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Research Article

Innovative Gel Mask *A. jiringa* (Jack) Nielsen: Effects of HPMC and Palm Stem Starch on Physical Characteristics and Antibacterial Activity

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ABSTRAK

Kulit jengkol (A. jiringa (Jack) Nielsen) merupakan hasil samping pertanian yang belum memiliki nilai ekonomis tinggi, namun diketahui memiliki aktivitas antioksidan dan antibakteri yang kuat. Potensi ini mendasari pengembangan masker gel antijerawat sebagai sediaan topikal kosmetik. Penelitian ini bertujuan untuk mengevaluasi pengaruh kombinasi hidroksipropilmetilselulosa (HPMC) dan pati batang kelapa sawit terhadap karakteristik fisik serta aktivitas antibakteri masker gel A. jiringa terhadap Propionibacterium acnes. Ekstrak diperoleh melalui metode maserasi dan diuji aktivitas antibakterinya pada konsentrasi 0,25%, 0,30%, 0,35%, dan 0,40%. Konsentrasi optimum yang menunjukkan daya hambat tertinggi diformulasikan ke dalam masker gel dengan rasio HPMC:pati pada Formula 1 (1:2), Formula 2 (1:1), dan Formula 3 (2:1). Evaluasi meliputi viskositas, daya sebar, adhesivitas, pH, waktu kering, dan uji difusi sumur terhadap P. acnes. Hasil penelitian menunjukkan bahwa ekstrak A. jiringa 0,40% memiliki aktivitas antibakteri sedang dengan zona hambat 9,82 ± 0,06 mm. Ketiga formula gel memiliki warna cokelat muda, aroma khas minyak atsiri, tekstur halus dan homogen, viskositas antara 46,67 hingga 736,67 cps, daya sebar antara 4,75–8,92 cm, adhesivitas antara 11,52–17,68 detik, waktu kering 5,27–7,57 menit, serta pH berkisar antara 7,30–7,47. Disimpulkan bahwa kombinasi HPMC dan pati batang kelapa sawit mempengaruhi sifat fisik sediaan, namun tidak meningkatkan aktivitas antibakteri A. jiringa dalam sistem gel.

Kata Kunci: A. Jiringa, P. Acnes, Antibakteri, Antijerawat, Pati Batang Kelapa Sawit

ABSTRACT

The peel of *Archidendron jiringa* (Jack) Nielsen, commonly known as jengkol, is an agricultural by-product with limited economic value but has been reported to possess strong antioxidant and antibacterial properties. This potential supports the development

of an anti-acne gel mask as a topical cosmetic preparation. This study aimed to evaluate the effects of combining hydroxypropyl methylcellulose (HPMC) and palm stem starch on the physical characteristics and antibacterial activity of A. jiringa gel masks against *Propionibacterium acnes*. The extract was obtained through maceration and tested for antibacterial activity at concentrations of 0.25%, 0.30%, 0.35%, and 0.40%. The optimum concentration, which exhibited the highest inhibitory activity, was formulated into gel masks with different HPMC-to-starch ratios: Formula 1 (1:2), Formula 2 (1:1), and Formula 3 (2:1). Evaluations included viscosity, spreadability, adhesiveness, pH, drying time, and antibacterial activity using the well diffusion method against *P. acnes*. The results showed that the 0.40% A. jiringa extract exhibited moderate antibacterial activity with an inhibition zone of 9.82 ± 0.06 mm. All three gel formulations had a light brown color, a characteristic essential oil aroma, a smooth and homogeneous texture, viscosities ranging from 46.67 to 736.67 cps, spreadability between 4.75–8.92 cm, adhesiveness ranging from 11.52 to 17.68 seconds, drying time from 5.27 to 7.57 minutes, and pH values between 7.30 and 7.47. It was concluded that the combination of HPMC and palm stem starch influenced the physical properties of the gel formulations but did not enhance the antibacterial activity of *A. jiringa* in the gel system.

Keywords: *A. jiringa, P. acnes*, Antibacteria, Anti-Acnes, Starch Palm Oil

I. INTRODUCTION

The demand for effective and naturally derived cosmetic products continues to grow in line with increasing public awareness of skincare and environmental sustainability. One of the most commonly used skincare products is the gel mask, favored for its refreshing sensation, ease of application, and ability to deliver active ingredients topically. Gel formulations are particularly beneficial for individuals with dry, sensitive, or acne-prone skin due to their hydrating and soothing properties (Andaryekti et al., 2015). Acne vulgaris is a common dermatological disorder characterized by inflammation of the pilosebaceous unit, often aggravated by bacterial infection, especially *Propionibacterium acnes* and *Staphylococcus aureus* (Meilina & Hasanah, 2018; Sarlina et al., 2017).

Archidendron jiringa (Jack) Nielsen, commonly known as jengkol, is an underutilized plant in Indonesia, with its peel typically regarded as agricultural waste. However, previous studies have reported that the peel contains phenolic compounds with strong antioxidant activity (IC_{50} = 23.821 ± 0.204 ppm) (Suryani et al., 2019). Additionally, it exhibits antibacterial potential against *S.aureus* dan *P.aeruginosa* at 5% extract concentration (Kanter & Untu, 2019) Despite these promising bioactivities, the use of *A. jiringa* peel extract in cosmetic gel formulations, particularly for anti-acne purposes, remains largely unexplored.

The selection of a suitable gelling agent is critical in formulating stable and effective for topical preparations. Hydroxypropyl methylcellulose (HPMC) is a widely used semi-synthetic polymer known for its safety, transparency, and excellent stability in gel systems (Rowe et al., 2009). Meanwhile, palm stem starch, derived from palm biomass, offers biocompatibility and sustainability advantages and has shown potential as a natural gel-forming agent (Cahyaningtyas et al., 2019).

This study was designed to investigate the effects of varying concentrations of HPMC and palm stem starch as gelling agents on the physical properties and antibacterial activity of *A. jiringa* peel extract gel masks. Specifically, this research aims to determine the optimal formulation based on parameters such as viscosity, spreadability, adhesiveness, drying time, pH, and antibacterial efficacy against *P. acnes*. The findings are expected to contribute to the development of innovative, eco-friendly, and effective topical anti-acne products based on locally sourced natural ingredients from Indonesian.

II. METHODS

A. Tools and Materials

The materials used in this study included *A. jiringa* peel, 96% ethanol, palm stem starch, HPMC, propylene glycol, triethanolamine (TEA), methylparaben, rose essential oil (*oleum rosae*), and distilled water. Microbiological materials included *Propionibacterium acnes* ATCC 6919, nutrient agar (NA), McFarland standard 0.5, and 0.9% NaCl solution. Clindamycin 1% and the gel base without active extract were used as positive and negative controls, respectively. The instruments utilized in this study included a macerator, oven, analytical balance, Brookfield viscometer (spindle 4), vortex mixer, digital pH meter, Petri dishes, autoclave, incubator, water bath, and standard laboratory glassware.

B. Sample Preparation

A. jiringa peel samples were collected from agricultural waste in Pingaran Village, Martapura, South Kalimantan, Indonesia. The samples were selected based on inclusion and exclusion criteria to ensure quality and consistency. Inclusion criteria included mature *A. jiringa* pods with intact, undamaged peels, harvested within 24 hours, free from microbial contamination, and showing no signs of spoilage. Peels that were moldy, physically damaged, stored for more than 24 hours before drying, or contaminated with soil or chemicals were excluded. The selected peels were washed thoroughly,

separated from seeds and pulp, cut into small pieces, and dried in an oven at 50 °C until a constant weight was achieved. The dried peels were then ground into powder and stored in airtight containers until further use (Mardiah et al., 2017).

C. Extraction and Decolorization

The powdered peel was extracted by maceration using 96% ethanol in a 1:10 (w/v) ratio for 3 × 24 hours with occasional stirring. The combined filtrate was concentrated using a water bath at 50°C. To remove pigments, decolorization was performed by dissolving the extract in ethanol and treating it with activated carbon at a 1:0.001 (w/w) ratio. The mixture was stirred, filtered, and re-concentrated (Kartinah et al., 2017).

D. Antibacterial Screening of Extract

The antibacterial activity of *A. jiringa* extract was evaluated against *P. acnes* using the agar well diffusion method. Bacterial cultures were prepared and adjusted to a 0.5 McFarland standard (approximately 1.5×10^8 CFU/mL). Wells (6 mm diameter) were filled with extract concentrations of 0.25%, 0.30%, 0.35%, and 0.40%. Plates were incubated at 37 °C under anaerobic conditions for 24 hours. The inhibition zone diameters were measured, and the concentration with the strongest activity was selected for gel formulation.

E. Gel Mask Formulation

The gel mask was prepared in three formulations with different HPMC-to-palm starch ratios: Formula 1 (1:2), Formula 2 (1:1), and Formula 3 (2:1). First, methylparaben was dissolved in half of the total volume of propylene glycol to form a preservative solution. In a separate container, HPMC was dispersed into hot distilled water (approximately 70 °C) at a 1:20 (w/v) ratio with continuous stirring for 15 minutes until a clear and uniform gel base formed.

Simultaneously, palm stem starch was dispersed in the remaining volume of distilled water and heated to facilitate solubilization. The starch solution was gradually added to the HPMC dispersion with moderate stirring to ensure homogeneity. Triethanolamine (TEA) was then added dropwise while stirring at 200 rpm to adjust the pH and promote gel formation.

Subsequently, the methylparaben–propylene glycol solution was added, followed by 0.40% decolorized *A. jiringa* extract (previously dissolved in a small amount of ethanol). The formulation was adjusted to 100 g with distilled water. Finally, 1–3 drops of rose essential oil were added for fragrance. The mixture was

stirred at 400 rpm for 15 minutes using a magnetic stirrer to ensure a uniform gel. The final product was transferred into sterile containers and stored at room temperature until evaluation.

Table I. Gel Mask Formula

Ingredient	Concentration (%w/w)		
	F1	F2	F3
Decolorized *A.jiringa* extract	0.40	0.40	0.40
HPMC	1.17	1.75	2.33
Palm stem starch	2.33	1.75	1.17
TEA	0.12	0.12	0.12
Propylene glycol	15	15	15
Methyl paraben	0.18	0.18	0.18
Oleum rosae	qs	qs	qs
Distilled water ad	100	100	100

F. Evaluation of Physical Properties

1. Organoleptic and Homogeneity Tests

Organoleptic properties were evaluated visually by assessing the texture, color, and aroma. A desirable gel should exhibit a clear, uniform appearance, a pleasant essential oil aroma, and a smooth texture. Homogeneity was assessed by spreading a thin layer of gel on a glass slide and observing it under light to detect the presence of any coarse particles (Sinala et al., 2019)

2. Viscosity Test

Viscosity was measured using a Brookfield viscometer (spindle No. 4, 0.6 rpm) and expressed in centipoise (cP)

3. pH Test

The pH was determined by dissolving 2 g of gel in 50 mL of distilled water and measuring the solution using a calibrated digital pH meter.

4. Spreadability Test

Spreadability was evaluated by placing 0.5 g of gel between two glass plates, applying a 200 g load for 1 minute, and recording the diameter of the spread. This assessed the gel's ability to spread over the skin surface (Rohana et al., 2019).

5. Adhesiveness Test

Adhesiveness was determined by placing 0.25 g of gel between two glass slides under a 500 g weight and measuring the time required for separation. Adhesion times exceeding 1 second were considered acceptable (Sunnah et al., 2018).

6. Drying Time Test

Drying time was assessed by applying a thin layer of gel on the back of the hand and recording the time required to dry completely at room temperature. Ideally, the drying time should not exceed 30 minutes (Sinala et al., 2019).

G. Antibacterial Activity of Gel Formulations

The antibacterial activity of the gel formulations (F1–F3) was evaluated using the agar well diffusion method against *P. acnes*. Each sample (50 µL) was introduced into a 6 mm well on nutrient agar plates inoculated with *P. acnes*. Clindamycin 1% gel and the gel base were used as positive and negative controls, respectively. Plates were incubated anaerobically at 37 °C for 24 hours, and inhibition zones were measured in millimeters.

H. Data Analysis

All results were presented as mean ± standard deviation (SD). Data normality was tested using the Shapiro–Wilk test, and homogeneity of variance was assessed using Levene's test. One-way analysis of variance (ANOVA) was conducted to evaluate significant differences between formulations. A p-value < 0.05 was considered statistically significant. Statistical analysis was performed using SPSS version 26.0.

III. RESULT AND DISCUSSION

A. Organoleptic and Homogeneity Properties

All gel mask formulations exhibited a light brown color, a smooth and homogeneous texture, and a distinct essential oil aroma. These visual and sensory characteristics remained consistent across all formulations, indicating that varying HPMC and palm starch ratios did not significantly affect the appearance or uniformity of the final product. The presence of a smooth texture and the absence of phase separation suggest successful gel formation and ingredient compatibility. This is consistent with previous studies involving HPMC and starch-based (Buana et al., 2025).

Table II. Organoleptic Characteristics of *A. jiringa* Gel Mask

Observation	F1	F2	F3
Texture	Smooth	Smooth	Smooth
Color	Brown	Brown	Brown
Odor	Essence	Essence	Essence

B. Viscosity

Viscosity is a critical parameter that affects gel stability, spreadability, and the release of active compounds.

Table III. Viscosity of *A. jiringa* Gel Mask

Formula	Viscosity Value (Spindle 4, 0.6 rpm)
F1	46,667 ± 2886.75*
F2	251,667 ± 2886.75*
F3	736,667 ± 23094.01*

*Note: * indicates a significant difference ($p<0.05$)

Viscosity values increased significantly with higher HPMC content. Only Formula 1 fell within the ideal viscosity range for topical gels (3,000–50,000 cps) (Dyah Pertiwi et al., 2016).

Formulas 2 and 3 exhibited very high viscosities, which may hinder effective diffusion of active compounds. The increase in viscosity is attributed to HPMC's capacity to form strong hydrogen bonds and three-dimensional networks in aqueous systems.

C. pH Evaluation

Table IV. pH Values of *A.jiringa* Gel Mask

Formula	pH Value
F1	$7.47 \pm 0.06^{*}$
F2	7.37 ± 0.06
F3	$7.30 \pm 0.00^{*}$

*Note: * indicates a significant difference ($p<0.05$)

The pH of all gel formulations ranged between 7.30 and 7.47, within the acceptable range for topical applications (pH 4.5–8.0). These values are close to the physiological pH of facial skin, minimizing the risk of irritation. The slight decrease in pH with increasing HPMC concentration may be attributed to the mildly acidic nature of HPMC. All formulations-maintained pH stability, which is essential for product safety and efficacy (Asfi & Rahmadani, 2022; Irianto et al., 2020).

D. Spreadability

Spreadability reflects ease of application and user comfort. The results indicated that spreadability decreased as HPMC concentration increased. Formula 2 was the only formulation within the ideal range of 5–7 cm for topical gel (Sayuti, 2015). This inverse correlation between viscosity and spreadability highlights the need to optimize polymer concentration to balance texture and application performance (Irianto et al., 2020).

Table V. Spreadability of *A. jiringa* Gel Mask

Formula	Spreadability (cm)
F1	$8.92 \pm 0.85^{*}$
F2	$6.02 \pm 0.21^{*}$
F3	$4.75 \pm 0.23^{*}$

*Note: * indicates a significant difference ($p<0.05$)

E. Adhesiveness

Adhesiveness represents the gel's ability to adhere to the skin, which affects contact time and therapeutic efficacy.

Table VI. Adhesiveness of *A.jiringa* Gel Mask

Formula	Adhesiveness (seconds)
F1	$11.52 \pm 0.25^{*}$
F2	$14.69 \pm 0.31^{*}$
F3	$17.68 \pm 0.13^{*}$

Notes: * indicates a significant difference ($p<0.05$)

All formulations exhibited adhesion values above the minimum acceptable threshold of 4 seconds (Wulandari *et al*., 2019). Adhesiveness increased with HPMC concentration, likely due to enhanced gel cohesiveness and molecular entanglement. Although increased adhesion can improve retention on the skin, excessively sticky

formulations may cause user discomfort (Fialho et al., 2024).

F. Drying Time

Drying time is a practical parameter influencing user acceptance. All formulations dried within the acceptable 30-minute threshold (Sinala et al., 2019). Drying time increased with HPMC concentration, consistent with its ability to retain water and form a denser gel matrix. Formula 1 dried the fastest, offering better convenience for consumers.

Table VII. Drying Time of *A. jiringa* Gel Mask

Formula	Dry Time (minutes)
F1	5.27 ± 0.25*
F2	6.07 ± 0.12*
F3	7.57 ± 0.51*

Notes: * indicates a significant difference ($p<0.05$)

G. Anti-Bacterial Activity

1. Antibacterial Activity of *A. jiringa* Extract

Table VIII. Antibacterial Activity of *A.jiringa* Extract Against *P. acnes*

Conc.	Inhibition Zone (mm)	Acvtivity Level
0.25%	7.12 ± 0.12	Moderate
0.30%	8.75 ± 1.26	Moderate
0.35%	7.90 ± 1.46	Moderate
0.40%	9.82 ± 0.06	Moderate
Control (-)	0.00±0.00*	None
Control (+)	30.10 ± 1.34	Very Strong

Notes: Conc = concentration, * indicates a significant difference ($p<0.05$)

The *A. jiringa* extract demonstrated moderate antibacterial activity against *P. acnes*, with the highest activity observed at 0.40% concentration. These effects are likely attributable to the phenolic and flavonoid content in *A. jiringa* peel (Senduk et al., 2020)

2. Antibacterial Activity of *A.jiringa* Gel Mask

Surprisingly, none of the gel formulations exhibited antibacterial activity against *P. acnes*. This result may be due to the high viscosity and dense polymer matrix of the gels, which hinder the diffusion of phenolic compounds into the agar medium (Purwaningsih et al., 2017). Although the extract was effective in its free form, its efficacy was not retained in the gel matrix. This highlights a critical challenge in formulation design: ensuring that bioactive compounds remain available and active when incorporated into semi-solid dosage forms.

Table IX. Antibacterial Activity of Gel Mask *A.jiringa*

Formula	Diameter Zone of Inhibition (mm)	Strength
F1	0.00±0.00	None
F2	0.00±0.00	None
F3	0.00±0.00	None
Control (-)	0.00±0.00*	None
Control (+)	26.77 ± 0.45	Very Strong

3. Statistical Analysis Discussion

One-way ANOVA confirmed that differences in HPMC and starch concentrations significantly affected physical properties, including viscosity, spreadability, adhesiveness, drying time, and pH ($p < 0.05$). However, no statistically significant differences were observed in antibacterial activity among the formulations ($p > 0.05$), reinforcing the hypothesis that the lack of activity resulted from formulation limitations rather than extract potensi (Vaou et al., 2022). Future improvements could involve reducing polymer concentrations or incorporating nanocarrier systems to enhance the release and bioavailability of active compounds (Lu et al., 2021)

IV. CONCLUSION

Variations in the concentrations of gelling agents—HPMC and palm stem starch—significantly influenced the physical properties of the gel masks formulations, including viscosity, pH, spreadability, adhesiveness, and drying time. However, the three *A. jiringa* gel mask formulations with different HPMC-to-palm starch ratios—Formula 1 (1:2), Formula 2 (1:1), and Formula 3 (2:1)—did not exhibit antibacterial activity against *P. acnes*. Additionally, altering the concentrations of HPMC and palm starch had no impact on the antibacterial efficacy of *A. jiringa* peel extract within the gel matrix. These findings suggest that while polymer composition plays a crucial role in determining the physical characteristics of topical gels, it may also hinder the diffusion and bioactivity of incorporated plant extracts. Further formulation optimization, such as the use of permeation enhancers or encapsulation technologies, may be necessary to retain and enhance the antibacterial potential of *A. jiringa* extract in gel systems.

CONFLICT OF INTEREST

All authors declare that there is no conflict of interest in this study.

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