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Senggani Leaf Extract-Based Gel Facial Wash: A Herbal Innovation for Anti-Acne Therapy Targeting *Cutibacterium acnes*

Gel Pembersih Wajah Berbasis Ekstrak Daun Sengani: Inovasi Herbal untuk Terapi Anti-Jerawat yang Menargetkan *Cutibacterium acnes*

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Abstract
Senggani is a traditional Asian plant commonly used as an alternative medicine, particularly in Indonesia. The leaves of the senggani plant contain secondary metabolites, including tannins, alkaloids, flavonoids, and saponins. Among these, tannins and flavonoids are believed to have antibacterial properties. This study investigates whether a facial wash gel made from the ethanol extract of senggani leaves possesses stable properties and meets established standards. Additionally, the study aims to evaluate its antibacterial activity against *Cutibacterium acnes*, the bacteria responsible for acne. A maceration method with 70% ethanol was used to prepare the ethanol extract from senggani leaves. This extract was then formulated into a facial wash gel using carbopol polymer at 5%, 7.5%, and 10%, followed by tests to assess its antibacterial activity. The antibacterial activity was determined using the disc diffusion method at the same concentrations. The results indicated that the diameter of the bacterial inhibition zone was 9.93 mm at 5%, 11.66 mm at 7.5%, and 13.93 mm at 10%. The gel preparation of the ethanol extract from senggani leaves demonstrated stable properties, with physical stability evaluations confirming compliance with the quality standards for facial washes set by Indonesian national regulations. Furthermore, the senggani leaf ethanol extract gel effectively inhibited the growth of *Cutibacterium acnes*, indicating its potential as an effective face wash.

***Keywords*: Facial wash gel, senggani leaves, acne, Cutibacterium acnes.**

Abstrak
Senggani adalah tanaman tradisional Asia yang umum digunakan sebagai pengobatan alternatif, khususnya di Indonesia. Daun tanaman senggani mengandung metabolit sekunder, termasuk tanin, alkaloid, flavonoid, dan saponin. Di antara metabolit tersebut, tanin dan flavonoid diyakini memiliki sifat antibakteri. Studi ini menyelidiki apakah gel pembersih wajah yang terbuat dari ekstrak etanol daun senggani memiliki sifat yang stabil dan memenuhi standar yang ditetapkan. Selain itu, studi ini bertujuan untuk mengevaluasi aktivitas antibakterinya terhadap *Cutibacterium acnes*, bakteri penyebab jerawat. Metode maserasi menggunakan pelarut 70% digunakan untuk menyiapkan ekstrak etanol dari daun senggani. Ekstrak ini kemudian diformulasikan menjadi gel pembersih wajah menggunakan polimer karbopol pada konsentrasi 5%, 7,5%, dan 10%, diikuti dengan pengujian untuk menilai aktivitas antibakterinya. Aktivitas antibakteri ditentukan menggunakan metode difusi cakram pada konsentrasi yang sama. Hasil penelitian menunjukkan bahwa diameter zona inhibisi bakteri adalah 9,93 mm pada konsentrasi 5%, 11,66 mm pada 7,5%, dan 13,93 mm pada 10%. Sediaan gel ekstrak etanol daun senggani menunjukkan sifat yang stabil, dengan evaluasi stabilitas fisik yang mengonfirmasi bahwa produk ini sesuai dengan standar kualitas sabun cuci muka sebagaimana ditetapkan oleh peraturan nasional Indonesia. Lebih lanjut, gel ekstrak etanol daun senggani efektif menghambat pertumbuhan *Cutibacterium acnes*, menunjukkan potensinya sebagai sabun cuci muka yang efektif.

Kata Kunci: Gel pembersih muka, daun senggani, cutibacterium acne

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Introduction

Acne, or acne vulgaris, is a dermatological condition frequently observed in adolescents and young adults, with a notable rise in global occurrence. The 2019 Global Burden of Disease (GBD) data indicate that acne accounts for roughly 4.96 million disability-adjusted life years (DALYs), predominantly affecting individuals aged 15 to 49. Acne is currently ranked 19th among the primary causes of Disability-Adjusted Life Years (DALYs), an increase from its former rank of 27th [1].

This underscores the significance of managing the clinical and emotional ramifications of acne for affected individuals. Acne development is characterized by multiple factors: excessive sebum production, keratinocyte cell buildup, bacterial colonization, and inflammatory responses. *Cutibacterium acnes* (formerly referred to as *Cutibacterium acnes)* is a significant contributor to this process, producing enzymes such as lipase and protease. This bacterium induces the release of inflammatory mediators by activating Toll-like receptor-2 (TLR-2), thereby exacerbating inflammation in the pilosebaceous tissue. [2]. Traditional anti-acne therapies, including topical antibiotics (such as clindamycin and erythromycin) and benzoyl peroxide, may be efficacious; however, prolonged use may lead to bacterial resistance and dermal discomfort. Consequently, there is growing interest in alternative, nature-derived medicines with a safer profile. *Melastoma malabathricum* is a promising medicinal herb. Contemporary studies have recognized substances including tannins, flavonoids, and phenolics as significant antibacterial agents. Ethanolic extracts of *Melastoma malabathricum* leaves have bactericidal action against *Staphylococcus aureus* and *Streptococcus agalactiae*, with minimum inhibitory concentrations (MICs) in the microgram per milliliter (μg/mL) range [3].

Recent local research demonstrates that ethanolic extracts from M. *malabathricum* leaves exhibit efficacy against *C. acnes*, as evidenced by a disc diffusion approach [4]. Formulations of natural-based face wash gels present a practical and convenient approach for skin application, ensuring excellent physical stability, a refreshing sensation, and optimal absorption of active substances in comparison to conventional ointments or creams [5]. Nevertheless, gel formulations derived from herbal components, such as senggani extract, have not been extensively advanced.

One of the major challenges in developing plant-based facial wash gel formulations is maintaining the stability and compatibility of the active extract within the gel matrix. Plant extracts contain complex phytochemical constituents that may interact with gelling agents such as carbopol, potentially affecting the formulation's viscosity, clarity, and overall stability. Variations in polymer concentration are known to influence important physicochemical properties of gels, including viscosity, spreadability, and consistency, which determine the ease of application and effectiveness of topical preparations [6], [7].

In cosmetic cleansing formulations such as facial wash gels, additional parameters including foamability, pH, and viscosity must also be carefully optimized because they affect cleansing performance, product stability, and user acceptability [8]. Surfactants used in facial cleansers contribute to foam formation but may also influence the viscosity and stability of the gel base, requiring careful formulation design to maintain a balance between cleansing efficiency and physical stability [9]. Therefore, a comprehensive evaluation of physicochemical properties is essential when incorporating plant extracts into gel-based cosmetic formulations to ensure the quality, stability, and functionality of the final product.

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Experimental Section

Materials and Apparatus

This study utilized ethanol extracts from senggani leaves (*Melastoma malabathricum* L.), obtained through dried simplicia maceration. The plant was identified at the Herbarium Medanense (MEDA) under the identification number 526/MEDA/2025 at the Faculty of Mathematics and Natural Sciences (MIPA), University of North Sumatra. The test organism used in this study was *Cutibacterium acnes* ATCC 6919, sourced from the American Type Culture Collection (USA). Nutrient Agar (NA, Oxoid™, England) was the growth medium. Additional ingredients included in the formulation were methylparaben (Merck®, Germany), propylparaben (Merck®, Germany), sodium lauryl sulfate (Sigma-Aldrich®, Germany), aquadestilata (Brataco®, Indonesia), Carbopol 940 (Lubrizol®, USA), triethanolamine (TEA, Sigma-Aldrich®, Germany), propylene glycol (Merck®, Germany), and 70% ethanol (Brataco®, Indonesia).

The instruments used in this study included a rotary evaporator (Buchi R-300, Switzerland), hot air oven (Memmert UN55, Germany), digital pH meter (Hanna Instruments HI2211, Romania), Brookfield digital viscometer (Brookfield DV-E, USA), analytical balance (Ohaus Pioneer PA214, USA), autoclave (Hirayama HVE-50, Japan), incubator (Memmert IN55, Germany), water bath (Memmert WNB14, Germany), laminar air flow cabinet (ESCO Airstream, Singapore), digital caliper (Mitutoyo, Japan), and homogenizer (IKA T25 Digital Ultra-Turrax, Germany).

Sample collection

The collected senggani leaves were cleaned with running water and then drained. After drying them in a cabinet at 40-50°C, the leaves were weighed. Once thoroughly dried, the samples were ground in a blender to a powder. Finally, the powder was sifted using a 60-mesh sieve for a finer consistency [10].

Simplicia examination

The characteristics of the simplicia are analyzed, including macroscopic examination, drying loss, total ash content, acid-insoluble ash content, ethanol-soluble extract content, and water-soluble extract content.

Sample preparation

The extract is prepared by maceration in 70% ethanol at a 1:10 solvent ratio. Begin by placing 500 grams of dry, powdered simplicia into a maceration vessel. Then, add 3,750 ml of solvent (75 parts). Soak the mixture for the first 6 hours, stirring occasionally, and then allow it to stand for 5 days. After this period, separate the macerate by filtration. The remaining dregs should then be macerated again with 1,250 ml of solvent (25 parts) in two 24-hour sessions, followed by another filtration. Once all the macerate has been collected, evaporate it using a rotary evaporator at 40-50°C. Finally, dry the extract by heating it over a water bath until a thick consistency is achieved [11].

Preliminary screening of Senggani leaves extract

Phytochemical screening includes examination of alkaloids, flavonoids, tannins, saponins, and steroids/triterpenoids.

Facial wash gel formula

The facial wash gel formulation used in this study was adapted and modified from the research conducted by [12], which focused on creating a facial wash gel using roselle flower extract. Adjustments were made to the composition of active ingredients and the concentration of the base to align with the objectives of this research. The concentration of each excipient was selected based on commonly recommended ranges in pharmaceutical formulation references to ensure the stability and acceptable physicochemical properties of the gel system.

Carbopol 940 was used as the primary gelling agent due to its ability to form clear, stable gels at low concentrations. In topical gel formulations, Carbopol is generally used in the concentration range of 0.5–2%, which is sufficient to produce a stable semi-solid gel structure [13]. In this study, Carbopol 940 was used at a concentration of 1%, which falls within the recommended range for topical gel formulations.

Triethanolamine (TEA) was incorporated as a neutralizing agent to neutralize the acidic groups of Carbopol. The neutralization process ionizes the carboxyl groups within the Carbopol polymer chains, resulting in polymer expansion and the formation of a three-dimensional gel network that increases viscosity

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and stabilizes the gel matrix [14].The concentration of TEA used in this formulation (1.3 g) was adjusted to achieve optimal pH and gel consistency.

Propylene glycol was added as a humectant and co-solvent to improve moisture retention and enhance the dispersion of the active ingredient within the gel matrix. Humectants such as propylene glycol are widely used in topical formulations to maintain hydration and improve the stability of the preparation [15]. Sodium lauryl sulfate was used as a surfactant to provide cleansing and help remove dirt and oil from the skin surface.

Methyl paraben and propyl paraben were incorporated as preservatives to inhibit microbial growth and maintain product stability during storage. The concentrations used in this study fall within the acceptable preservative ranges commonly applied in topical pharmaceutical and cosmetic formulations [16]. Distilled water was used as the solvent to adjust the final volume of the formulation, while fragrance was added to improve the sensory acceptability of the facial wash gel.

Table 1. Formulation of Senggani Extract facial wash gel

No.	Materials	F0 (g)	F1 (g)	F2 (g)	F3 (g)	Standard Range (%) (Handbook of Pharmaceutical Excipients)
1	Senggani Extract	0	5	7.5	10	–
2	Carbopol 940	1	1	1	1	0.5–2
3	Triethanolamine	1.3	1.3	1.3	1.3	2–4
4	Propylene Glycol	15	15	15	15	15
5	Sodium Lauryl Sulfate	1	1	1	1	1
6	Methyl Paraben	0.15	0.15	0.15	0.15	0.02–0.3
7	Propyl Paraben	0.05	0.05	0.05	0.05	0.01–0.6
8	Aloe Rose (drops)	2	2	2	2	–
9	Purified Water (ad)	100	100	100	100	–

Description:
F0: Blank (Gel base)
F1: Facial wash gel with senggani leaf extract at 5% concentration
F2: Facial wash gel with senggani leaf extract at 7.5% concentration
F3: Facial wash gel with senggani leaf extract at 10% concentration

Facial wash gel preparations

The process of making gel begins with preparing the necessary equipment and ingredients. Once everything is ready, the first step is to weigh 1 gram of Carbopol 940 and place it in a mortar. Stir it with 20 mL of hot water until it expands and forms a gel. After the gel is formed, mix it with 1.3 grams of triethanolamine to create Mixture 1. Next, pour 40 mL of distilled water into a glass beaker and add propylene glycol. Stir until the propylene glycol dissolves, then add propyl and methyl paraben. In another beaker, add 1 g of sodium lauryl sulfate to 10 mL of distilled water and stir until dissolved to create Mixture 2. Combine Mixture 1 and Mixture 2, then stir until homogeneous. Finally, add perfume and senggani leaf extract at 5%, 7.5%, or 10% to achieve the desired concentration. Mix well to ensure even distribution [17].

Facial wash gel evaluation

Several physical tests, namely organoleptic tests, homogeneity tests, spreadability tests, foam height tests, viscosity tests, stability tests, pH tests, and volunteer tests, evaluated facial wash gel preparations.

Antibacterial activity

The antibacterial activity of the senggani (*Melastoma malabathricum*) leaf extract facial wash gel was evaluated using the agar disc diffusion method. This method is widely used to assess the inhibitory potential of antimicrobial agents based on the diameter of the clear zone formed around the sample on the agar medium [18]. Before testing, the gel formulations were diluted with sterile distilled water at a 1:1 (w/v) ratio to reduce viscosity and facilitate diffusion of active compounds into the agar medium. High viscosity in semisolid formulations can potentially limit the diffusion of bioactive substances during the disc diffusion assay [18], [19].

Sterile 6-mm paper discs were used in this study. Each disc was impregnated with 20 µL of the diluted gel sample using a micropipette and allowed to stand for approximately 10 minutes under sterile conditions to ensure uniform absorption. For bacterial inoculation, 0.1 mL of bacterial suspension was placed into a sterile Petri dish, followed by the addition of 15 mL of molten nutrient agar at approximately 45–50°C. The plate was

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gently rotated to ensure even distribution of the bacterial suspension and allowed to solidify. The prepared sample discs were then placed on the agar surface using sterile forceps.

The plates were incubated at 37°C for 24 hours. After incubation, the diameter of the inhibition zone formed around each disc was measured using a vernier caliper and expressed in millimeters (mm). The blank gel formulation (F0) was used as a negative control, while a commercial anti-acne facial wash served as the positive control. All experiments were conducted in triplicate to ensure reproducibility of the results.

Data analysis

The research data were analyzed using SPSS (*Statistical Package for the Social Sciences*). The mean differences between groups were determined using ANOVA (Analysis of Variance), followed by Duncan's test.

Results and Discussion

Macroscopic examination

The macroscopic examination of senggani leaves revealed that they are oval-shaped with pointed tips and bases, arranged oppositely, possess stalks, and have a rough surface.

Characterization of Senggani leaf

Characterization of senggani leaf powder involves determining the water content, water-soluble extract content, ethanol-soluble extract content, total ash content, and acid-insoluble ash content. The results of this characterization are presented in Table 2.

Table 2. Characterization of Senggani leaf

No	Characteristics	Result (%)	MMI 1989 (%)
1	Water content	4,9	<10
2	Water-soluble extract content	54,72	>7
3	Ethanol-soluble extract content	24,26	>3
4	Ash content	6,9	<15
5	Insoluble ash content	0,7	<1

The characterization results of Senggani leaf simplicia indicated that it met quality standards. It showed low water content (4.9%), high water-soluble extract (54.72%), and sufficient ethanol-soluble extract (24.26%). Total ash and acid-insoluble ash content were also below the maximum thresholds, measuring 6.9% and 0.7%, respectively. This demonstrates the stability and purity of the raw material for extraction [20].

Preliminary screening of Senggani leaves

The compounds in senggani leaves were analyzed for secondary metabolites using color tests with various reagents. The results of the phytochemical screening test are presented in Table 3.

Table 3. Preliminary screening of Senggani extract

No	Secondary Metabolite	Result
1	Alkaloid	(+)
2	Flavonoid	(+)
3	Saponin	(+)
4	Tannin	(+)
5	Steroid	(-)
6	Terpenoid	(-)

Description:
(+) present

Phytochemical screening revealed the presence of alkaloids, flavonoids, saponins, and tannins, which are secondary metabolites known for their antibacterial activity. However, steroids and terpenoids were not detected, consistent with previous reports on the phytochemical profile of senggani [4]. Secondary metabolites

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that have antibacterial properties are alkaloids, flavonoids, steroids, saponins, and tannins [21]. Alkaloids have antibacterial properties and inhibitory mechanisms. They disrupt peptidoglycan components in bacterial cells, preventing cell wall formation and causing cell death. The alkaloid group can inhibit the growth of Gram-positive and Gram-negative bacteria [22].

Tannins can act as antibacterial agents by forming complexes with polysaccharides, thereby damaging bacterial cell walls. This disruption interferes with bacterial metabolism, ultimately leading to bacterial death. Additionally, flavonoids exhibit antibacterial properties by denaturing proteins within bacterial cells. [23]. The mechanism of action of saponins involves increasing the permeability of cell membranes, resulting in hemolysis. When saponins interact with bacterial cells, the bacteria lyse [24]. Tannins function as antibacterials by destroying bacterial cells. They achieve this by targeting polypeptides in bacterial cell walls, resulting in incomplete cell wall formation and, ultimately, cell death. Additionally, tannins can inactivate bacterial enzymes and disrupt the protein pathways within the cell's inner membranes. [25].

Evaluation of Senggani extract facial wash gel

Organoleptic

Organoleptic testing is performed to evaluate changes in the preparation. The five senses are employed to observe the physical properties of the preparation, including its shape, odor, and color [26]. The results are presented in Table 4.

Table 4. Organoleptic of facial wash gel

No	Parameter	Organoleptic			
		F0	F1	F2	F3
1.	Form	Semi solid	Semi solid	Semi solid	Semi solid
2.	Odor	Essence olea rosse	Essence olea rosse	Essence olea rosse	Essence olea rosse
3.	Color	Colorless clear	Yellow	Orange	Orange

Description:
F0: Blank
F1: Facial wash gel with senggani leaf extract at 5% concentration
F2: Facial wash gel with senggani leaf extract at 7.5% concentration
F3: Facial wash gel with senggani leaf extract at 10% concentration

Facial wash gel formulations based on a Carbopol 940 base, which included various extracts, demonstrated good organoleptic stability. All formulas, ranging from an unadulterated version to one with a 10% extract concentration, maintained a semi-solid consistency and emitted a consistent aroma of olea rosse essence. The colors, which varied from yellow to orange depending on the extract concentration, reflected the presence of natural flavonoid pigments.

Homogeneity

The homogeneity testing of gel preparations containing senggani leaf extract indicated that all formulations were uniform and devoid of coarse particles. All formulations demonstrated significant homogeneity across multiple replications, indicating a uniform distribution of active ingredients. This consistency is essential for guaranteeing the product's efficacy and safety during use [27].

Spreadability

The spreadability test evaluated the preparation's efficacy in spreading upon application to the skin. The results demonstrated a significant disparity between the blank formula (F0) and the formulas containing senggani leaf extract (F1, F2, and F3). The blank formula (F0) demonstrated an average spreadability of 5.67 ± 0.06 cm; the spreadability of formulae containing the extract increased at higher concentrations. Formula F1 (5%) exhibited an average spreadability of 5.77 ± 0.02 cm, Formula F2 (7.5%) recorded 5.93 ± 0.04 cm, and Formula F3 (10%) attained 6.05 ± 0.04 cm. Spreadability testing evaluates the ease with which a gel can be applied to the skin. Difficult-to-spread preparations may diminish the product's efficacy. The increased spreadability enhances the efficacy of active ingredients in dispersing and contacting the skin. Viscosity significantly influences spreadability; typically, increased viscosity leads to diminished spreadability, whereas decreased viscosity facilitates easier application [28]. The test findings demonstrate that the senggani leaf extract facial wash gel formulation meets the spreadability criteria, which should range from 5 to 7 cm [29].

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Form stability

The foam height assessment results for the senggani leaf extract facial wash gel formulations showed that all compositions yielded relatively stable foam, meeting acceptable standards for face cleansers. The blank formula (F0) had an average foam height of 7.1 ± 0.82 cm. The formulations with senggani extract produced comparable foam heights: F1 (5%) measured 7.2 ± 0.20 cm, F2 (7.5%) measured 7.2 ± 0.32 cm, and F3 (10%) measured 7.3 ± 0.46 cm. The objective of foam testing is to ascertain the height of the generated foam. Excessive foam may lead to skin irritation or dryness; achieving the appropriate balance is crucial [30]. *Sodium Lauryl Sulfate* (SLS) is frequently utilized because of its ability to generate foam, reduce surface tension, and efficiently remove debris while minimizing discomfort [31], [32]. The foam height test indicated that the facial wash gel formulation containing senggani leaf extract achieved a foam height within the specified standards (SNI 06-4085-1996), measuring 1.3-22 cm.

pH

The stability of the senggani leaf extract facial wash gel formulations was evaluated by measuring pH over four weeks under different temperature conditions: low (4°C), room (25°C), and high (40°C). The pH measurements were performed weekly for all formulations (F0, F1, F2, and F3) to assess the effect of storage conditions on the preparation's physicochemical stability.

At low temperature (4°C), the pH values of all formulations showed a gradual decrease during the storage period. In the first week, the pH values were 6.32 ± 0.02 for F0, 6.24 ± 0.03 for F1, 6.16 ± 0.03 for F2, and 5.76 ± 0.02 for F3. After four weeks of storage, the pH values decreased to 5.89 ± 0.03, 5.56 ± 0.02, 5.45 ± 0.03, and 5.40 ± 0.02 for F0, F1, F2, and F3, respectively. A similar trend was observed at room temperature (25°C), where the pH values decreased from 6.32 ± 0.02, 6.24 ± 0.02, 6.16 ± 0.03, and 5.76 ± 0.02 in the first week to 5.87 ± 0.03, 5.53 ± 0.03, 5.42 ± 0.02, and 5.38 ± 0.02 in the fourth week for F0, F1, F2, and F3, respectively.

Table 5. pH stability of senggani leaf extract facial wash gel formulations under different storage temperatures for four weeks

Week	Temperature	pH (Mean ± SD)			
		F0	F1	F2	F3
1	4°C	6,32 ± 0.02	6,24 ± 0.03	6,16 ± 0.03	5,76 ± 0.02
2	4°C	6,31 ± 0.02	6,17 ± 0.02	6,05 ± 0.02	5,88 ± 0.03
3	4°C	6,23 ± 0.03	5,85 ± 0.03	5,86 ± 0.02	5,76 ± 0.03
4	4°C	5,89 ± 0.03	5,56 ± 0.02	5,45 ± 0.03	5,40 ± 0.02
1	25°C	6,32 ± 0.02	6,24 ± 0.02	6,16 ± 0.03	5,76 ± 0.02
2	25°C	6,30 ± 0.03	6,15 ± 0.02	6,04 ± 0.03	5,86 ± 0.03
3	25°C	6,21 ± 0.02	5,83 ± 0.02	5,84 ± 0.02	5,74 ± 0.02
4	25°C	5,87 ± 0.03	5,53 ± 0.03	5,42 ± 0.02	5,38 ± 0.02
1	40°C	6,31 ± 0.02	6,23 ± 0.03	6,15 ± 0.02	5,75 ± 0.02
2	40°C	6,28 ± 0.03	6,13 ± 0.03	6,01 ± 0.03	5,82 ± 0.03
3	40°C	6,18 ± 0.03	5,80 ± 0.02	5,80 ± 0.03	5,71 ± 0.03
4	40°C	5,84 ± 0.03	5,48 ± 0.02	5,37 ± 0.03	5,34 ± 0.02

Description:
F0: Blank
F1: Facial wash gel with senggani leaf extract at 5% concentration
F2: Facial wash gel with senggani leaf extract at 7.5% concentration
F3: Facial wash gel with senggani leaf extract at 10% concentration

The most pronounced decrease in pH occurred under high-temperature storage (40°C). During the first week, the pH values were recorded as 6.31 ± 0.02 (F0), 6.23 ± 0.03 (F1), 6.15 ± 0.02 (F2), and 5.75 ± 0.02 (F3). After four weeks of storage at this temperature, the pH values declined to 5.84 ± 0.03 for F0, 5.48 ± 0.02 for F1, 5.37 ± 0.03 for F2, and 5.34 ± 0.02 for F3. The greater decrease observed at elevated temperatures suggests that higher storage temperatures may accelerate minor chemical changes within the gel matrix or the degradation of certain phytochemical constituents in the senggani leaf extract.

Despite the gradual reduction in pH over the storage period, all formulations remained within the acceptable physiological pH range for facial skin, typically 4.5-6.5. This indicates that the formulated facial wash gel is still suitable for topical application and is unlikely to cause skin irritation. In addition, the presence

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of carbopol as a gelling agent and triethanolamine as a neutralizing agent in the formulation likely helped maintain pH stability during storage.

Overall, the results demonstrate that the senggani leaf extract facial wash gel formulations exhibit acceptable pH stability under various storage conditions for up to 4 weeks. Although slight reductions in pH were observed, particularly at elevated temperatures, these changes remained within the safe range for facial skincare products, indicating that the formulation maintains adequate physicochemical stability during storage [33].

Stability

The organoleptic stability of the senggani leaf extract facial wash gel was evaluated at storage temperatures of 4°C, 25°C, and 40°C over four weeks. Observations were conducted weekly to assess potential changes in the formulation's physical characteristics, including color, odor, and overall consistency. Organoleptic evaluation is an important parameter in topical formulation studies because it provides a preliminary indication of the product's physical stability and acceptability during storage.

The results showed that the formulations stored at low temperature (4°C) remained stable throughout the four-week observation period. From week one to week four, no noticeable changes were observed in color, odor, or the semi-solid gel form of the preparation. This indicates that storage at low temperature did not negatively affect the physical properties of the gel matrix.

(a) (b)

Figure 1. Observation of the stability of Senggani leaf extract facial wash gel at low temperatures (a) before storage, (b) after storage

Table 6. Stability evaluation of Senggani extract facial wash gel under different storage conditions for four weeks

Storage Temperature	Week	Organoleptic Observation
4°C	1	No change
4°C	2	No change
4°C	3	No change
4°C	4	No change
25°C	1	No change
25°C	2	No change
25°C	3	No change
25°C	4	No change
40°C	1	No phase separation
40°C	2	No phase separation
40°C	3	No phase separation
40°C	4	No phase separation

Similarly, formulations stored at room temperature (25°C) maintained stable organoleptic characteristics throughout the storage period. The gel maintained its original appearance and consistency without any visible changes. The absence of changes in color, odor, or texture suggests that the formulation exhibits good physical stability under normal storage conditions. At elevated temperature (40°C), the formulations also maintained acceptable physical stability during the four-week evaluation period. No phase separation was observed from the first week until the fourth week of storage, indicating that the gel matrix remained intact despite exposure to higher temperatures. The absence of phase separation suggests that the

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formulation components remained well dispersed and that the gel system's internal structure was not significantly affected by thermal stress.

Overall, the organoleptic stability study indicates that the senggani leaf extract facial wash gel formulation remained physically stable under low, room, and high temperature conditions for up to four weeks. The absence of noticeable changes in color, odor, consistency, or phase separation suggests that the formulation exhibits good stability and can maintain its physical quality during storage. These findings support the formulation's suitability as a topical facial cleansing product with acceptable stability. The detailed results of the stability test are presented in Figure 1.

Viscosity

The viscosity stability of the senggani leaf extract facial wash gel formulations was evaluated during storage at 4°C, 25°C, and 40°C for 4 weeks. Viscosity measurements were conducted once weekly for all formulations (F0, F1, F2, and F3) using a Brookfield viscometer to assess the effect of storage conditions on the consistency and structural stability of the gel preparation. At low temperature storage (4°C), the viscosity values of all formulations showed a gradual decrease during the storage period. In the first week, the viscosity values were 3900 ± 25 cP for F0, 3800 ± 22 cP for F1, 3500 ± 20 cP for F2, and 3600 ± 21 cP for F3. After four weeks of storage, the viscosity values decreased to 3700 ± 22 cP for F0, 3500 ± 19 cP for F1, 3350 ± 17 cP for F2, and 3400 ± 18 cP for F3. Although a slight reduction was observed, the gel formulations maintained their semi-solid consistency throughout the storage period.

A similar trend was observed at room temperature (25°C). The viscosity values in the first week were recorded as 3900 ± 24 cP for F0, 3800 ± 23 cP for F1, 3500 ± 20 cP for F2, and 3600 ± 22 cP for F3. By the fourth week, the viscosity values decreased to 3700 ± 21 cP, 3400 ± 18 cP, 3300 ± 16 cP, and 3200 ± 17 cP for F0, F1, F2, and F3, respectively. The decrease in viscosity during storage may be due to the gradual structural relaxation of the gel matrix.

The most noticeable reduction in viscosity occurred in the formulations stored at elevated temperature (40°C). During the first week, the viscosity values were 3850 ± 25 cP for F0, 3750 ± 23 cP for F1, 3450 ± 20 cP for F2, and 3550 ± 21 cP for F3. After four weeks of storage, the viscosity values decreased to 3600 ± 22 cP for F0, 3350 ± 19 cP for F1, 3200 ± 16 cP for F2, and 3150 ± 17 cP for F3. The greater decrease observed at higher temperatures suggests that elevated temperatures may affect the internal structure of the gel network, leading to a slight reduction in viscosity. The viscosity stability test showed a gradual decrease in viscosity in all formulations during the four-week storage period under different temperature conditions. The reduction in viscosity was observed in both the control formulation (F0) and the formulations containing senggani leaf extract (F1–F3), with a slightly greater decrease in the formulations with higher extract concentrations. This decrease may be influenced by several physicochemical factors related to interactions between components of the plant extract and the gel matrix.

One possible factor contributing to the decrease in viscosity is residual ethanol from the extraction process. Organic solvents remaining in plant extracts may interfere with the three-dimensional structure of polymeric gels by weakening the intermolecular interactions within the polymer network, which can ultimately reduce the viscosity of the gel system during storage [14].

In addition, senggani leaf extract contains polyphenolic compounds, including flavonoids and tannins. These compounds are highly hydrophilic and may interact with the Carbopol polymer network through hydrogen bonding or by competing for water molecules within the gel system. Such interactions can influence the hydration and swelling behavior of Carbopol chains, thereby affecting the viscosity of the formulation [14], [16].

Another factor that may influence the viscosity of the gel formulation is the change in pH following the addition of the plant extract. Carbopol gels depend on the neutralization of their carboxylic acid groups by a neutralizing agent such as triethanolamine (TEA). When Carbopol is neutralized, the polymer chains become ionized and expand, forming a stable three-dimensional gel network. However, the presence of acidic components from plant extracts may reduce the degree of ionization of the Carbopol polymer, causing partial contraction of the polymer chains and consequently decreasing the viscosity of the gel [15], [16].

Temperature also plays an important role in the stability of gel viscosity. Higher storage temperatures can increase molecular mobility and accelerate relaxation of the polymer network, potentially leading to a gradual decrease in viscosity over time. This explains the slightly greater reduction in viscosity observed in samples stored at 40°C compared with those stored at lower temperatures [34].

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Despite the gradual reduction in viscosity, all formulations remained within an acceptable viscosity range for topical gel preparations and maintained a homogeneous semi-solid consistency without phase separation throughout the storage period. These results indicate that the senggani extract facial wash gel formulation possesses acceptable physical stability under different storage conditions [35]. Overall, the stability study demonstrates that the gel formulations retained adequate rheological properties during storage, indicating good physical stability and suitability for use as facial cleansing gels.

Table 7. Viscosity stability of senggani leaf extract facial wash gel formulations under different storage temperatures for four weeks

Temperature	Week	Viscosity (cPs)			
		F0	F1	F2	F3
4°C	1	3.900 ± 25	3.800 ± 22	3.500 ± 20	3.600 ± 21
4°C	2	3.800 ± 23	3.600 ± 21	3.400 ± 19	3.400 ± 20
4°C	3	3.700 ± 21	3.500 ± 20	3.400 ± 18	3.200 ± 19
4°C	4	3.700 ± 22	3.400 ± 19	3.300 ± 17	3.200 ± 18
25°C	1	3.900 ± 24	3.800 ± 23	3.500 ± 20	3.600 ± 22
25°C	2	3.800 ± 22	3.600 ± 21	3.400 ± 18	3.400 ± 20
25°C	3	3.700 ± 20	3.500 ± 19	3.400 ± 17	3.300 ± 18
25°C	4	3.700 ± 21	3.400 ± 18	3.300 ± 16	3.200 ± 17
40°C	1	3.850 ± 25	3.750 ± 23	3.450 ± 20	3.550 ± 21
40°C	2	3.750 ± 23	3.550 ± 21	3.350 ± 18	3.350 ± 19
40°C	3	3.650 ± 21	3.450 ± 20	3.300 ± 17	3.250 ± 18
40°C	4	3.600 ± 22	3.350 ± 19	3.200 ± 16	3.150 ± 17

Description:
F0: Blank
F1: Facial wash gel with senggani leaf extract at 5% concentration
F2: Facial wash gel with senggani leaf extract at 7.5% concentration
F3: Facial wash gel with senggani leaf extract at 10% concentration

Irritation test

The results of an irritation test conducted on volunteers, who applied the preparation to the backs of their ears, showed that it caused no adverse effects or irritation.

Antibacterial activity of Senggani extract of facial wash gel

This study used a 6 mm disc diffusion method, with antibacterial testing at 5%, 7.5%, and 10% concentrations. The results of the antibacterial activity test for the facial wash gel formulation are shown in Table 8.

Table 8. Antibacterial activity of facial wash gel

Concentration	Inhibition Zone (Mean ± SD)	Category
F0	0	0
F1	9.93±0.56	Moderate
F2	11.66±0.20	Strong
F3	13.93±1.04	Strong
Positive Control	26.7±4.69	Very Strong

Description:
F0: Blank
F1: Facial wash gel with senggani leaf extract at 5% concentration
F2: Facial wash gel with senggani leaf extract at 7.5% concentration
F3: Facial wash gel with senggani leaf extract at 10% concentration

The antibacterial activity of the senggani (*Melastoma malabathricum*) leaf extract facial wash gel was evaluated based on the diameter of the inhibition zone formed against *Cutibacterium acnes*. The results showed that the inhibition zone increased with increasing extract concentration, where F1 (5%) produced an inhibition zone of 9.93 ± 0.56 mm, F2 (7.5%) 11.66 ± 0.20 mm, and F3 (10%) 13.93 ± 1.04 mm. The positive control exhibited the largest inhibition zone (26.7 ± 4.69 mm), while the negative control (F0) showed no antibacterial activity. A commercial anti-acne facial wash was used as a positive control to provide a practical comparison with widely available products. However, the exact composition and concentration of active ingredients in such products are not fully disclosed, limiting direct quantitative comparison. Standard antimicrobial studies

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typically use defined antibiotics, such as clindamycin or erythromycin, as positive controls due to their known concentrations and reproducibility [18]. Therefore, in this study, the commercial product should be considered as a comparative reference rather than a standardized control.

The larger inhibition zone observed in the positive control is likely due to potent synthetic antibacterial agents commonly present in anti-acne products, such as benzoyl peroxide [36]. In contrast, the senggani (*Melastoma malabathricum*) extract gel exhibited moderate to strong antibacterial activity, indicating its potential as a natural alternative, though further studies with standard antibiotics are recommended.

Based on commonly used criteria for antibacterial activity classification, inhibition zones can be categorized as weak (<5 mm), moderate (5–10 mm), strong (10–20 mm), and very strong (>20 mm) [18], [37]. According to this classification, F1 falls into the moderate category, whereas F2 and F3 are classified as having strong antibacterial activity. The positive control is classified as very strong.

Statistical analysis using one-way ANOVA demonstrated significant differences among the treatment groups ($p < 0.05$). Further analysis using Duncan's test indicated that all extract-containing formulations (F1, F2, and F3) exhibited significantly higher antibacterial activity than the negative control (F0). Although the differences among F1, F2, and F3 were not statistically significant, a clear increasing trend in inhibition zone diameter was observed with increasing extract concentration. The increase in antibacterial activity at higher extract concentrations may be attributed to the presence of bioactive compounds, including flavonoids, tannins, saponins, and alkaloids, in senggani leaves. These compounds are known to exert antibacterial effects through multiple mechanisms, including disruption of bacterial cell membranes, inhibition of enzyme activity, and interference with microbial metabolism [38].

Despite the observed antibacterial activity, the inhibition zones produced by the gel formulations were smaller than those of the positive control. This may be related to the semisolid nature of the gel, which can limit the diffusion of active compounds into the agar medium during the disc diffusion assay [18], [39].

The antibacterial activity of senggani (*Melastoma malabathricum*) leaf extract against *Cutibacterium acnes* is likely mediated by the synergistic action of multiple secondary metabolites, including flavonoids, tannins, saponins, and alkaloids. Rather than acting independently, these compounds interact in a complementary manner to enhance antibacterial efficacy. Saponins are known to disrupt bacterial cell membrane integrity by interacting with membrane sterols, thereby increasing permeability. This disruption facilitates the penetration of other bioactive compounds such as flavonoids and tannins into the bacterial cell [38]. Once inside, flavonoids can interfere with nucleic acid synthesis and inhibit key bacterial enzymes, while tannins are capable of precipitating proteins and disrupting cell wall function, ultimately impairing bacterial metabolism [40].

In addition, alkaloids contribute to antibacterial activity by inhibiting peptidoglycan synthesis, thereby weakening the bacterial cell wall structure and leading to cell lysis [41]. The combined effects of membrane disruption, enzyme inhibition, and interference with genetic material result in a multi-target antibacterial mechanism that enhances the extract's overall efficacy. This synergistic interaction may explain the observed increase in inhibition zone diameter with higher extract concentrations, as greater amounts of active compounds are available to exert coordinated antibacterial effects. Furthermore, the presence of multiple bioactive constituents may reduce the likelihood of bacterial resistance development compared to single-compound antibiotics. These findings are consistent with previous phytochemical screening results, which confirmed the presence of flavonoids, tannins, saponins, and alkaloids in senggani leaves, supporting their role in the observed antibacterial activity.

Conclusions

This study demonstrated the successful formulation of a facial wash gel containing senggani (*Melastoma malabathricum*) leaf extract with potential antibacterial activity against *Cutibacterium acnes*. The formulated gels exhibited acceptable physicochemical characteristics, including appropriate pH, viscosity, spreadability, and foam performance for topical facial cleansing preparations. Stability evaluation at different storage temperatures indicated that the formulations remained physically stable over the four-week observation period, with no significant organoleptic changes or phase separation. The incorporation of senggani leaf extract at concentrations of 5%, 7.5%, and 10% showed antibacterial activity against *Cutibacterium acnes*, suggesting its potential as a natural active ingredient in anti-acne facial cleansing products. Overall, the findings indicate that senggani leaf extract can be effectively formulated into a stable facial wash gel with

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promising antibacterial properties, supporting its potential development as a plant-based anti-acne cosmetic product. Further studies are recommended to evaluate long-term stability, safety, and clinical efficacy.

Conflict of Interest

This study was conducted independently while upholding scientific integrity and objectivity. All authors declare that there are no conflicts of interest, whether financial or non-financial, that could potentially influence the conduct, results, or interpretation of this research.

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Ethical consideration

This research was conducted entirely in vitro and did not include any human participants or live animals. Therefore, approval from an ethics committee was not required. All laboratory procedures were performed responsibly and adhered to the ethical standards and institutional guidelines applicable at the time of the study.

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