



Formulation and Evaluation of Antibacterial Activity of Roll-On Deodorant Based on Arab Jujube Leaf Extract (*Ziziphus spina-christi* L.) against *Staphylococcus epidermidis*

Formulasi dan Evaluasi Aktivitas Antibakteri Deodoran Roll-On Berbasis Ekstrak Daun Bidara Arab (*Ziziphus spina-christi* L.) terhadap *Staphylococcus epidermidis*

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Abstract

This study aimed to develop a roll-on deodorant formulation based on Arab jujube leaf extract (*Ziziphus spina-christi* L.) and to evaluate its antibacterial activity against *Staphylococcus epidermidis*. The research methods included extraction of Arab jujube leaves using 70% ethanol, phytochemical screening to identify secondary metabolites, formulation of roll-on deodorant with varying extract concentrations, and evaluation of physical characteristics and antibacterial activity using the disc diffusion method. The results showed that the extract contained flavonoids, alkaloids, and saponins, which contribute to antibacterial effects. The formulation with the highest extract concentration produced the largest inhibition zone against *Staphylococcus epidermidis*, while maintaining stable and user-friendly physical properties. In conclusion, Arab jujube leaf extract is effective as a natural active ingredient in roll-on deodorants, providing an alternative herbal-based cosmetic product that is safe and efficient.

Abstrak

Penelitian ini bertujuan untuk mengembangkan formulasi deodoran roll-on berbahan dasar ekstrak daun bidara Arab (*Ziziphus spina-christi* L.) serta mengevaluasi aktivitas antibakterinya terhadap *Staphylococcus epidermidis*. Metode penelitian meliputi ekstraksi daun bidara Arab menggunakan etanol 70%, skrining fitokimia untuk mengidentifikasi kandungan metabolit sekunder, formulasi deodoran roll-on dengan variasi konsentrasi ekstrak, serta pengujian karakteristik fisik dan aktivitas antibakteri menggunakan metode difusi cakram. Hasil penelitian menunjukkan bahwa ekstrak daun bidara Arab mengandung senyawa flavonoid, alkaloid, dan saponin yang berperan dalam aktivitas antibakteri. Formulasi dengan konsentrasi ekstrak tertinggi menghasilkan zona hambat terbesar terhadap *Staphylococcus epidermidis* dengan tetap mempertahankan karakteristik fisik yang stabil dan nyaman digunakan. Berdasarkan hasil tersebut, ekstrak daun bidara Arab berpotensi dimanfaatkan sebagai bahan aktif alami dalam sediaan deodoran roll-on serta menjadi alternatif produk kosmetik berbasis herbal yang efektif dan aman.

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INTRODUCTION

Body odor is one of the most common personal care problems in society. It is caused by the interaction between excessive sweat and microorganisms on the skin, particularly *Staphylococcus epidermidis* bacteria.¹ The activity of eccrine and apocrine glands in the skin, especially in the underarm area, can produce high levels of moisture that create

ideal conditions for microbial growth. If not properly controlled, excessive sweat production may lead to the accumulation of bacterial metabolites that contribute to body odor and user discomfort. This condition often causes psychological distress, decreased self-confidence, and impaired social interaction. Therefore, addressing body odor through the use of topical preparations, such as deodorants, is an important strategy in daily personal hygiene.²

Deodorant is a cosmetic product designed to reduce or mask body odor by inhibiting microbial growth and decreasing sweat gland activity. This product can be formulated using either synthetic or herbal ingredients.³ Herbal ingredients have become increasingly popular because they are considered safe for the skin, environmentally friendly, and often contain bioactive compounds with additional functions, such as antioxidant and antibacterial activities.⁴ One promising herbal plant as an active ingredient in deodorant is Arabian bidara leaves (*Ziziphus spina-christi* L.), which have been widely recognized in traditional medicine in various countries, including Indonesia, India, and Malaysia, for treating skin diseases, diarrhea, fever, and beauty-related concerns.⁴

Arabian bidara leaves contain various secondary metabolite compounds, such as flavonoids, saponins, alkaloids, tannins, and terpenoids, which have antibacterial and antioxidant potential.⁵ These compounds are known to inhibit the growth of *Staphylococcus epidermidis*, one of the dominant bacteria found on human skin and frequently associated with body odor.⁶ Previous studies have shown that Arabian bidara leaf extract, both with 96% ethanol as a solvent and through maceration methods, can form inhibition zones against *S. epidermidis* at certain concentrations. However, its effectiveness varies depending on the dosage form, concentration, and testing method used.⁷

Although previous studies have demonstrated the antibacterial potential of Arabian bidara leaves, most of them have used dosage forms such as paper soap or ointment.⁸ The development of deodorant formulations, particularly in roll-on form, remains limited. Roll-on deodorant has advantages in the form of compact packaging that facilitates direct application to the skin, reduces the risk of spillage, and allows more precise dose regulation.⁹ In addition, the more fluid physical characteristics of roll-on deodorant enable even distribution, making it more comfortable to use while reducing sweat secretion and effectively inhibiting bacterial growth.¹⁰

The novelty of this study lies in the use of 70% ethanol as a solvent for extracting Arabian bidara leaves, which is more polar than 96% ethanol. A more polar solvent is capable of extracting more complex and diverse bioactive compounds while minimizing the risk of irritation on sensitive skin. This is important because deodorant products are applied directly to the underarm area, where the skin is relatively thin and prone to irritation.¹¹ Furthermore, this study evaluates formulations with different extract concentration variations, thereby allowing the identification of the optimal concentration that is effective as an antibacterial agent without reducing user comfort.¹²

This study also considers the safety and physical quality aspects of the preparation. Evaluation of organoleptic properties, pH, homogeneity, viscosity, and spreadability is an important indicator in determining whether the product is suitable for use and safe for human skin.¹³ Optimal physical characteristics not only influence user comfort but may also affect antibacterial effectiveness, since uneven distribution of the active ingredient can reduce inhibitory activity against bacteria.¹⁴ Thus, this study is designed to produce a roll-on deodorant preparation based on Arabian bidara leaves that is not only antibacterial in effectiveness but also safe and comfortable to use.¹⁵

Overall, this study has two main objectives: (1) to explore the antibacterial potential of Arabian bidara leaves against *Staphylococcus epidermidis*; and (2) to develop a roll-on deodorant preparation that is stable, safe, and effective. This study is expected to provide a scientific contribution to the development of herbal cosmetics, as well as to offer an alternative personal care product based on natural ingredients that is environmentally friendly and has minimal side effects. Through this study, the public may also gain greater awareness of the benefits of Arabian bidara leaves in the form of an easy-to-apply cosmetic preparation, thereby supporting healthier and safer personal hygiene practices.¹⁶

METHODS

Materials. This study used a set of standard laboratory instruments for the formulation and evaluation of deodorant preparations, including an analytical balance (Shimadzu, Japan), a pH meter (Hanna Instruments, model HI991001), a water bath (Mettler, Germany), a rotary evaporator (Buchi, Switzerland), an autoclave (Sanyo, Japan), dropper pipettes (Eppendorf, Germany), a glass mortar and pestle, and an Ostwald viscometer. The materials used included Arabian bidara leaf extract (*Ziziphus spina-christi* L.), carbopol, triethanolamine, propylene glycol, distilled water, fragrance, and a bacterial culture medium for *Staphylococcus epidermidis* in the form of Mueller Hinton Agar (MHA). All chemical materials were obtained from a standardized laboratory at the Mathematics and Natural Sciences

Laboratory Unit, UIN Siber Syekh Nurjati Cirebon, as attached on the final page, and were used in accordance with laboratory safety protocols.

Research Procedure. This study was designed as an experimental study focusing on the formulation and evaluation of a roll-on deodorant preparation based on Arabian bidara leaf extract, as well as the antibacterial activity test against *Staphylococcus epidermidis*. The research procedure consisted of the following stages:

Collection and Preparation of Simplicia

Arabian bidara leaves were collected from Klagenan Village, Klagenan District, Cirebon Regency, with a total weight of approximately 10 kg. The collected leaves were subjected to wet sorting to remove foreign particles, such as soil and small insects, and were then dried under sunlight for 2 to 3 days. After drying, the leaves were ground into powder and sieved using a 60-mesh sieve to obtain homogeneous simplicia.

Preparation of the Extract

A total of 500 g of simplicia powder was macerated with 2,500 mL of 70% ethanol in a closed glass container for 3 × 24 hours, with occasional stirring. The solution was filtered using filter paper, after which the solvent was evaporated using a rotary evaporator at 50°C to obtain a thick extract. The extract yield was calculated using the following equation:

$$\text{Yield (\%)} = \frac{\text{Extract Weight}}{\text{Simplicia Weight}} \times 100\%$$

Phytochemical Screening

The extract was tested for the presence of secondary metabolite compounds, including flavonoids, alkaloids, saponins, tannins, and terpenoids, using standard color reaction and precipitation methods.¹⁷

Formulation of the Roll-On Deodorant Preparation

Arabian bidara leaf extract was formulated into a roll-on preparation with three different concentrations: F1 (5 g), F2 (15 g), and F3 (20 g). The thickening agent, namely carbopol, the pH neutralizer, namely triethanolamine, the solvents, namely propylene glycol and distilled water, and fragrance were added according to the formulation procedure. The mixture was stirred until homogeneous and then transferred into roll-on containers.

Table 1. Formulation of the Roll-On Deodorant Preparation

No.	Formulation	Function	Control	F1	F2	F3
1	Arabian bidara leaf extract	Active ingredient	(-)	5 g	15 g	20 g
2	Carbopol	Thickening agent	1 g	1 g	1 g	1 g
3	Triethanolamine	pH neutralizer	0.25 g	0.25 g	0.25 g	0.25 g
4	Propylene glycol	Solvent	15 g	15 g	15 g	15 g
5	Distilled water	Solvent	q.s. ad 100	q.s. ad 100	q.s. ad 100	q.s. ad 100

Evaluation of the Preparation

The preparation was evaluated for its organoleptic properties, including color, odor, and physical form, as well as pH, homogeneity, viscosity, and spreadability in accordance with cosmetic preparation standards. The organoleptic test was conducted through visual and sensory observation. The pH was measured using a pH meter, homogeneity was observed on a glass slide, viscosity was measured using an Ostwald viscometer, and spreadability was tested using the graded-load method on a Petri dish.¹⁸

Antibacterial Activity Test

The antibacterial activity test was conducted using the disk diffusion method against *Staphylococcus epidermidis*. The bacterial suspension was prepared according to the McFarland standard and inoculated onto Mueller Hinton Agar (MHA) medium. Paper disks that had been soaked in the deodorant extract were then placed on the surface of the medium. Incubation was carried out for 24 hours at 37°C, and the inhibition zones were measured vertically and horizontally.¹⁹ After incubation, the inhibition zones formed were measured using a vernier caliper in vertical (Dv) and horizontal (DH) directions. The disk diameter (Dc) was subtracted from the measurement results, and the mean inhibition zone was calculated using the following equation:

$$\text{Inhibition zone} = \frac{(DV - Dc) + (DH - DC)}{2}$$

Notes:

DC: Disk diameter

DV: Vertical diameter of the inhibition zone

DH: Horizontal diameter of the inhibition zone

Data Analysis

The data obtained from the preparation evaluation, including pH, viscosity, spreadability, and antibacterial inhibition zones, were analyzed descriptively. The mean values and standard deviations were calculated from three replications for each parameter. The interpretation of the results focused on the effectiveness of the preparation in inhibiting the growth of *S. epidermidis*, its physical stability, and the relationship between extract concentration and antibacterial activity. These results were used to determine the optimal formulation of the Arabian bidara leaf-based roll-on deodorant.

RESULT AND DISCUSSION

Extract Yield of Arabian Bidara Leaves

The extraction of Arabian bidara leaves using 70% ethanol produced a yield of 15.2%, indicating that 76 g of thick extract was obtained from 500 g of simplicia. This yield reflects the efficiency of the maceration method in extracting polar and semi-polar compounds with potential antibacterial activity.²⁰

The yield value was relatively high compared with previous studies using 96% ethanol, indicating that 70% ethanol was able to extract a greater amount of bioactive compounds and was more skin-friendly. This finding supports the objective of the study, namely to obtain a deodorant preparation that is safe and effective.²¹

Phytochemical Screening

The extract was tested for the presence of secondary metabolites. The screening results are presented in Table 2.

Table 2. Phytochemical screening results of Arabian bidara leaf extract

Compound	Result	Conclusion
Flavonoids	Positive	Supports antibacterial activity
Alkaloids	Positive	Supports antibacterial activity
Saponins	Positive	Supports antibacterial activity
Tannins	Negative	Not detected
Terpenoids	Negative	Not detected

The presence of flavonoids, alkaloids, and saponins supports the antibacterial potential of the extract, in accordance with the target of developing a roll-on deodorant preparation. These compounds may work by damaging bacterial cell membranes or inhibiting bacterial metabolism.²²

Formulation of the Roll-On Deodorant Preparation

The evaluation was conducted on four formulas, namely F0 as the control, F1, F2, and F3. The most significant results were shown in three main parameters: pH, viscosity, and spreadability.

Evaluation of the Roll-On Deodorant Preparation

The evaluation was conducted on four formulas, namely F0 as the control, F1, F2, and F3. The most significant results were shown in three main parameters: pH, viscosity, and spreadability.

Table 3. Evaluation of pH, viscosity, and spreadability of the preparation

Formula	pH	Viscosity (P)	Spreadability (cm)
F0	4.73	38.37	6.6
F1	5.14	14.70	6.83
F2	4.86	2.21	6.73
F3	4.97	1.80	6.93

Notes:

1. The pH of the preparations was within the safe range for the skin, namely 4.5 to 5.5, thereby reducing the risk of irritation.
2. Viscosity decreased as the extract concentration increased, resulting in a more fluid preparation in F2 and F3, which may influence spreadability.
3. F3 showed the highest spreadability, indicating that a higher extract concentration improved the ability of the preparation to spread on the skin.

Antibacterial Activity Test

The inhibition zones against *Staphylococcus epidermidis* are presented in Table 4.

Table 4. Antibacterial inhibition zones of the roll-on deodorant preparation

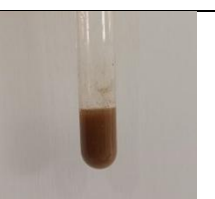
Formula	Replication 1 (mm)	Replication 2 (mm)	Replication 3 (mm)	Mean inhibition zone (mm)
F0	0	0	0	0
F1	6.2	8.2	8.6	7.2
F2	7.8	10.85	10.05	9.5
F3	8.8	11.1	13.05	10.9
Positive control	5.95	5.65	6.25	5.95

Notes:

1. F3, with the highest extract concentration, demonstrated the best antibacterial activity, even exceeding the positive control.
2. The inhibition zone increased with increasing extract concentration, indicating a dose-response relationship.
3. These results indicate the potential of Arabian bidara leaf extract as a natural active ingredient for antibacterial deodorant products.

Phytochemical Screening Results of Arabian Bidara Leaf Extract

Table 5. Secondary metabolite compounds

Phytochemical compound	Criterion	Observation result	Conclusion
Flavonoids	A yellow color was formed without ring formation		Positive
Alkaloids	An orange-brown precipitate was formed		Positive
Saponins	Foam was formed		Positive
Tannins	A bluish-black precipitate was formed		Positive

Terpenoids	A brown ring was formed between the two liquid layers		Positive
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Notes:

1. The extract showed positive results for flavonoids, alkaloids, and saponins, which support its antibacterial potential against *Staphylococcus epidermidis* and its antioxidant activity.
2. Tannins and terpenoids were negative, possibly due to degradation during drying, exposure to heat or light, the limited sensitivity of the test method, or low compound levels resulting from the age of the leaves at the time of sample collection.
3. The characteristic odor of Arabian bidara leaves confirmed the authenticity of the sample.
4. Overall, this phytochemical profile supports the use of Arabian bidara leaf extract as an active ingredient in roll-on deodorant formulations, with sufficient bioactive compound content to provide antibacterial and antioxidant effects.

Limitation

This study has several limitations that should be considered when interpreting the findings. The antibacterial activity test was limited to *Staphylococcus epidermidis*, although body odor may also involve other microorganisms; therefore, the antibacterial effectiveness of the formulation cannot be generalized to all bacteria associated with body odor formation. In addition, the antibacterial test was conducted using the disk diffusion method under in vitro laboratory conditions, which does not fully represent actual underarm skin conditions, where sweat production, skin temperature, friction, skin microbiota balance, and product contact duration may influence deodorant performance. This study also evaluated only selected physical characteristics of the roll-on deodorant preparation, including organoleptic properties, pH, homogeneity, viscosity, and spreadability, without conducting long-term stability testing, accelerated stability testing, storage stability testing, microbial contamination testing, irritation testing, or user acceptability assessment. Furthermore, the extract was not standardized based on the quantitative levels of its active compounds, since phytochemical screening only provided qualitative information on the presence of secondary metabolites such as flavonoids, alkaloids, and saponins. The plant material was also obtained from one specific location, namely Klenganan Village, Cirebon Regency, so variations in soil condition, climate, leaf maturity, harvesting time, and drying process may influence the chemical composition of the extract. Despite these limitations, this study provides preliminary evidence that Arabian bidara leaf extract has potential as a natural active ingredient in roll-on deodorant formulations, although further studies involving broader antibacterial testing, standardized extraction, long-term stability evaluation, irritation testing, and user acceptability assessment are needed to support its development as a safe and effective herbal cosmetic product.

CONCLUSION

This study demonstrates that Arabian bidara leaf extract can be formulated into a roll-on deodorant with stable physical characteristics and good user comfort. The formulation with the highest extract concentration produced the most effective antibacterial activity against *Staphylococcus epidermidis*. These findings support the hypothesis that Arabian bidara leaf extract can serve as a natural active ingredient in a deodorant preparation that is safe and effective.

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Author Contribution Statement

The author was responsible for the conceptualization of the study, research design, preparation of plant materials, extraction process, formulation of the roll-on deodorant preparation, laboratory evaluation, antibacterial activity testing, data analysis, and manuscript preparation. The academic supervisors contributed to research guidance, methodological supervision, critical review, and revision of the manuscript to ensure scientific accuracy and academic quality.

Conflict of Interest Declaration

The author declares that there is no conflict of interest related to this research. The study was conducted objectively, and no financial, personal, institutional, or commercial interests influenced the research design, data collection, analysis, interpretation, or manuscript preparation.

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