



Green Formulation of an Antibacterial Bath Soap Using *Elatostema rostratum* Leaf Extract as a Sustainable Natural Agent

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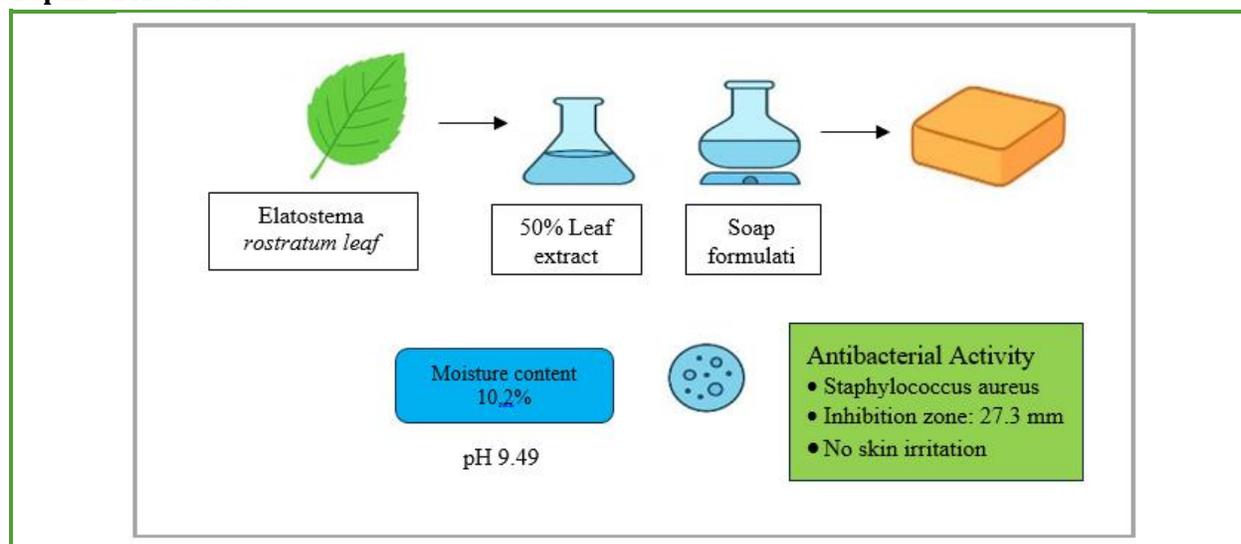
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ABSTRACT

Antibacterial soap plays a vital role in maintaining skin hygiene and preventing infections caused by pathogenic microorganisms. This study aimed to develop a transparent solid soap formulated with *cocok bubu* (*Elatostema rostratum* (Blume) Hassk) leaf extract, an endemic plant from Sukabumi, as a natural antibacterial agent. The extraction was performed by maceration using methanol, and the extract was subsequently concentrated using a rotary evaporator. The soap was formulated with 50% extract concentration and evaluated for its physicochemical quality parameters, including pH, moisture content, free alkali, foam height, and saponification value. Additionally, skin irritation and antibacterial activity tests were conducted against *Staphylococcus aureus*. The results showed that the produced soap met the Indonesian national standard (SNI), with pH 9.49, moisture content 10.2%, free alkali 0.032%, saponification value 210.4 mg KOH/g, and foam height 3.2 cm. The product did not cause skin irritation and exhibited strong antibacterial activity with an inhibition zone of 27.3 mm, exceeding the positive control Asepsol (23.0 mm). Therefore, solid soap formulated with *cocok bubu* leaf extract has great potential as a safe, effective, and environmentally friendly natural antibacterial product.

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Graphical Abstract



Introduction

Skin diseases remain among the most common public health problems, with a high prevalence worldwide, including in Indonesia. These conditions are often caused by colonization with pathogenic microorganisms such as *Staphylococcus aureus* [1], which can lead to a range of skin disorders from superficial infections to chronic wounds. Moreover, *Staphylococcus aureus* is known to exacerbate atopic dermatitis by disrupting the skin's barrier function. Recent epidemiological reports indicate that most *Staphylococcus aureus* isolates in Indonesia have developed multidrug resistance (MDR) to several classes of antibiotics [2], underscoring the declining effectiveness of conventional treatments and the urgent need for safer, more effective, and sustainable antibacterial alternatives. Along with the growing awareness of the adverse effects of synthetic chemicals, recent studies have emphasized the potential of natural products as antibacterial agents that are non-toxic, biodegradable, and environmentally friendly [3]. Secondary metabolites in plants, such as flavonoids, alkaloids, saponins, and steroids, are known to possess antibacterial, antifungal, and

antioxidant properties [4]. These compounds act through multiple mechanisms, including damaging bacterial cell membranes, inhibiting protein synthesis, and interfering with enzymatic systems. Several studies have demonstrated the successful formulation of antibacterial soaps using natural extracts. For instance, Pranata *et al.* reported that transparent solid soap formulated with teak leaf (*Tectona grandis* L.f.) extract met physicochemical standards and exhibited strong antibacterial activity [5]. Similarly, research by Khumaisah *et al.* revealed that *Elatostema rostratum* (Blume) Hassk, an endemic plant from Sukabumi, contains flavonoids, alkaloids, saponins, and steroids responsible for significant antibacterial effects against *Staphylococcus aureus* and several Gram-negative bacteria [6]. This finding suggests that *E. rostratum* could serve as a promising natural source of antibacterial agents for herbal soap formulation. Recent studies have highlighted the importance of bioactive compounds from natural sources in the development of antibacterial and dermatological formulations. Polyphenolic compounds, for instance, are known for their strong antioxidant and antimicrobial properties that contribute to

skin protection and healing processes [7]. In addition, understanding the molecular mechanisms of phytochemicals is essential to designing effective natural-based therapies for skin-related disorders. Epidemiological research on skin conditions, such as lichen planus, also emphasizes the need for safer, plant-derived alternatives to synthetic treatments [8]. Moreover, molecular docking analyses have demonstrated that natural compounds, such as rosmarinic acid and its analogs, can interact with biological targets, supporting their potential as bioactive ingredients in pharmaceutical and cosmetic formulations [9]. On the other hand, advances in extraction techniques, such as supercritical CO₂ and ultrasound-assisted methods, have significantly improved the recovery efficiency and stability of plant-derived compounds like carvacrol from *Olivaria decumbens* [10]. Similarly, investigations into the secondary metabolites of medicinal plants, such as *Medicago sativa* L., have shown that metabolite composition varies with plant organ and harvest time, influencing their biological activity and potential applications [11]. In this context, the utilization of *E. rostratum* (Blume) Hassk leaf extract represents a sustainable and promising approach for the formulation of antibacterial solid bath soaps. This plant may provide active natural compounds that enhance both cleansing and antimicrobial efficacy, aligning with the current trend toward eco-friendly and health-conscious personal care products. Solid soap is a widely used personal care item that functions through the saponification process [12,13], producing surfactant molecules capable of reducing surface tension and emulsifying oils and dirt. Incorporating plant extracts into soap not only improves its cleansing capacity but also enriches its biological activity, particularly its antibacterial function. The development of solid soap based on local natural ingredients such as

E. rostratum also aligns with the principles of green chemistry [14], emphasizing the use of renewable resources, reduction of chemical waste, and enhancement of product safety for consumers. This research presents novelty by integrating three essential aspects: (1) the utilization of an Indonesian endemic plant, *Elatostema rostratum*, as a natural antibacterial active ingredient [15]; (2) the development of a transparent solid soap formulation that complies with the Indonesian national standard (SNI 3532:2016); and (3) a comprehensive evaluation encompassing physicochemical characteristics, antibacterial activity against *Staphylococcus aureus*, and skin irritation safety testing. The combination of these elements has been rarely reported in the literature, making this study a valuable contribution to the advancement of safe, effective, and environmentally friendly natural antibacterial skincare products.

Experimental

Object, time, and location of research

The object of this study was the plant *E. rostratum* (Blume) Hassk, collected from the Selabintana region, Sukabumi City, West Java, Indonesia. The research was conducted over a period of three months, from April to July 2024, at the Chemistry Laboratory of Universitas Muhammadiyah Sukabumi and PT Herba Utama, Cikarang, West Java. The identification of the plant species followed the method described by Uddin *et al.*, ensuring accurate botanical classification before extraction and formulation [2].

Instruments and materials

The instruments used in this study included beakers, Erlenmeyer flasks, soap-making tools, a digital pH meter, an oven, a magnetic stirrer, a

thermometer, an analytical balance, a water bath, Petri dishes, forceps, an incubator, and a caliper. The materials used were distilled water, methanol, citric acid ($C_6H_8O_7$), stearic acid ($C_{18}H_{36}O_2$), virgin coconut oil (VCO), castor oil, 96% ethanol, glycerol ($C_3H_8O_3$), sucrose, hydrochloric acid (HCl), sodium hydroxide (NaOH), phenolphthalein indicator, and sodium chloride (NaCl). *E. rostratum* (Blume) Hassk leaf *simplicia* was used as the plant material. For the antibacterial assay, *Staphylococcus aureus* ATCC 6538 strain, Trypticase Soy Agar (TSA) medium, and a 0.5 McFarland turbidity standard were used, following the standard microbiological testing procedures described by Omojate *et al.* and Byrd *et al.*

Extraction of plant samples

A total of 1 kg of dried *E. rostratum* (Blume) Hassk leaves were macerated in methanol for 24 hours, and the process was repeated three times to maximize extraction efficiency. The filtrate was collected using a Büchner funnel and Whatman filter paper, then concentrated under reduced pressure using a rotary evaporator at 50 °C until a thick extract was obtained. This extraction method was adapted from Uddin *et al.*, who demonstrated the effectiveness of methanol in extracting polar bioactive compounds such as flavonoids and phenolics [2].

Preparation of solid soap

The solid soap was prepared using the hot process method described by Pranata *et al.* with slight modifications [5]. Virgin coconut oil and castor oil were heated to 50 °C, followed by the gradual addition of NaOH solution while stirring with a magnetic stirrer until saponification occurred. Subsequently, molten stearic acid, ethanol, glycerol, sugar solution, and citric acid were added sequentially, each stirred for

approximately five minutes. Natural colorants and fragrances were added after the mixture became homogeneous. The *E. rostratum* extract was then incorporated at a concentration of 50 g (50% b/v) into the soap base. The mixture was poured into molds, allowed to solidify for 24 hours, and then cured at room temperature for 3 weeks to obtain transparent solid soap (Table 1).

Evaluation of soap quality

The physicochemical evaluation of the soap was conducted following the Indonesian SNI 3532:2016 for solid soap [14,15].

Saponification value

The saponification value was determined according to Equation 1. An accurately weighed 2 g sample of oil was refluxed with 25 mL of 0.5 N alcoholic KOH solution for one hour. After the reflux process, the mixture was allowed to cool to room temperature, and then titrated with 0.5 N HCl using phenolphthalein as an indicator. The saponification value was calculated using Equation 1:

$$\text{Saponification value} = \frac{56.1 \times T \times (V_0 - V_1)}{M} \quad (1)$$

Where, V_0 = blank titration volume, V_1 = sample titration volume, T = normality of HCl, and M = sample mass (g).

Moisture content

The moisture content was determined according to Equation 2. A 4 g sample of soap was dried in an oven at 105 °C for two hours until a constant weight was obtained. The percentage of moisture content was then calculated using Equation 2:

$$\text{Moisture content} = \frac{(W_1 - W_2)}{W} \times 100\% \quad (2)$$

Table 1. Basic formula of antibacterial solid soap containing *Cocok bubu* leaf extract

Ingredient	Function	Concentration (b/v)
<i>Cocok bubu</i> leaf extract	Active antibacterial agent	50 g
Virgin coconut oil (VCO)	Emollient/foaming agent	40 g
Castor oil	Moisturizer/viscosity enhancer	30 g
NaOH solution	Alkaline saponifying agent	35 g
Ethanol	Solvent	30 mL
Sugar solution	Humidity binder	60 mL
Glycerol	Humectant / softener	30 mL
Stearic acid	Hardness regulator	10 g
Citric acid	pH stabilizer	1 g

Where W_1 = weight of sample + weighing bottle, W_2 = weight after drying, and W = initial sample weight.

Free Alkali Content

The free alkali content was determined using Equation 3. A 5 g sample of soap was dissolved in 200 mL of 96% ethanol and titrated with 0.1 N HCl using phenolphthalein as an indicator. According to SNI 3532:2016, the free alkali level must not exceed 0.1%. The percentage of free alkali was calculated according to Equation 3:

$$\% \text{ Free Alkali} = \frac{V \times N \times 0.04}{g \text{ sample}} \times 100\% \quad (3)$$

Foam height

The foam height was determined using Equation 4. 1 g sample of soap was dissolved in 10 mL of distilled water and shaken vigorously for one minute. The foam height was measured both before and after shaking, and the difference was used to calculate the foam height according to Equation 4 [16]:

$$\text{Average Foam Height} = \frac{(\text{Initial Height} + \text{Final Height})}{2} \quad (4)$$

An ideal foam height ranges between 1.3 and 22 cm, as specified by SNI 3532:2016.

pH measurement

1 g sample of soap was dissolved in 10 mL of distilled water, and the pH of the resulting solution was measured using a calibrated digital pH meter after the reading had stabilized.

Organoleptic evaluation

Organoleptic parameters, including color, aroma, and texture, were evaluated by five trained panelists following the sensory assessment protocol described in SNI 3532:2016 and the method outlined by Halden for consumer acceptability testing [8,17,18].

Antibacterial activity test against *Staphylococcus aureus*

The antibacterial activity was evaluated using the disc diffusion method as described by Omojate *et al.* and Byrd *et al.* [19,20]. Trypticase Soy Agar (TSA) medium (15 mL) was poured into sterile Petri dishes and inoculated with a *Staphylococcus aureus* suspension adjusted to a 0.5 McFarland standard. Sterile paper discs (6 mm in diameter) were immersed in the soap solution (prepared by dissolving 1 g of soap in 2 mL of distilled water) and placed on the inoculated agar surface. Asepsol was used as the positive control, while NaOH solution served as the negative control. The plates were incubated at 35 °C for 24 hours, after which the diameter of

the inhibition zones was measured in millimeters using a digital caliper. Antibacterial potency was classified based on the criteria described by Pelczar *et al.* [21], where inhibition zones greater than 20 mm indicate strong antibacterial activity.

Skin irritation test

The skin irritation test was conducted using an open patch method on ten healthy volunteers aged 19–28 years, in accordance with the ethical guidelines of UHAMKA's Non-Clinical Ethics Committee [13]. Soap samples were applied to the upper back area and left uncovered for 24 hours. The skin was then examined for any signs of redness, itching, swelling, pain, or allergic reactions. The formulation was considered safe if no visible irritation or allergic response was observed during or after the exposure period. This test was performed to assess the dermatological safety and skin compatibility of the soap formulation for topical application.

Results and Discussion

Plant determination

Based on the taxonomic identification conducted at the Biology Laboratory of Universitas Muhammadiyah Sukabumi, the plant locally known as *cocok bubu* was identified as *E. rostratum* (Blume) Hassk., a species belonging to the family Urticaceae. The official identification certificate is provided in Appendix 2. The plant material was collected from the Salabintana region, Sukabumi Regency, West Java, Indonesia.

Extraction of samples

The extraction process of *E. rostratum* (Blume) Hassk leaves represents a critical step in the formulation of the solid soap. Methanol was chosen as the extraction solvent because of its high polarity, which enables efficient solubilization of various polar bioactive compounds such as flavonoids, phenolics, and carbohydrates. Its relatively low boiling point (64.7 °C) also facilitates solvent removal under reduced pressure using rotary evaporation at 50 °C and 50 Pa, thereby minimizing thermal degradation of heat-sensitive phytochemicals. The yield of the methanolic extract was 16.4%, as presented in Table 2.

The relatively high yield indicates that methanol effectively extracted the bioactive constituents from *E. rostratum* leaves. Similar findings were reported by Uddin *et al.* for *Elatostema papillosum*, confirming that methanol is an optimal solvent for isolating phenolic-rich plant metabolites [9].

Saponification value

This parameter represents the amount of potassium hydroxide (mg KOH) required to saponify one gram of fat or oil. It serves as an indicator of the average molecular weight or chain length of the fatty acids present in the sample. A higher saponification value generally suggests the presence of shorter-chain fatty acids, which typically produce a harder soap with superior cleansing properties. The saponification value was calculated using Equation 1. As shown in Table 3, the control formulation (F0) exhibited a saponification value of 168.3 mg KOH/g, while the formulation

Table 2. Extraction yield

Sample	Dried sample (g)	Extract weight (g)	Yield (%)
<i>E. rostratum</i> leaves	1000	164.51	16.4

Table 3. Saponification values

Sample	Saponification value (mg KOH/g)	SNI standard (mg KOH/g)
F0	168.3	180–250
EDCB 50%	210.4	180–250

containing 50% *E. rostratum* extract (EDCB 50%) showed a higher value of 210.4 mg KOH/g. This increase indicates a greater proportion of shorter-chain fatty acids, which may enhance the hardness and cleansing efficiency of the resulting soap. Both formulations complied with SNI 3532:2016 standards (180–250 mg KOH/g). The increase in saponification value with *E. rostratum* extract addition suggests a higher content of short-chain fatty acids, enhancing the hardness of the soap and cleansing properties.

Moisture content

Moisture content represents the amount of water retained within the soap formulation. Maintaining an optimal moisture level is essential for ensuring product stability, hardness, and shelf life. Excessive moisture may promote microbial growth and reduce the soap's durability, whereas insufficient moisture can make the soap brittle and less appealing in texture. The moisture content was determined using Equation 2. As shown in Table 4, moisture level greatly influences the physical stability, texture, and longevity of the soap. According to SNI (1994), the maximum permissible moisture content for solid soap is 15%. The results show

that the control formulation (F0) contained 9.8% moisture, while the formulation containing 50% *E. rostratum* extract (EDCB 50%) contained 10.2%. Both values fall within the acceptable range of 10–15%, confirming that the formulations meet the required quality standards.

Free alkali content

Free alkali content represents the amount of unreacted sodium or potassium hydroxide remaining in the soap after the saponification process. Excessive free alkali may cause skin irritation and compromise product safety. According to the Indonesian SNI 3532:2016, the acceptable limit for free alkali in solid soap is $\leq 0.1\%$, ensuring that the product remains mild and safe for regular skin application. The free alkali content was determined using Equation 3. As shown in Table 5, both the control formulation (F0) and the formulation containing 50% *E. rostratum* extract (EDCB 50%) complied with the permissible limit established by SNI 3532:2016. These findings confirm that both soap formulations are mild, non-irritating, and meet the required safety standards.

Table 4. Moisture content

Sample	Moisture content (%)	SNI moisture standard (%)
F0	9.8	10–15
EDCB (50%)	10.2	10–15

Table 5. Free alkali content

Sample	Free alkali (%)	SNI limit (%)
F0	0.024	≤ 0.1
EDCB 50%	0.032	≤ 0.1

Foam height

Free alkali content refers to the amount of unreacted sodium or potassium hydroxide remaining in the soap after the saponification process. Excessive free alkali can cause skin irritation and compromise product safety. According to the Indonesian SNI 3532:2016, the acceptable limit for free alkali in solid soap is $\leq 0.1\%$, ensuring that the product remains mild and safe for regular skin use. The free alkali content was determined using Equation 3. As shown in Table 6, both the control formulation (F0) and the formulation containing 50% *E. rostratum* extract (EDCB 50%) were within the permissible limit established by SNI 3532:2016. These findings confirm that both soap formulations are mild, non-irritating, and meet the required safety standards. Both samples produced sufficient foam, indicating that the incorporation of plant extract did not adversely affect foaming capacity.

pH measurement

The pH value is an important indicator of a soap's safety and compatibility with the skin. Maintaining the pH within an optimal range is essential to ensure effective cleansing

performance while minimizing the risk of skin irritation. According to the Indonesian SNI 3532:2021, the acceptable pH range for solid soap is 6–11. As shown in Table 7, both the control formulation (F0) and the formulation containing 50% *E. rostratum* extract (EDCB 50%) exhibited pH values within this acceptable range. The slightly alkaline nature of both formulations supports effective cleansing performance while maintaining skin compatibility, thereby ensuring user safety and comfort.

Organoleptic evaluation

Organoleptic evaluation was conducted to assess the soap's shape, color, and aroma, as summarized in Table 8. The incorporation of *E. rostratum* extract enhanced the soap's aroma and color without compromising its physical stability. This assessment aimed to evaluate the physical appearance and sensory attributes of the soap, which are critical factors influencing consumer preference and perceived product quality. Parameters such as color uniformity, pleasantness of aroma, and smoothness of texture were considered indicators of formulation stability and overall aesthetic appeal.

Table 6. Foam height

Sample	Average foam height (cm)	SNI (cm)	Remarks
F0	2.5	1.3–22	Meets standard
EDCB 50%	3.2	1.3–22	Meets standard

Table 7. pH values

Sample	pH	Remarks
F0	9.34	Within standard
EDCB 50%	9.49	Within standard

Table 8. Organoleptic properties

Sample	Form	Aroma	Color
F0	Solid	Neutral	Green
EDCB 50%	Solid	Characteristic herbal	Dark green

Antibacterial activity against *Staphylococcus aureus*

Antibacterial activity was evaluated using the disk diffusion method against *Staphylococcus aureus* ATCC 6538, as presented in Table 9. The formulation containing 50% *E. rostratum* extract (EDCB 50%) exhibited an inhibition zone of 27.3 mm, which was greater than that of the positive control (Asepsol, 23.0 mm).

According to Pelczar *et al.*, inhibition zones exceeding 20 mm indicate strong antibacterial activity. The superior antibacterial performance of the EDCB 50% formulation is likely attributed to the synergistic effects of bioactive compounds such as flavonoids, alkaloids, saponins, and steroids present in *E. rostratum*. These phytochemicals are known to disrupt bacterial cell membranes and interfere with essential enzymatic functions. Comparable results have been reported for *Elatostema papillosum*, which produced inhibition zones ranging from 20 to 25 mm, further supporting the potent antibacterial potential of this genus.

Irritation test

The skin irritation test was conducted on five volunteers under ethical approval from the Non-

Clinical Ethics Committee of UHAMKA. No signs of erythema, itching, or swelling were observed in any of the participants, as shown in Table 10. These findings confirm that the soap formulation is safe for topical application and suitable for routine use. The formulation was considered safe when no visible signs of irritation or allergic response were detected during or after the exposure period. This evaluation was performed to assess the dermatological safety and skin compatibility of the soap formulation, ensuring its suitability for regular topical use.

Mechanism of soap cleansing action

The cleansing mechanism of soap is primarily attributed to its surfactant properties, which reduce surface tension and facilitate the interaction between water and oily substances. The polar (hydrophilic) head of the soap molecule dissolves in water, while the nonpolar (hydrophobic) tail associates with grease and dirt. During rinsing, these interactions lead to the formation of micelles that encapsulate oils, debris, and microorganisms, allowing them to be effectively removed with water [14,15]. This mechanism underlies the observed cleansing performance and antibacterial efficacy of the *E. rostratum*-based soap formulation.

Table 9. Antibacterial activity results

Sample	Concentration	Inhibition zone (mm)	Interpretation
F0	-	5.05	Inactive
Asepsol (control +)	-	23.0	Active
EDCB 50%	50%	27.3	Strongly active

Table 10. Skin irritation test results

Volunteer	Age	Observation
1	19	Non-irritating
2	21	Non-irritating
3	19	Non-irritating
4	25	Non-irritating
5	24	Non-irritating

Conclusion

The study successfully identified the local plant known as *Cocok Bubu* as *E. rostratum* (Blume) Hassk., a species belonging to the family Urticaceae. This scientific confirmation provides a reliable botanical foundation for its potential use in pharmaceutical and cosmetic applications. Extracts obtained from *E. rostratum* demonstrated significant antifungal activity against *Malassezia furfur*, the primary causative agent of dandruff. These results suggest that the bioactive compounds present in the plant possess strong potential as natural antifungal agents. The formulated anti-dandruff shampoo containing celery, ginger, and *E. rostratum* extracts exhibited good physical stability, acceptable pH, viscosity, foaming capacity, and homogeneity. The product also maintained its organoleptic properties throughout the storage period, indicating formulation stability. Furthermore, antifungal testing of the shampoo showed a clear inhibition zone comparable to that of commercial anti-dandruff formulations, confirming its effectiveness. The synergistic interaction among the natural extracts contributed to enhanced antifungal activity while maintaining eco-friendly and non-toxic characteristics. Overall, this research demonstrates that *E. rostratum* extract can be effectively utilized in natural anti-dandruff formulations, supporting the development of sustainable and green cosmetic innovations. Further studies involving compound isolation and penetration testing using Franz diffusion cell models are recommended to better understand the bioactive mechanisms and optimize formulation efficacy.

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Disclosure Statement

The authors declare that no conflicts of interest exist.

Authors' Contributions

All authors contributed to data analysis, drafting, and revising the article.

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References

- [1] Tyasningsih, W., Ramandinianto, S.C., Ansharieta, R., Witaningrum, A.M., Permatasari, D.A., Wardhana, D.K., Effendi, M.H., Ugbo, E.N. [Prevalence and antibiotic resistance of staphylococcus aureus and escherichia coli isolated from raw milk in east java, Indonesia](#). *Veterinary World*, **2022**, 15(8), 2021–2028.
- [2] Uddin, M.Z., Emran, T.B., Dutta, M., Ullah, S., Rana, S. [In vivo antidepressant, analgesic, anti-inflammatory activities, in vitro antioxidant and antibacterial potential of fractionated elatostema papillosum wed. extract](#). *Pharma Innovation Journal*, **2019**, 8, 241–246.
- [3] Vahidipour, H.R., Cheniany, M., Lahouti, M., Ganjeali, A., Matin, M.M. [The correlation of some secondary metabolites of alfalfa \(medicago sativa L.\) with plant organ and harvest time](#). *International Journal of Advanced Biological and Biomedical Research*, **2024**, 12(1), 28–43.
- [4] Yussuf, M.D., Samuel, A.O., Dayo, U., Abdul, S.O., Stanley, O.C., Okunade, A. [Lipophilic vitamins \(D and E\) and flavonoids \(quercetin and naringin\) attenuate the effects of dichlorvos toxicity on catalase activity](#). *International Journal of Advanced Biological and Biomedical Research*, **2014**, 12(1), 67–91.

- [5] Pranata, C., Irwanto, R. **Transparent soap formulation with various levels of concentration of teak leaf extract (*Tectona grandis* L.F.) as antibacterial soap.** *Jurnal Farmasimed (JFM)*, **2023**, 5(2), 192–197.
- [6] Khumaisah, L.L., Ayuningtias, R., Muharam, S., Mulyani, R., Awaliah, L. **Antibacterial activity against gram-positive and gram-negative bacteria and biolarvicide to aedes aegypti from cocok bubu (*elastostema rostratum* (blume) hassk) leaves extract.** *Jurnal Riset Kimia*, **2023**, 14(2), 158–166.
- [7] Modhugur Sathyanarayanan, P., Gollamudi, R., Rath, D., Panigrahi, S., Pratap Singh, L., Ranjan Kar, N., Kumar Sharma, R., Raj Ali, S., Kumar, A., Prasad Panigrahy, U. **Molecular mechanisms of polyphenols in skin cancer therapy: Advances and future perspectives.** *Journal of Chemical Reviews*, **2025**, 8(2), 180–213.
- [8] Handayani, P.A., Rizky Aditiya, D., Jannatin, O.A. **Production of liquid soap from virgin coconut oil with the active ingredient citronella oil.** *Saintekno : Jurnal Sains dan Teknologi*, **2023**, 21(1), 36–42.
- [9] Meizalin, A.A., Paramita, V. **Quality analysis of liquid soap formulation made from virgin coconut oil with addition of white tea extract.** *Journal of Vocational Studies on Applied Research*, **2021**, 3(2), 47–51.
- [10] Mulyani, R., Mulyadi, D., Ratnasari, J., Maulana, F. **Assessment of the quality of a shampoo formulation made from celery (*Apium graveolens*) and giant ginger (*Zingiber officinale* var. *Officinarium*).** *Rasayan Journal of Chemistry*, **2025**, 18(2), 832–841.
- [11] Mohebbipour, A., Amani, F., Ahmadi, A., Eghtedari, F. **Epidemiological study of lichen planus in ardabil province, northwest of Iran.** *Eurasian Journal of Science and Technology*, **2025**, 5(3), 252–261.
- [12] Yousefi, R. **Molecular docking study of rosmarinic acid and its analog compounds on sickle cell hemoglobin.** *Eurasian Journal of Science and Technology*, **2024**, 4(4), 303–330.
- [13] Gach, M.W., Lazarus, G., Simadibrata, D.M., Sinto, R., Saharman, Y.R., Limato, R., Nelwan, E.J., van Doorn, H.R., Karuniawati, A., Hamers, R.L. **Antimicrobial resistance among common bacterial pathogens in Indonesia: A systematic review.** *The Lancet Regional Health – Southeast Asia*, **2024**, 26, 100414.
- [14] Yousefi, R., Mokaramian, S. **The antibacterial potential of dillapional and scopoletin extracted from *Foeniculum vulgare*.** *Eurasian Journal of Science and Technology*, **2025**, 5(1), 34–42.
- [15] Vaeli, N. **Laboratory study of effective factors on how to extract carvacrol from *oliveria decumbens* plant with the help of supercritical fluid CO₂ and using ultrasound waves.** *Eurasian Journal of Science and Technology*, **2022**, 2(1), 34–45.
- [16] Halden, R.U. **On the need and speed of regulating triclosan and triclocarban in the United States.** *Environmental Science & Technology*, **2014**, 48(7), 3603–3611.
- [17] Awaliah, L. **Skrining fitokimia dan uji aktivitas antibakteri ekstrak daun cocok bubu (*Elatostema rostratum* (Blume) Hassk).** Undergraduate thesis, Universitas Muhammadiyah Sukabumi, **2020**.
- [18] Badan Standardisasi Nasional (BSN). **Sabun mandi padat (Solid bathing soap).** Jakarta, SNI 3532-2016, **2016**.
- [19] Omojate Godstime, C., Enwa Felix, O., Jewo Augustina, O., Eze Christopher, O. **Mechanisms of antimicrobial actions of phytochemicals against enteric pathogens—a review.** *Journal of Pharmaceutical, Chemical and Biological Sciences*, **2014**, 2(2), 77–85.
- [20] Byrd, A.L., Belkaid, Y., Segre, J.A. **The human skin microbiome.** *Nature Reviews Microbiology*, **2018**, 16(3), 143–155.
- [21] Pelczar, M.J., Chan, E.C.S., Krieg, N.R. **Microbiology: Concepts and applications (5th ed.).** New York, McGraw-Hill, **1999**.

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