OPTIMIZATION OF CLAY MASK FORMULA FROM LEAF SI KEJUT (*Mimosa pudica L.*) EXRACT USING SIMPLEX LATTICE DESIGN METHOD

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ABSTRACT

Clay mask is a facial mask used to remove dirt and blackheads from the skin. It is particularly suitable for acne-prone skin, as clay masks provide a refreshing sensation, absorb excess oil, and help manage blackheads. Mimosa pudica, commonly known as the "Sensitive Plant" or "Touch-me-not," contains bioactive compounds such as alkaloids, flavonoids, tannins, and saponins. According to a study by Utami et al. (2021), Mimosa pudica L. leaves exhibit strong inhibitory effects against Propionibacterium acnes, the primary bacterium responsible for acne. The objective of this research is to determine the optimal formulation of ethanol extract from Mimosa pudica leaves in a clay mask using the Simplex Lattice Design (SLD) method. Optimization was performed by comparing two clay base formulations—kaolin and bentonite. Physical quality testing included organoleptic evaluation, homogeneity, adhesion strength, spreadability, pH testing, and drying time. The results of the physical quality tests were analyzed using Design Expert software. Through the Simplex Lattice Design (SLD) method, the optimal formula was identified as Formula I, containing 34.75% kaolin and 6.25% bentonite..

KEYWORDS

Leaf si kejut, Mimosa pudica L, clay mask, simplex lettice design

INTRODUCTION

Studies in Southeast Asia indicate that up to 80% of acne vulgaris cases occur (Munawarrah et al., 2021). Both physical and psychological factors can contribute to acne. Physical factors include increased sebum production, while psychological factors encompass hormones, stress, age, diet, weather, activity level, environment, cosmetic use, and skincare routines. In addition to these, acne can also be caused by bacteria. Some bacteria associated with acne include Staphylococcus aureus, Staphylococcus epidermidis, and Propionibacterium acnes.

Mimosa pudica leaves contain polyphenolic compounds such as alkaloids, flavonoids, tannins, and saponins. According to a study by Utami et al. (2021), Mimosa pudica leaves exhibit significant inhibitory effects against Propionibacterium acnes, the primary bacterium responsible for acne. This was demonstrated through the study, which showed that a 30% concentration of Mimosa pudica leaf extract produced a strong antibacterial inhibition zone. Another study (Maramis et al., 2023) reported that the most abundant secondary metabolite in Mimosa pudica leaves is flavonoids, specifically of the flavonol subgroup. Flavonoids exert their antibacterial activity through three main mechanisms: inhibiting bacterial nucleic acid synthesis, disrupting cell membrane function, and interfering with bacterial metabolism (Kusumawati, 2018).

One of the cosmetics used for cleansing is cleansing milk, soap, and masks. Masks come in various types, including cream masks, peel-off masks, sheet masks, and clay masks. Given the wide variety of masks available, the author is interested in developing a cosmetic formulation of clay mask using Mimosa pudica L. leaves.

Facial clay masks are used to remove dirt and blackheads from the skin. Clay masks are especially suitable for acne-prone skin, as they provide a refreshing sensation, absorb excess oil, and help unclog pores. This, in turn, helps reduce a key acne trigger—excessive sebum production. The clay mask formulation requires minimal drying time, effectively cleanses the skin, offers good absorption, and is non-irritating (Dian et al., 2022).

Based on the background, the researcher is interested in conducting a study to determine the optimal formulation of ethanol extract from Mimosa pudica leaves in a clay mask preparation. In this study, the researcher employs the Simplex Lattice Design method to identify the optimum formulation of the product.

RESEARCH METHOD

This study employs an experimental method aimed at developing a clay mask formulation from Mimosa pudica L. ethanol extract. The primary objective is to determine the optimal formulation of ethanol extract from Mimosa pudica leaves in the clay mask preparation using the Simplex Lattice Design method. The research process began with the collection of Mimosa pudica leaves from Bina Agro Mandiri, followed by the preparation of 70% ethanol extract. Subsequently, various formulations of the clay mask were developed, physical quality testing was conducted on the preparations, and the optimal formulation was analyzed using the Simplex Lattice Design approach.

Sample

The samples used in this study were Mimosa pudica L. leaf crude drug (simplisia) collected from Bina Agro Mandiri, located at Jl. Bantul No. 428, Dongkelan, Panggungharjo, Sewon, Bantul.

Equipment and Materials

The equipment used in this study included an analytical balance (Ohaus), water bath, mortar and pestle, beaker, graduated cylinder, metal spatula, glass funnel, filter paper, Erlenmeyer flask, stirring rod, porcelain crucible, mortars and pestles, electric pot and stove, mesh sieve (No. 40), dropper pipette, horn spoon, aluminum foil, glass slide, cover slip, pH meter, scaled Petri dish, adhesion test apparatus, stopwatch, vernier caliper, viscometer, rotary evaporator, moisture balance, test tubes, pipettes, inoculating loop, laminar airflow cabinet (LAF), incubator, and weight sets.

The materials used in this study included Mimosa pudica leaf extract, kaolin, bentonite, glycerin, nipagin, xanthan gum, titanium dioxide, fragrance, and purified water (aquadest).

Research Procedure

The research began with the collection of 1,000 grams of dried Mimosa pudica leaf crude drug (simplisia) from Bina Agro Mandiri, Bantul. The samples were then ground using a blender and passed through a No. 40 mesh sieve to obtain a fine powder. The powder was extracted using the maceration technique with 70% ethanol at a ratio of 1:10 (10 liters of ethanol per 1 kg of powder) over three cycles of 24 hours each, with regular stirring. The resulting filtrate was filtered, and the residue was subjected to re-maceration using the same solvent. After being stored for two days in a closed container, protected from light and kept in a cool environment, the filtrate was separated from the sediment. The liquid extract was then concentrated using a rotary evaporator at 50°C until it became a thick extract, which was further dried using a water bath to achieve an even higher concentration.

To improve purity, the extract underwent purification via repeated n-hexane extraction until the n-hexane layer became clear, indicating the absence of impurities. The purified extract was then sterilized and tested for stability through standardization, including determination of moisture content, drying loss (must be ≤ 10%), ethanol-soluble extractives (measured via constant weight), and phytochemical screening to detect bioactive compounds such as: flavonoids (orange-purple color), alkaloids (white to yellowish or red precipitate), saponins (stable foam), tannins (dark blue or black color), and terpenoids (brown to violet ring at the solvent boundary). The results demonstrated the biological and pharmacological potential of Mimosa pudica leaf extract, confirming its suitability for further research applications.

Optimization of Claymask Formulation

The first step in applying the Simplex Lattice Design method was determining the number of components to be optimized using Design Expert software version 13. In this study, the components optimized were kaolin and bentonite. Kaolin was used at concentrations ranging from 5% to 40% as a topical formulation, while bentonite was used at concentrations between 1% and 8% as a topical agent. Therefore, using the Simplex Lattice Design method, the lower and upper limits for kaolin were set at 33% and 40%, respectively, while those for bentonite were set at 1% and 8%, respectively.

Preparation of Clay Mask Based on SLD Formulations

The clay mask was prepared according to the optimized formulations obtained from the Simplex Lattice Design (SLD). The process began by accurately weighing each ingredient according to its respective formula. The first step involved dissolving bentonite and nipagin separately in a sufficient amount of hot purified water, followed by continuous stirring until fully dissolved. The mixture was then left to stand for 15 minutes to allow complete hydration and dispersion.

Next, the dissolved bentonite and nipagin solution was transferred to a mortar, and xanthan gum was added gradually while grinding until a homogeneous mixture was achieved. Titanium dioxide was then incorporated into the mixture and blended thoroughly. Subsequently, glycerin and Mimosa pudica leaf extract were added and mixed uniformly. Kaolin was added incrementally to the mortar while continuously grinding and stirring to ensure complete homogenization of the formulation.

Finally, 4 drops of fragrance were added, followed by the remaining purified water to adjust the consistency. The mixture was stirred thoroughly until a smooth, uniform, and homogeneous clay mask was obtained. This procedure followed the method described by Syamsidi et al. (2021).

Physical Quality Testing of the Formulation

Physical quality testing was conducted to evaluate the quality and suitability of the formulation, particularly for topical applications such as facial masks. First, organoleptic testing was used to assess the stability of the preparation by examining changes in color, odor, and physical appearance. Any observed alterations may indicate chemical, physical, or biological degradation, potentially caused by microbial activity.

Second, homogeneity testing ensured that the formulation was uniformly distributed without coarse particles when applied onto glass or transparent surfaces.

Third, pH testing was performed using a digitally calibrated pH meter with standard buffer solutions (pH 4.01 and 7.01), conducted at a 1% concentration in distilled water. A well-formulated product should have a pH range of 4.5–6.5, which aligns with the natural pH of human skin. Fourth, drying time testing measured how quickly the formulation dried and formed a film on the skin, with an ideal drying time of 15–30 minutes.

Fifth, adhesion testing evaluated the duration the preparation remained adhered to the skin, where a good formulation should exhibit adhesion time exceeding 4 seconds. Sixth, spreadability testing measured the distance the formulation spread across a facial skin surface during application; optimal spreadability ranges between 5–7 cm.

Finally, viscosity testing was performed to assess the thickness of the formulation using a Brookfield viscometer at 50 rpm with an L-4 spindle, with an optimal viscosity range of 2,000–50,000 cP to ensure ease of application and good adherence.

All these tests are crucial to ensure the formulation is safe, effective, and comfortable for topical use.

Optimization of the Formula Using Simplex Lattice Design

After the preparation of the clay mask formulation and the completion of physical quality testing, all test results were analyzed using Design Expert software. This analysis enabled the identification of the optimal formulation, characterized by a desirability value approaching 1.

RESULT AND DISCUSSION

Powder and Extraction of Mimosa pudica L. Leaves

The Mimosa pudica leaf simplisia was sourced from Bina Agro Mandiri, which provided a Certificate of Analysis (CoA). The powdered leaves were sieved and passed through a No. 40 sieve, yielding 1,000 grams of raw material suitable for extraction. The extraction was carried out using the maceration method with 70% ethanol as the solvent. The sample was soaked for three cycles of 24 hours each, with periodic stirring, followed by filtration. The filtrate was then subjected to two additional re-maceration steps (each lasting 24 hours) with fresh 70% ethanol. After the final filtration, the filtrate was separated from the residue, and the solvent was removed using a rotary evaporator at 50 °C. The resulting liquid extract was transferred to a dish and concentrated using a water bath until a thick paste was obtained, which was then weighed. This process yielded a high-quality standardized extract suitable for further research applications.

Table 1. Yield table of Mimosa Pudica L. leaf extract

Simplex	Weight Extract	Weight Yield %
1000 gram	137,32 gram	13,732 %

Based on the table above, the ethanol extract yield percentage of Mimosa pudica leaves was found to be 13.732%. This result meets the requirement of the Indonesian Herbal Pharmacopeia, which specifies a minimum yield of 7.2%. The organoleptic evaluation of the ethanol extract revealed a dark green color, a thick consistency, and a characteristic odor.

Purification and Standardization of *Mimosa pudica* L. Leaf Extract

The purification process began by dissolving 100 grams of the thick *Mimosa pudica* leaf extract in 70% ethanol and transferring it to a separatory funnel. Then, 1,000 mL of n-hexane was added, the mixture was shaken vigorously, and allowed to stand until two distinct layers formed: an upper layer of n-hexane and a lower layer of ethanol. This process was repeated multiple times until the n-hexane layer became clear, indicating the successful removal of non-polar compounds. The ethanol fraction containing the active compounds was then evaporated using a water bath to recover the purified extract. Subsequently, standardization was performed through phytochemical screening to detect the presence of bioactive compounds. The results revealed that the extract contains five important classes of chemical compounds: flavonoids, alkaloids, tannins, saponins, and terpenoids.

Table 2. Phytochemical screening results

No	Active Compounds	Reagent	results	Information
1	Flavanoid	Mg powder and concentrated HCl	yellowish	+
2	Alkaloid	Reagen Dagendrof	A red precipitate forms	+
		Reagen Mayer	A white precipitate forms	+
		Reagen Wagner	A brown precipitate forms	+
3	Tannin	FeCl 3%	A blackish green color is formed	+
4	Saponin	HCl	Stable foam after adding HCl	+
5	Terpenoid	Kloroform + H_2SO_4	a brownish ring forms at the boundary of the layers	+

Moisture Content Determination of Mimosa pudica L. Leaf Extract

The determination of moisture content was carried out to establish the maximum allowable or acceptable range of water content in the sample. The test was performed using a moisture balance at a temperature of 105 °C. A sample of 2 grams of ethanol extract from Mimosa pudica L. leaves was used for the analysis.

In triplicate measurements, the moisture content of the ethanol extract was found to be 10.50% in replicate I, 8.20% in replicate II, and 7.85% in replicate III. The average moisture content from the three replicates was calculated to be 8.85%. This result indicates that the Mimosa pudica leaf extract meets the standard requirement for moisture content, which is less than 10% (Utami et al., 2017).

Loss on Drying of Mimosa pudica L. Leaf Extract

The loss on drying test was conducted to determine the amount of volatile substances, primarily ethanol, that evaporate from the Mimosa pudica leaf extract during drying. The test was performed using a moisture balance at a temperature of 105 °C, with the measurement stopped once a constant weight was achieved.

In triplicate measurements, the loss on drying values for the ethanol extract of Mimosa pudica L. leaves were 10.50% in replicate I, 8.15% in replicate II, and 7.80% in replicate III. The average loss on drying from the three replicates was calculated to be 8.82%. This result indicates that the Mimosa pudica leaf extract meets the standard requirement for loss on drying, which is less than 10% (Ramadhani and Novema, 2022).

Ethanol-Soluble Extract Content

5 gram sample of the extract was macerated with 100 mL of 70% ethanol and shaken hourly for the first 6 hours, followed by an additional 18 hours of standing. The mixture was then filtered, and 20 mL of the filtrate was collected and evaporated to dryness in a previously tared dish. The determination of ethanol-soluble extract content was performed to assess the quantity of compounds soluble in ethanol.

The results of the ethanol-soluble extract content are shown in the table above. The obtained value was 16%, which meets the standard requirement of the Indonesian Herbal Pharmacopeia, stipulating a minimum of 8% (Tampubolon and Hutabarat, 2023).

Optimization of Clay Mask Formulation

Formula optimization was carried out using the Simplex Lattice Design (SLD) method with Design Expert software version 13. The optimal formula was determined by setting target responses (goals) such as minimize, maximize, target, in range, or equal to, based on desired performance criteria. The physical quality responses of the clay mask—namely adhesion, spreadability, viscosity, and pH—were analyzed and input into the software. The optimized formulation results are presented in Table.3.

Table 3. Optimization formula for clay mask preparation

Material	Formula						Function
	F1	F2	F3	F4	F5	%	
putri malu leaf extract	30	30	30	30	30		Active ingredients
Kaolin	34,75	40	36,5	33	38,25	33-40	Basis
Bentonit	6,25	1	4,5	8	2,75	1-8	Basis
Gliserin	8	8	8	8	8	2-10	Humectan
Nipagin	0,9	0,9	0,9	0,9	0,9	<1	Preservatives
Xanthan Gum	0,5	0,5	0,5	0,5	0,5	0,1 – 1,0	Thickening agent
Titanium Dioxide	0,5	0,5	0,5	0,5	0,5	<1	Stabilizer
Parfume	4 tts	4 tts	4 tts	4 tts	4 tts	qs	Parfume
Aquadest	ad 50 gram						Solvent

The physical quality tests were subsequently performed, including spreadability, adhesiveness, pH, viscosity, organoleptic evaluation, and homogeneity. The results of these physical quality assessments were then input into the Simplex Lattice Design (SLD) to obtain the optimal formulation of the clay mask containing Mimosa pudica L. leaf extract.

Tabel 4. Hasil organoleptik optimasi clay mask

Organoleptic Test	F1	F2	F3	F4	F5
exture	Semi-Solid	Semi-Solid	Semi-Solid	Semi-Solid	Semi-Solid
Color	Grey	Grey	Grey	Grey	Grey
Odor	Typical	Typical	Typical	Typical	Typical

Organoleptic Evaluation

Organoleptic evaluation was used to estimate the chemical, physical, and biological stability of the formulation (Hanistya et al., 2020). The organoleptic results for the optimized clay mask formulations I, II, III, IV, and V showed a semi-solid texture, gray color, and characteristic aroma.

Spreadability Test

The spreadability test was conducted to evaluate the ability of the formulation to spread over the surface of facial skin during application. An acceptable spreadability range is between 5 cm and 7 cm (Hanistya et al., 2020). In the spreadability assessment of the clay mask optimization, only two of the five optimized formulas met the spreadability criterion: formula I and formula III.

Table 5. Results of clay mask optimization spread power

Formula	Replication of Spread Power Test			Average
	1	2	3	
I	4,98 cm	5,67 cm	5,31 cm	5, 32 cm
II	3,50 cm	3,59 cm	3,67 cm	3,59 cm
III	5,10 cm	5,65 cm	5,60 cm	5,45 cm
IV	4,85 cm	4,68 cm	4,69 cm	4,74 cm
V	4,09 cm	4,17 cm	4,31 cm	4,19 cm

Adhesion Test

The adhesion test was performed to determine the ability of the clay mask formulation to remain adhered to the skin over a specific period. Adequate adhesion is a prerequisite for a formulation to be effectively applied to the skin. A good mask should have an adhesion time of more than 4 seconds (Ratu, Fifendy, and Advinda, 2022). The results from the adhesion testing of the five optimized clay mask formulations (Formula I to V) indicated that all formulations exhibited good adhesion, with a duration exceeding 4 seconds

Table 6. Results of the clay mask optimization adhesion test

Formula	Replication of Adhesion Test			Average
	1	2	3	
I	5,23 second	5,11 second	5,17 second	5,17 second
II	4,00 second	4,06 second	4,03 second	4,03 second
III	5,16 second	5,11 second	5,06 second	5,11 second
IV	4,29 second	4,27 second	4,25 second	4,27 second
V	4,84 second	4,80 second	4,88 second	4,84 second

Homogeneity Test

The homogeneity test was conducted by applying the formulation onto a glass slide. If no visible coarse particles were observed, the preparation was considered homogeneous (Eliasari, 2021). The results of the clay mask evaluation for Formulas I, II, III, IV, and V indicated that all formulations were homogeneous, as no coarse particles were visible upon application to the glass slide.

Table 7. Results of clay mask optimization homogeneity

Formulasi	Result
I	
II	
III	Homogen
IV	
V	

pH Test

The pH test was conducted to determine the acidity level of the clay mask formulation to ensure it does not irritate the skin. Topical preparations should have a pH that matches the natural pH of facial skin. A formulation with a pH that is too alkaline may cause dryness, while one that is too acidic can lead to skin irritation (Hanisetya et al., 2020). The ideal pH range for facial skin is 4.5–6.5 (Ardhany et al., 2022). The results of the pH optimization test for the clay mask showed that Formulas I, IV, and V did not meet the pH criteria, whereas Formulas II and III were within the acceptable range

Table 8. Results of the clay mask optimization pH test

Formula	Replication			Average
	1	2	3	
I	4, 24	4, 27	4, 21	4,24
II	5, 11	5, 20	5, 05	5,12
III	4, 66	4, 62	4, 64	4,64
IV	4, 13	4, 10	4, 16	4,11
V	4, 36	4, 30	4, 36	4,34

Viscosity Test

The viscosity test was conducted to evaluate the consistency of the clay mask formulation, ensuring it is easy to apply. A desirable viscosity is one that is neither too thin nor too thick (Tungadi et al., 2023). The acceptable viscosity range for topical formulations is 2,000–50,000 cP (Eliasari, 2021). The results of the viscosity test are presented in Table 15. The average viscosity values for Formulas I, II, III, IV, and V all fell within the standard range of 2,000–50,000 cP, indicating that all formulations exhibited appropriate viscosity for application.

Table 9. Results of clay mask optimization viscosity test

Formula	Replication			Average
	1	2	3	
I	5028	5076	5176	5093
II	6542	6556	6573	6557
III	5010	4914	4943	4956
IV	5136	5199	5528	5288
V	6512	6439	6395	6449

Optimization Target: Desirability Value

Table 10. Criteria for determining the optimum formula

Nama	Goal	Lower Limit	Uper Limit
A: Kaolin	In Range	33	40
B: Bentonit	In Range	1	8
Ph	Minimaze	4.11	5.27
Daya lekat	In Range	4.03	5.11
Daya sebar	In Range	5	5.34
Viskositas	In Range	4956	6449

The target optimization value achieved is known as the desirability value, which ranges from zero to one. A desirability value close to one indicates that the formulation successfully achieves the optimal response according to the desired variables. Conversely, a value approaching zero suggests that the formulation is unlikely to reach the optimal point based on the specified response variables.

Optimal Formula and Physical Quality Evaluation

The optimal formulation, with a kaolin-to-bentonite ratio of 34.75% : 6.25%, achieved a desirability value of 1. This optimized formula, identified through software analysis, was subsequently subjected to physical quality evaluation. The tests included spreadability, adhesion, viscosity, and pH to assess the stability of the clay mask formulation. Based on the data presented in the table above, the desirability value of the optimal formula is 1, indicating that the formulation successfully reaches the optimal response across the targeted variables: adhesion, spreadability, pH, and viscosity.

Table 11. Optimum formula table

Kaolin	Bentonit	Ph	adhesive power	spreading power	Viscosity	Desirability
34,750	6,250	4,45	4,674	5.02	5.586	1,000

CONCLUSION

The optimization of the formulation using the Simplex Lattice Design (SLD) method yielded the optimal formula in Formula I, with a kaolin concentration of 34.75% and a bentonite concentration of 6.25%.

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