the testing area, and no history of allergies or hypersensitivity to cosmetics or the tested ingredients. The exclusion criteria include subjects with skin abnormalities, wounds, irritation, or infection in the testing area, a history of allergies or hypersensitivity to the test substances, currently using medications or topical products that may affect the results, or unable to complete the study procedures.

Cream Type Test

The cream-type test involves applying 0.5 g of cream to a glass surface, adding a few drops of methylene blue, and observing the result. If the dye spreads uniformly, the cream type is O/W; if it separates, the type is W/O (17).

Stability Test

Stability testing involved centrifugation and cycling methods (18–20). For the centrifugation test, 5 grams of the cream were placed in a centrifuge tube and centrifuged at 5000 rpm for 30 minutes to assess phase separation. The cycling test was conducted over 6 cycles, each consisting of 24 h at 4±2 °C and 24 h at 40±2 °C. During each cycle, the sample's appearance, colour, and odour were monitored.

In Vitro Sunscreen Evaluation

Sun Protection Factor (SPF)

Determination of SPF value using Mansur's equation (12,21). SPF testing was conducted using spectrophotometry (Shimadzu-1780) at wavelengths of 290 –320 nm. The cream was dissolved in 96% ethanol to a 5% concentration. The blank used was 96% ethanol. Analysis using a cuvette with a path length of 1 cm and quartz material. Absorbance data was used to determine the SPF value through Mansur's equation, as shown in **Equation 1**, where CF is the correction factor (10). EE is the erythemal effect spectrum, and I is the solar intensity spectrum. EE×I are constant, and Abs is the sample absorbance.

Erythema and Pigmentation Transmission Percentage

Determination of Erythema and pigmentation transmission

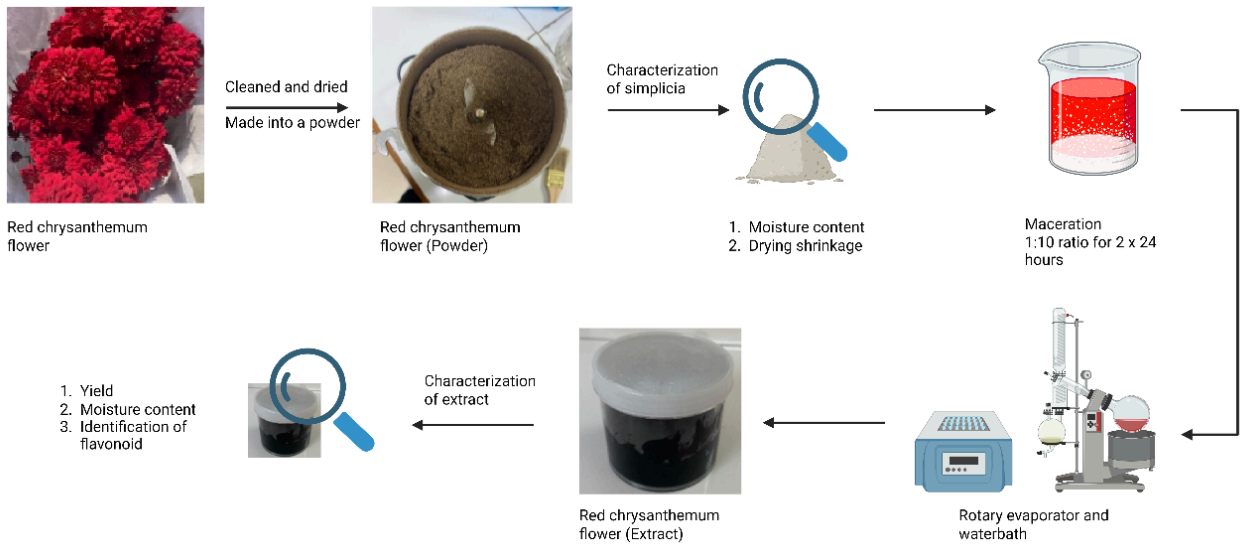


Figure 1. The graphical extraction workflow.

Table 2. Qualitative identification results of flavonoid compounds.

Test	Reagent	Criteria	Result	Conclusion
Shibata	Methanol 50% + powder mg + concentrated HCl	The colour red indicates the presence of flavonol (24)	Red colour	Presence Flavonoid
Pew's	Zinc powder + sulfa acid	The colour red indicates the presence of flavone (24)	Red colour	Presence Flavonoid
Alkaline	NaOH + a few drops of HCl	Yellow-red, coffee-orange, purple-red or blue colours indicate the presence of xanthone and/or flavon, flavonol, limon and anthocyanin (25)	Yellow-red colour	Presence Flavonoid



Figure 2. Red *Chrysanthemum* flower extract.

percentages using the equations developed by Cumpelik (12,22). The measurement of absorbance at the erythema transmission percentage (%Te) is conducted over a wavelength range of 292.5-337.5 nm, while pigmentation transmission (% Tp) is measured at wavelengths of 322.5 – 372.5 nm using UV-Vis spectrophotometry. The calculations for %Te and %Tp are shown in **Equations 2** and **3**. Where %TE= erythema transmission; Fe = flux of erythema (constant); %Tp = pigmentation transmission; Fp = flux of pigmentation (constant); %T = transmission percentage.

Results and Discussion

Extraction

The determination was done at UPT Herbal Laboratory Materia Medica Batu, Batu City, East Java, with letter number 000.9.3/1654/102.20/2026 showing the type as *Chrysanthemum* × morifolium (Ramat.) Hemsl. The graphical extraction workflow is shown in **Figure 1**. Red *Chrysanthemum* flowers (1.3 kg) produced 122 g of simplisia with a moisture content of 7.92%. This meets the requirement that simplisia moisture content be below 10% (23). The drying shrinkage of red *Chrysanthemum* flower simplicia was 9.4%. It used 96% ethanol for maceration due to its high capacity for extracting flavonoids. The extraction yield was 25.45%, higher than the 23.45% reported in previous research (6). The red *Chrysanthemum* flower extract is shown in **Figure 2**. The moisture content of the extract produced was 8.17%, lower than the 24.94% reported in previous research (6). The moisture content of the red *Chrysanthemum* flower extract meets the requirement of < 10%. The results of the identification of flavonoid compounds contained in the extract are listed in **Table 2**. The limitation in this study is that it did not perform total flavonoid content analysis via spectrophotometry or HPLC.

Cream Formulation

The red *Chrysanthemum* flower extract cream was prepared in 8 runs, following the SLD recommendation. It had a greenish-yellow colour, characteristic red *Chrysanthemum* scent, and no distinctive smell from other ingredients. The cream was homogeneous, with no visible coarse particles. Results are shown in **Figure 3**.

Evaluation

The cream containing red *Chrysanthemum* flower extract was then evaluated for pH, viscosity, spreadability, and adhesion. The evaluation results are shown in **Table 3**. The results represent individual measurements. It was used as



Figure 3. Results of the formulation of red *Chrysanthemum* flower extract cream.

Table 3. The Evaluation of red *Chrysanthemum* flower extract cream.

Respons	Run 1	Run 2	Run 3	Run 4	Run 5	Run 6	Run 7	Run 8
pH	6.68	6.16	6.11	6.51	6.70	6.13	6.31	6.40
Viscosity (dPas)	371.52	414.83	426.77	389.37	386.56	430.9	400.88	408.06
Spreadability (cm)	6.36	5.84	5.28	6.31	6.37	5.13	6.13	6.00
Adhesion (second)	10.78	12.07	12.68	10.78	10.43	12.42	11.54	11.49

Table 4. ANOVA statistical analysis and response model.

Respon	P-value		Model	R2	R2		Equation
	Model	Lack of Fit			Adjusted	Predicted	
pH (Y1)	0.0001	0.2752	Linear	0.9650	0.9592	0.9411	Y1 = 0.274(X1) + 0.567(X2)
Viscosity (Y2)	0.0001	0.9851	Linear	0.9479	0.9392	0.8887	Y2 = 23.924(X1) – 1.035(X2)
Spreadability (Y3)	0.0001	0.4597	Quadratic	0.9798	0.9717	0.9486	Y3 = 0.079(X1) – 3.711(X2) + 0.311(X1X2)
Adhesion (Y4)	0.0001	0.5748	Linear	0.0637	0.9576	0.9258	Y4 = 0.727(X1) – 0.280(X2)

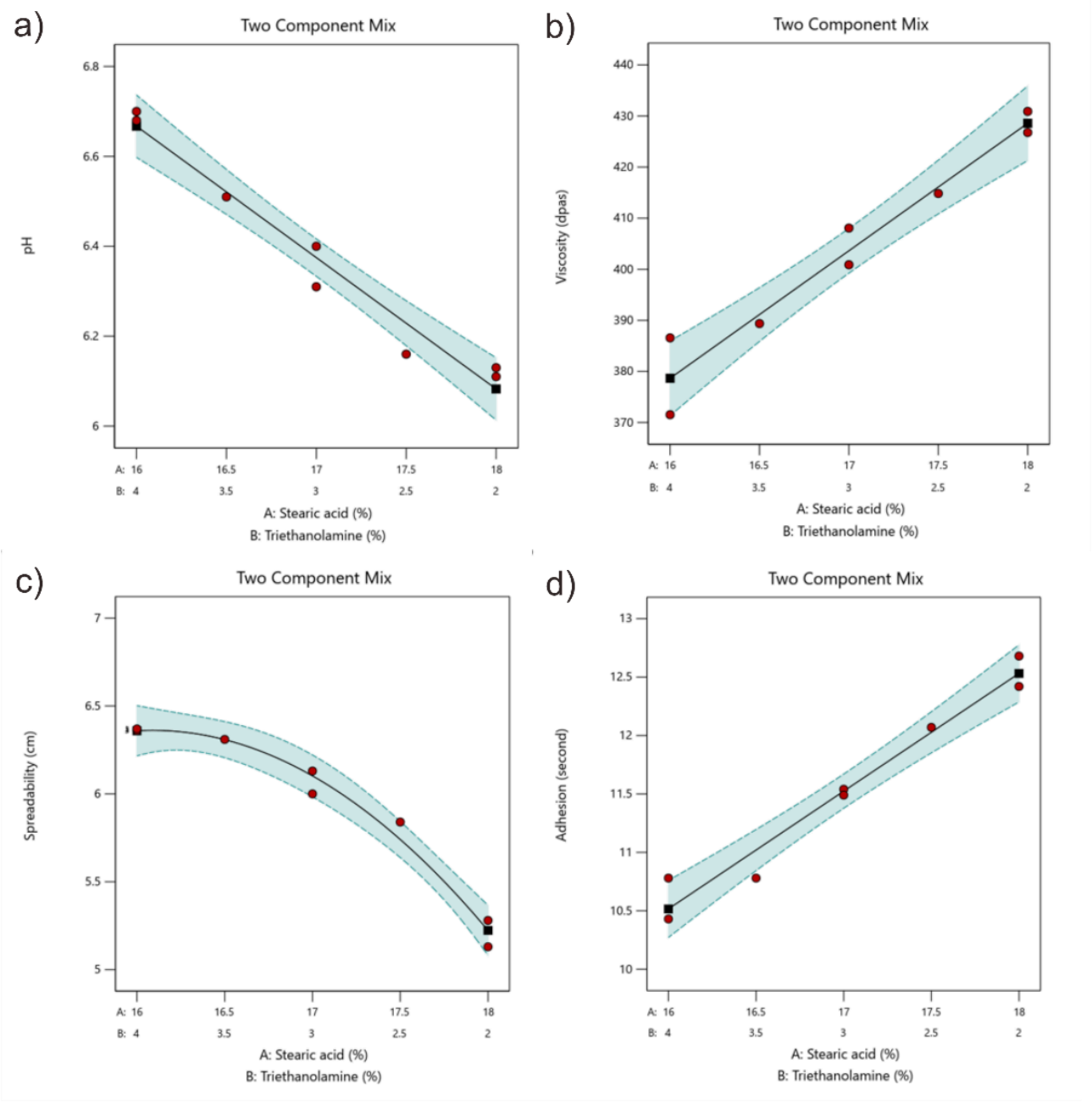


Figure 4. Model graph a) pH, b) Viscosity, c) Spreadability, d) Adhesion.

a response in the SLD analysis. Statistical analysis considers the P-value in the model and lack of fit. The results of the statistical analysis are shown in **Table 4**. A significant model (< 0.05) indicates that the model explains the response. Meanwhile, the lack-of-fit test is not significant (p> 0.05), suggesting that the model adequately represents the data without significant bias. The equation for the model of each response (Y) is shown, where X1 is stearic acid and X2 is triethanolamine. These variables represent actual concentrations.

The pH measurement ensures that the cream does not irritate the skin during use (26). The pH results for the *Chrysanthemum* flower extract cream are shown in **Table 3**. The required pH range for the cream is 4.5-6.5 (15). Runs 2, 3, 6, 7, and 8 fall within this range, indicating their safety for skin application. However, some formulations, specifically Runs 1, 4, and 5, do not meet the pH requirements. Based on the statistical analysis, the recommended model is linear, as shown in **Table 4**. The pH response has an Adjusted R^2 of 0.9592 and a Predicted R^2 of 0.9411. The linear model explains 95.92% of the variation in pH, while the remaining 4.08% is influenced by factors outside the model. The model's predictive ability is considered good. The difference between the two R^2 values is only 0.0181, indicating a good model fit and adequate predictive performance. The equation indicates that triethanolamine has a larger coefficient than stearic acid, meaning it has a greater influence on the cream's pH. The two-component mix graph model for pH testing is shown in **Figure 4**. The relationship between the variation in two emulsifiers and pH follows a linear model. The graph indicates that pH decreases as stearic acid concentration increases and triethanolamine concentration decreases. Basically, stearic acid is an acid and triethanolamine is a base (12). The results align with prior research (11).

Viscosity measures its resistance to spreading (8). Optimal viscosity occurs when the cream's concentration is neither too runny nor too thick. The viscosity results for the *Chrysanthemum* flower extract cream are shown in **Table 3**. The required viscosity range for the cream is 50-1000 dPas (15). All runs fall within the required range. Based on the statistical analysis, the recommended model is linear, the equation is shown in **Table 4**. For the viscosity response, an Adjusted R^2 of 0.9392 indicates that the linear model explains 93.92% of the variation, while a Predicted R^2 of 0.8887 indicates that it can predict 88.87% of the variation. The relatively small difference between the two (0.0505) indicates that the model's ability to explain the data is consistent with its ability to predict the response. Thus, the linear model provides a reasonably good description of the effect of the combination of formulation components on the viscosity of the preparation. The equation indicates that stearic acid has a larger coefficient than triethanolamine, meaning it has a greater influence on the cream's viscosity. The two-component mix graph model for viscosity testing is shown in **Figure 4**. The relationship between the variation in two emulsifiers and viscosity follows a linear model. The graph indicates that viscosity increases as the concentrations of stearic acid increase and triethanolamine decrease. Basically, stearic acid is the oil phase; the higher the oil phase content in the cream, the greater the viscosity. Meanwhile, triethanolamine is the water phase; the higher its content, the lower the viscosity (12,27). These results are consistent with previous research (11).

The spreadability test evaluates the cream's dispersion when applied to the skin (28). The spreadability test was conducted over a load range of 50–250 g in 50 g intervals, but the data used for analysis were from the highest load. The spreadability results for the *Chrysanthemum* flower extract cream are shown in **Table 3**. The required spreadability range for the cream is 5-7 cm (15). All runs fall within the required range. Based on the statistical analysis, the recommended model is quadratic, the equation is shown in **Table 4**. The spreadability response has an Adjusted R^2 of 0.9717 and a Predicted R^2 of 0.9486. The quadratic model explains 97.17% of the variation in the response and has very good predictive ability. The difference between the two values, 0.0231, indicates a high degree of agreement between explanatory and predictive ability. Compared with the other responses, spreadability has the highest values for both R^2 measures, so the quadratic model best explains and predicts this response. These results also indicate the effects of linear terms and interactions between formulation components. The equation indicates that stearic acid has a larger coefficient than triethanolamine, meaning it has a greater influence on the cream's spreadability. The two-component mix graph model for spreadability testing is shown in **Figure 4**. The relationship between the variation in two emulsifiers and viscosity follows a quadratic model. The graph indicates that spreadability increases as the concentrations of triethanolamine and stearic acid decrease. Basically, stearic acid is the oil phase; the higher the oil phase content in the cream, the lower the spreadability. Meanwhile, triethanolamine is the water phase; the higher its content, the higher the spreadability (12,29). These results are consistent with previous research (11).

Adhesion testing aims to determine the time required for the cream to adhere to the skin (30). Good adhesion keeps the cream attached longer, enhancing its effect. The adhesion results for the *Chrysanthemum* flower extract cream are shown in **Table 3**. The required spreadability range for the cream is > 4 seconds (18). All runs fall within the required range. Based on the statistical analysis, the recommended model is linear, the equation is shown in **Table 4**. For the adhesion response, an Adjusted R^2 of 0.9576 indicates that the model explains 95.76% of the variation, while a Predicted R^2 of 0.9258 indicates a predictive capability of 92.58%. The difference of 0.0318 suggests relatively good agreement between the model's ability to explain the data and to predict the response. Thus, the linear model is adequate for describing the relationship between formula composition and adhesion. The equation indicates that stearic acid has a larger coefficient than triethanolamine, meaning it has a greater influence on the cream's adhesion. The two-component mix graph model for adhesion testing is shown in **Figure 4**. The relationship between the variation in two emulsifiers and adhesion follows a linear model. The graph indicates that adhesion increases as the concentrations of stearic acid and triethanolamine decrease. Basically, stearic acid is the oil phase; the higher the oil phase content in the cream, the greater the adhesion. Meanwhile, triethanolamine is the water phase; the higher its content,

Table 5. Optimal cream formula verification.

Response	Prediction	Actual	Verification		Conclusion	PPE
			T-table	T-calculated		
pH	6.11	6.12 ± 0.01	4.303	1.732	Not significant	0,164%
Viscosity	426.246 dPas	420.13± 3.13 dPas	4.303	3.384	Not significant	1,436%
Spreadability	5.332 cm	5.31± 0.11 cm	4.303	0.407	Not significant	0,188%
Adhesion	12.438 second	12.47 ± 0.17 seconds	4.303	0.301	Not significant	0,257%

Table 6. Additional evaluation of the optimal cream.

Sample	Irritation test	Cream type	Stability		Photoprotective		
			Centrifugation	Cycling test	SPF	%Te	%Tp
Optimal cream	Not irritating	Oil in water	Stable	Stable	24.15 ± 0.78	0.37 ± 0.10	0.35 ± 0.03

the lower the adhesion (12). These results are consistent with previous research (11).

The optimal formula is determined by the desirability value, which indicates how well a model meets target expectations. The desirability value is 0.892, with 17.907 g of stearic acid and 2.093 g of triethanolamine. The predicted responses are a pH of 6.110, a viscosity of 426.246 dPa·s, a spreadability of 5.332 cm, and an adhesion time of 12.438 seconds. The results were then verified, and the actual values for each response were obtained. The statistical analysis is shown in **Table 5**. The actual response value was determined using three replicates. The results of the statistical analysis indicate that there is no significant difference between the prediction and the actual.

The optimal formula also underwent additional evaluations, including a cream irritation test, a stability test, and a photoprotective test. The evaluation results are shown in **Table 6**. Irritation testing assessed the cream's skin safety by measuring erythema and oedema. The irritation test has obtained ethical clearance from the Health Research Ethics Commission of Universitas Pekalongan, No. 150/B.02.01/KEPK/V/2026. Results showed scores of 0 for both, indicating the red *Chrysanthemum* flower extract cream is non-irritating. Cream type testing verifies that the product conforms to the specified standards. When methylene blue disperses uniformly, the cream is classified as oil-in-water (O/W). The test outcomes for the optimal red *Chrysanthemum* extract cream demonstrate that it is an O/W emulsion, as evidenced by the uniform dispersal of methylene blue. Stability testing demonstrated that the cream remained stable after centrifugation, with no phase separation observed. The cycling test indicated that the cream's appearance, colour, odour, shape, and texture remained consistent, exhibiting no physical changes. This study presents only qualitative data, which is a limitation. Quantitative data are needed for future research.

The SPF value was determined using measurements with a UV-Vis spectrophotometer (31). The *in vitro* SPF result obtained was 24.15 ± 0.78. This value falls into the moderate category (32). %Te and %Tp *in vitro* refer to the Cumpelik equations for assessing erythema and pigmentation(12,22). The %Te is 0.37 ± 0.10 and the %Tp is 0.35 ± 0.03, with both values classified as sunblock (*in vitro*) (33). The activity is based on the photoprotective activity of red *Chrysanthemum* flower extract. In this study, a concentration of 300 ppm was used, which has been previously researched to have photoprotective activity, thus forming the basis of this formulation. However, in the SPF test, the extract was diluted in ethanol to a concentration of 5%, resulting in an extract concentration of 15 ppm in the solution. The SPF results are thought to be related to the absorption of ultraviolet rays by chromophore groups in the flavonoid compounds found in *Chrysanthemum* flower extract, possibly apigenin and luteolin. Spectrophotometric photoprotection estimation is a preliminary screening approach and does not replace standardised *in vivo* or validated broad-spectrum sunscreen testing. *In vitro* photoprotective activity rather than demonstrating clinical sunscreen efficacy. However, the SPF evaluation used 96% ethanol as the blank, rather than a placebo cream. Therefore, the reported SPF value cannot be attributed specifically to the *Chrysanthemum* extract. This is a limitation of the study.

Conclusion

Stearic acid and triethanolamine influence the red *Chrysanthemum* flower extract cream, affecting parameters such as pH, spreadability, adhesion, and viscosity. The optimal formulation obtained had a desirability of 0.892: 17.907 g stearic acid and 2.093 g triethanolamine. The cream containing red *Chrysanthemum* flower extract demonstrates limited *in vitro* sunscreen activity (SPF 24.15 ± 0.78, %Te is 0.37 ± 0.10, and %Tp is 0.35 ± 0.03).

Abbreviations

SLD: *Simplex Lattice Design*; UV: Ultraviolet; OMC: Octyl Methoxycinnamate; PABA: Para-aminobenzoic Acid; O/W: Oil in Water; W/O: Water in Oil; SPF: *Sun Protection Factor*; HCl: Hidrogen Klorida; CF: correction factor; EE: erythemal effect; I: solar intensity spectrum; %Te: Erythema Transmission; Fe: Flux of Erythema; %Tp: Pigmentation Transmission; Fp: Flux of Pigmentation; PPE: Percentage Prediction Error.

Declaration

Author Information

Nur Cholis Endriyatno *(*Corresponding author)*, Department of Pharmaceutics, Faculty of Pharmacy, Universitas Pekalongan, Pekalongan - 51115, Indonesia. **Contribution:** Conceptualization, Methodology, Software, Visualization, Writing – Original Draft, Validation.

Erin Efrilia, Department of Pharmaceutics, Faculty of

Pharmacy, Universitas Pekalongan, Pekalongan-51115, Indonesia. **Contribution:** Writing – Original Draft, Methodology, Conceptualization .

Sukma Sona, Bachelor of Pharmacy, Faculty of Pharmacy, Universitas Pekalongan, Pekalongan - 51115, Indonesia. **Contribution:** Investigation, Methodology, Resources, Writing – Original Draft.

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The authors declare that no artificial intelligence (AI) or AI-assisted technologies were used in the research, analysis, or preparation of this manuscript.

Conflict of Interest
The authors declare no conflict of interest.

Data Availability
The datasets generated and/or analyzed during the current study are not publicly available due to [reason, e.g., privacy or ethical restrictions].

Ethics Statement
The study was conducted in accordance with the Declaration of Helsinki and approved by the Institutional Review Board (IRB) of the Health Research Ethics Commission of Universitas Pekalongan (Approval No. 150/B.02.01/KEPK/V/2026).

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Additional Information

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