BIOMA: Berkala Ilmiah Biologi

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Effectiveness test of red shoot leaf extract (*Syzygium myrtifolium* Walp.) as a natural antiperspirant in inhibiting sweat production and the growth *of Pseudomonas aeruginosa* bacteria that cause body odor

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A B S T R A C T

Body odor is a problem caused by the activity of microorganisms, one of which is *the Pseudomonas aeruginosa bacteria* by metabolizing sweat released by the body. The use of antiperspirant products is thought to reduce sweat production and bacterial decay . However, antiperspirants available in the market contain active chemicals that can cause irritation so it is necessary to use plant extracts as an alternative preparation of natural antiperspirant products. This study aims to determine the effectiveness of natural antiperspirant extracts of red shoot leaves (*Syzygium myrtifolium* Walp.) in inhibiting the growth of *Pseudomonas aeruginosa bacteria* that cause body odor. The method used is descriptive quantitative with parameters of simplicia and extract yield tests, extract characteristics, phytochemical screening, antibacterial effectiveness of extracts, physical quality tests of antiperspirants, antiperspirant effectiveness and Scanning Electron Microscope (SEM). The results of the study showed that the red shoot leaf extract meets the general standards of medicinal plant extracts and contains secondary metabolite compounds that are able to inhibit the growth of *Pseudomonas aeruginosa bacteria* with the formulated product producing suitable characteristics as an antiperspirant that is able to inhibit sweat production and the growth *of Pseudomonas aeruginosa bacteria* which is supported visually by Scanning Electron Microscope (SEM). Based on the results obtained, it is known that the natural antiperspirant red shoot leaf extract (*Syzygium myrtifolium* Walp.) has antibacterial effectiveness against *Pseudomonas aeruginosa* . Thus, the use of natural ingredients can be a solution to overcome the causes of body odor and reduce the use of conventional antiperspirant products that contain chemicals that are harmful to health.

Keywords: Red shoot leaf extract; Antiperspirant; *Pseudomonas aeruginosa*

1. INTRODUCTION

Body odor is a common problem experienced by humans in everyday life. Body odor, or in medical terms, bromhidrosis, is a condition characterized by excessive body odor. Body odor occurs when sweat is metabolized by bacteria, producing a rancid, musty, and sour odor. A survey conducted by the International Hyperhidrosis Society (2022) reported that more than 90% of respondents felt embarrassed, lacked confidence, or avoided social activities due to excessive body odor. In Indonesia, data from the Ministry of Health (2023) shows that around 65% of adolescents experience body odor, especially during puberty, due to increased apocrine gland activity. This unpleasant odor usually appears when a person begins to sweat (Anggraini, 2024).

Pseudomonas aeruginosa is one of the causes of body odor. This bacterium produces enzymes such as lipase and protease, which can break down proteins and fats in sweat. These enzymes can break down sweat components into odorous compounds. Unlike other skin bacteria, which are considered normal flora, *Pseudomonas aeruginosa* is an opportunistic pathogen that exploits impaired host defense mechanisms to trigger infections. This bacterium is resistant to various environmental conditions, including chemicals, making it suitable for testing the antimicrobial effectiveness of natural ingredients. (Nurfalah, 2023).

Some plants, such as red shoots (*Syzygium myrtifolium* Walp.), are known to have antibacterial potential due to their phytochemical content, including alkaloids, flavonoids, saponins, and tannins. This plant also has

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Received: 1 July 2025, **Accepted:** 6 October 2025
Cite this article as: Arnita et al., (2026) *BIOMA: Berkala Ilmiah Biologi*, 28(1): 1 - 16

pharmacological activity that can be used as active antioxidant compounds, antibacterials, antifungals, antivirals, astringents, and anti-inflammatory agents. These phytochemical compounds play a role in inhibiting bacterial growth and helping reduce excessive sweat production, although specific research on their effectiveness in inhibiting *Pseudomonas bacteria is still lacking. aeruginosa* has never been tested. Furthermore, red shoot leaf extract (*Syzygium myrtifolium* Walp.) has never been specifically formulated into an antiperspirant product, thus opening up new opportunities for developing safer and more environmentally friendly natural-based body care products (Anjelin, 2023).

With these properties, red shoot leaf extract has the potential to be used as a safe and skin-friendly alternative active ingredient in natural antiperspirant products.

Antiperspirants are products that can reduce sweat production by inhibiting sweat ducts and bacterial decomposition, thereby controlling body odor. However, antiperspirants on the market generally contain active ingredients such as aluminum chlorohydrate, propylene glycol, triclosan, aluminum zirconium chlorohydrate, and others, which can cause irritation if used frequently on the skin. As an alternative, the use of plant extracts with antibacterial properties may provide a better solution (Chandra, 2023).

Limited research on the antibacterial activity of red shoot leaf extract (*Syzygium myrtifolium* Walp.) against bacteria that cause body odor and the absence of antiperspirant products that utilize this ingredient, makes this research important to be conducted as a solution to overcome body odor and reduce the use of conventional antiperspirant products. Therefore, this study aims to determine the effectiveness of red shoot leaf extract (*Syzygium myrtifolium* Walp.) as a natural antiperspirant in inhibiting sweat production and the growth of *Pseudomonas aeruginosa bacteria* that cause body odor. The results of this study are expected to add new knowledge about the potential of local plants that have antibacterial properties for the development of environmentally friendly and sustainable natural products.

2. MATERIAL AND METHODS

This study was conducted in February–June 2025 with a laboratory-based quantitative descriptive method to systematically describe the characteristics through controlled observations and measurements, using a Completely Randomized Design (CRD) chosen because it is appropriate to homogeneous environmental conditions with 5 different extract treatments, namely 10%, 20%, 30%, 40%, and 50% with 4 repetitions. The concentrations represent a gradual range from low to high to determine at what concentration the extract begins to show significant antibacterial activity or antiperspirant effects. Then, the two best concentrations were incorporated into the antiperspirant product formulation and one of the most effective product concentrations was tested for further testing.

2.1 Study area

This research was conducted in several locations, including the Medanense Herbarium Laboratory, Faculty of Mathematics and Natural Sciences, University of North Sumatra. Natural Organic Chemistry Laboratory, Padang Bulan, Medan Baru Regency, North Sumatra. Industrial Chemical Technology Polytechnic Development Laboratory, Jl. Medan Tenggara VII Medan, North Sumatra. Microbiology Laboratory of the State Islamic University of North Sumatra, Jl. Golf Course, Tuntugan II, Medan Tuntungan Regency, North Sumatra.

2.2 Tools and materials

The tools used in this research include Biosafety Cabinets, Glass Jars, Analytical Scales, Stirring Rods, Measuring Cups, Test Tubes, Spuid Needles, Dropper Pipettes, Erlenmeyer, Ovens, Autoclaves, Bunsen, Ose Needles, Hotplates, Plastic Warp, Freezers, Incubators, Object Glasses, Cover Glasses, Microscopes, Petri Dishes, Vernier Calipers, Spray Bottles, Magnetic Stirrers, Beakers, pH Meters. The materials used include red shoot leaves (*Syzygium myrtifolium* Walp.), water, 70% ethanol, NaOH, disc paper, cotton, aluminum foil, plastic warp, mica plastic, Nutrient Agar (NA) media, Muellen Hiton Agar (MHA) media, distilled water, *Pseudomonas aeruginosa*

bacteria, amoxicillin, DMSO, propyl paraben, isopropyl alcohol, glycerin, menthol, Tween 80, Perspirex, assessment blank, pH buffer, and cotton buds.

2.3 Extraction procedure

The extraction process begins with the identification of red shoot leaves (*Syzygium myrtifolium* Walp.) to ensure authenticity and species suitability. Then, a simple preparation was performed using 10 kg of fresh red shoot leaves that had been sorted, washed, and air-dried for 7 days. The yield of this simple preparation was then calculated using the following formula. A good yield value is greater than 10% (Wardaningrum, 2019).

$$\text{Simplex result} = \frac{(\text{dry weight of simple drugs (g)})}{(\text{fresh simplicia weight (g)})} \text{ x } 100\% \quad (1)$$

Next, 800 grams of red bamboo shoot leaf extract was extracted using 70% ethanol for 24 hours using the maceration method. The resulting filtrate was concentrated using a rotary evaporator and evaporated over a water bath to obtain a thick extract (Syafriana, 2022).

The extract yield percentage is calculated using the following formula. The yield of the thick extract must be more than 10% (Ministry of Health of the Republic of Indonesia, 2017).

$$\text{Extract Result} = \frac{(\text{weight of the extract obtained(g)})}{(\text{weight of extracted simplex(g)})} \text{ x } 100\% \quad (2)$$

2.4 Extract characteristics

This test was conducted at the Industrial Chemical Technology Polytechnic Development Laboratory which included organoleptic tests, drying loss, determination of ash content, ethanol and water solubility tests (Ministry of Health of the Republic of Indonesia, 2000).

1. Organoleptic testing is carried out by describing the shape, smell and color .
2. Loss on drying, as much as 1–2 g of extract is weighed into a heated weighing bottle, leveled, then dried at 105°C to a constant weight and calculated.

$$\text{Drying Shrinkage Rate} = \frac{\text{Initial sample weight} - \text{Final sample weight}}{\text{Initial sample weight}} \; x \; 100\% \quad (3)$$

3. To determine the ash content, 2–3 g of the extract is placed in a silicate crucible, heated, and tared, then weighed. The ash content is calculated on a dry matter basis.

$$\text{Total ash content} = \frac{\text{Ash weight} + \text{Constant rate} - \text{Constant rate}}{\text{Extract weight}} \; x \; 100\% \quad (4)$$

4. Ethanol soluble extract content: 5 g of extract was macerated with 100 ml of 95% ethanol for 24 hours, filtered, then 20 ml of the filtrate was evaporated and heated at 105°C until it reached a constant weight. The extract content was calculated as a percentage of the initial extract weight.

$$\text{Essence content in ethanol} = \frac{\text{Bottle weight} + \text{sample} - \text{Empty bottle weight}}{\text{Sample weight}} \; x \; 10 \; x \; 100\% \quad (5)$$

5. Contents: 1 g of extract is weighed in a container, dried at 105°C for 5 hours, and then weighed. Drying is continued every hour until the weight difference is less than 0.25%, and then the water content is calculated.

$$\text{Water content} = \frac{\text{Sample weight} - \text{Sample weight after drying}}{\text{Sample weight}} \; x \; 100 \quad (6)$$

Next, a phytochemical screening test was conducted to detect secondary metabolites in the red shoot leaf extract, such as alkaloids, flavonoids, saponins, tannins, and other bioactive compounds that play a role in antibacterial activity. This test was conducted at the Natural Materials Organic Chemistry Laboratory at the

University of North Sumatra to examine the compounds contained in the red shoot leaves, generally alkaloids, flavonoids, steroids, tannins, and saponins (Syafriana, 2022).

2.5 Testing the effectiveness of red pucuk leaf extract (*Syzygium myrtifolium* Walp.) against *Pseudomonas aeruginosa bacteria*

Antibacterial activity testing began with sterilization of equipment using an oven (160°C, 45 minutes) and a flame for the loop, as well as sterilization of NA and MHA media using an autoclave (121°C/15 minutes). After that, *Pseudomonas aeruginosa was subcultured* on NA media and incubated for 24 hours at 37°C to obtain pure colonies. Colonies were then tested by Gram staining to confirm bacterial morphology. To standardize bacterial density, a 0.5 McFarland solution was prepared from a mixture of 1% $BaCl_2$ and 1% H_2SO_4, then homogenized, then the colonies were suspended and their turbidity adjusted before being used in the antibacterial test. Antibacterial effectiveness testing was carried out by the disc diffusion method at extract concentrations of 10%, 20%, 30%, 40%, and 50%. In the solidified media, bacteria were suspended using cotton. Then, paper discs were dipped into each concentration and control and placed on the surface of the media. The paper discs were incubated at 37°C for 24 hours, and the resulting inhibition zones were measured (Sari, 2018). The calculation of the inhibition zone is carried out using the following formula (Fadhillah, 2019):

$$\text{Inhibition zone (mm)} = \frac{\left((Dv - Dc) + (Dh - Dc)\right)}{2} \quad (7)$$

Where Dv is vertical diameter of clear zone (mm), Dh is horizontal diameter of clear zone (mm), and Dc is diameter of disc paper (mm). The results of the average inhibition zone diameter for each treatment were then compared with the David Stout standard inhibition zone and the Pharmacopoeia IV edition.

2. 6 Natural antiperspirant product formulations from red shoot leaf extract (*Syzygium myrtifolium* Walp.)

Antiperspirant was made with 2 extract formulations based on 2 effective concentrations of extract effectiveness test results and negative control without extract. The formulated product was tested for its effectiveness against *Pseudomonas aeruginosa bacteria* using the disc diffusion method to observe the inhibition zone as an indicator of the effectiveness of the antimicrobial compound (Rollando, 2019). *Pseudomonas aeruginosa bacteria* were inoculated on MHA media using the swab method. The disc paper was dipped into the antiperspirant preparation according to the concentration with good extract effectiveness, the positive control using a conventional product, and the negative control using a base product without extract, then incubated at 37°C/24 hours and the inhibition zone formed was measured (Huzaemah, 2024).

Table 1. Antiperspirant preparation formula (Kurniawan, 2023)

Material	Dosage Formula		
	F1	**F2**	**K-**
Red shoot leaf extract	X	X	0%
NaOH	0.004 grams	0.004 grams	0.004 grams
Phenoxyethanol	0.1 gram	0.1 gram	0.1 gram
Isopropyl Alcohol	5 ml	5 ml	5 ml
Glycerin	2 ml	2 ml	2 ml
Menthol	1 gram	1 gram	1 gram
Tween 80	4 ml	4 ml	4 ml
Aquadest	100	100	100

2.7 Physical quality test of antiperspirant preparations

This test includes organoleptic tests by observing the shape, color, and aroma using the five senses, then pH tests by measuring the preparation using a calibrated pH meter, viscosity tests using an Oswald viscometer using a standard water liquid comparator (0.8904 Cp), homogeneity tests by spraying the preparation on an object glass, leveling it and observing it visually, spray spreadability tests by spraying the preparation on mica plastic from a distance of ±5 cm then measuring it, and irritation tests by spraying the preparation on the armpits of panelists who have given informed consent before participating and observing skin reactions after 15 minutes to determine the presence of irritation.

2.8 Testing the effectiveness of natural antiperspirant extract from red pucuk leaves (*Syzygium myrtifolium* Walp.)

The antiperspirant test was conducted on 20 panelists. All panelists were fully explained the purpose and procedure of the test and volunteered to participate. Cotton swabs were weighed before and after being applied to the panelists' underarms for one hour, with antiperspirant applied to the right side and untreated to the left side. Results were calculated using the following formula (Mahmudah, 2023).

$$\text{Percentage (\%)} = \frac{(\text{Final value} - \text{Initial value})}{(\text{Final score})} \text{ x } 100\% \quad (8)$$

where Initial value is weight of cotton before application and Final value is weight of cotton after application.

2.9 Data analysis

The research data consisted of evaluation of red shoot leaf extract (*Syzygium myrtifolium* Walp.) which was directly observed for measurement and calculation. Then, the effectiveness data of red shoot leaf extract was analyzed statistically by first conducting a data normality test (Shapiro-Wilk) and a data homogeneity test (Levene's Test), followed by a One-Way ANOVA (ANOVA) test using the SPSS 20 program by comparing the results of the inhibitory power test against *Pseudomonas aeruginosa bacteria.* Significant differences ($p < 0.05$) in the ANOVA results were further analyzed using the Duncan test to determine the most influential treatment (Hamka, 2024).

3. RESULTS AND DISCUSSION

3.1 Effectiveness of red pucuk leaf extract (*Syzygium myrtifolium* Walp.) aainst *Pseudomonas aeruginosa bacteria*

Based on the identification results, the effectiveness test of red shoot leaf extract (*Syzygium myrtifolium* Walp.) against *Pseudomonas aeruginosa bacteria* using five variations of extract concentrations obtained the following results.

Table 2. Effectiveness test data of red pucuk leaf extract (*Syzygium myrtifolium* Walp.) against *Pseudomonas aeruginosa bacteria*

Concentration (%)	Bacterial Inhibition Zone *Pseudomonas aeruginosa bacteria*				Average Inhibition Zone	Criteria
	U1	U2	U3	U4		
Control (+)	23.5 mm	17 mm	21 mm	14 mm	18.8	Strong
Control (-)	0 mm	0 mm	0 mm	0 mm	0 mm	No activity
10%	14.5 mm	13.75 mm	13.3 mm	14 mm	13.8 mm	Strong
20%	16.65 mm	15.25 mm	13.8 mm	14.8 mm	15.1 mm	Strong
30%	16 mm	14.85 mm	14.85 mm	14 mm	14.9 mm	Strong
40%	17.75 mm	14.75 mm	14.5 mm	15 mm	15.5 mm	Strong
50%	17 mm	16.5 mm	14.75 mm	15.5 mm	15.9 mm	Strong

Note: Positive Control (+) : Amoxicillin**,** Negative Control (-) : DMSO**.** Red Shoot Leaf Extract (*Syzygium myrtifolium* Walp.): Concentrations 10%, 20%, 30%, 40%, 50%

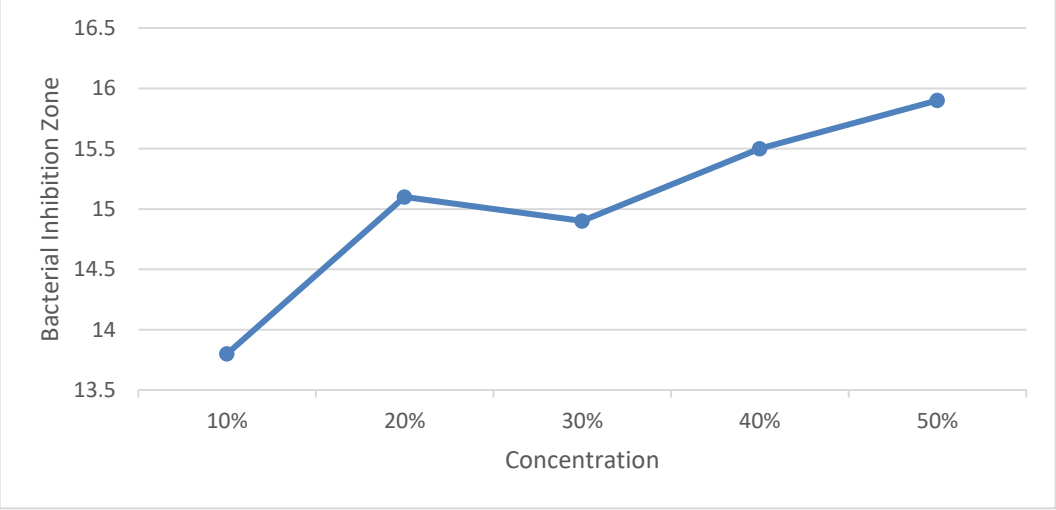

Figure 1. Graph of the inhibition zone of red pucuk leaf extract (*Syzygium myrtifolium* Walp.) against *Pseudomonas aeruginosa bacteria*

The inhibition zones of the five extract concentrations showed relatively increased and stable results, although the increase in concentration was not in line with the increase in the inhibition zone. In general, the higher the concentration, the larger the inhibition zone formed, although a potential decrease at some concentrations can occur. The increase in the inhibition zone at concentrations of 10% and 20% indicates that increasing concentration is followed by an increase in antibacterial activity. However, at a concentration of 30%, there was a decrease in the inhibition zone, possibly due to the aggregation of active compounds, so that the diffusion of compounds into the

agar medium was slightly hampered. Then at concentrations of 40% and 50%, the higher increase in the amount of active compounds was able to overcome the diffusion barrier, so that the inhibition zone increased again. This is in line with research by Elifah (2010), Ambarwati (2007), and Noor (2006) which found that the diameter of the inhibition zone does not always increase with increasing extract concentration, this occurs because of differences in the diffusion speed of antibacterial compounds in agar media as well as differences in the type and concentration of antibacterial compounds (Dianah, 2020).

In this study, the tested extract concentrations showed a strong inhibition zone against *Pseudomonas aeruginosa* based on David Stout's inhibition zone criteria. Meanwhile, the Indonesian Pharmacopoeia, IV edition (1995), stipulates that the effective inhibition zone is in the range of 14 mm - 16 mm. When compared to this standard, a concentration of 10% with an average inhibition zone of 13.8 mm almost meets the effectiveness limit, but is still below the established standard. In contrast, concentrations of 20%, 30%, 40%, and 50% are categorized as effective according to the Pharmacopoeia. Increasing the concentration did not show a very significant difference in the size of the inhibition zone, meaning that after a concentration of 20%, increasing the dose of the substance no longer produces a significant difference in antibacterial activity. Therefore, the selection of extract concentrations of 30% and 40% is the basis for optimal selection and has met the effectiveness standards, in order to reduce excessive use of active ingredients without significantly increasing their benefits.

The data obtained were then analyzed using an ANOVA table. The results of the data analysis showed a significance value of 0.000 ($p < 0.05$), indicating effectiveness and significant differences between treatments in the bacterial inhibition zone. Based on these results, a Duncan Advanced Test was conducted, with the following results.

Table 3. Duncan's advanced test data with bacterial inhibition zone against red shoot leaf extract (*Syzygium myrtifolium* Walp.)

Treatment	Average
Negative Control	$0.00 \pm 0.00^{\text{per year}}$
10%	13.88 ± 0.50^{b}
20%	15.12 ± 1.18^{b}
30%	14.92 ± 0.82^{b}
40%	15.5 ± 0.51^{b}
50%	15.93 ± 1.00^{b}
Positive Control	18.87 ± 4.21^{c}

Note: Data is the result of LSD testing. Data with different notations show significant differences ($P > 0.05$). Data taken from the results of the red shoot leaf extract test (*Syzygium myrtifolium* Walp.)

From the analyzed data, the results of Duncan's further test showed that the negative control group and the positive control group had an average inhibition zone value that was significantly different from the other groups. This was because the negative control using DMSO did not have antibacterial properties while the positive control Amoxicillin had high antibacterial properties. Then in the groups with extract concentrations of 10%, 20%, 30%, 40%, and 50% there was no significant difference, this was because the maximum effectiveness of the extract had been achieved at low concentrations so that increasing the extract concentration no longer provided an increase in the inhibition zone with a significant difference. Although there were variations in the average inhibition zone, the differences between concentrations were not statistically significant. This indicates that all concentrations are quite

effective, so that in selecting the formulation, material efficiency, stability, and product safety can be considered without reducing antibacterial effectiveness.

To support the effectiveness test of red shoot leaf extract (*Syzygium myrtifolium* Walp.) against the growth of *Pseudomonas aeruginosa bacteria*, plant identification was carried out to ensure the sample came from *the Syzygium myrtifolium* Walp species. The identification results showed that this type of plant is red shoot (*Syzygium myrtifolium* Walp.). Red shoot (*Syzygium myrtifolium* Walp.) is a type of shrub whose leaves usually change color. When they first grow, the color will be bright red, then change to brown, then change again to green (Cambaba, 2022).

The identified leaves were then processed into herbal medicine and extracted. The resulting 2,000 grams of herbal medicine powder had a yield of 20%. This result aligns with research by Wardaningrum (2019), which found that a good yield is greater than 10%. The higher the yield, the higher the concentration of substances attracted to the raw material. Furthermore, 800 grams of herbal medicine extracted with 70% ethanol produced a yield of 27.31%. According to the Indonesian Herbal Pharmacopoeia, Edition II, 2017, the yield of thick extract should not be less than 10%. The higher the yield, the more chemical compounds are attracted.

3.2 Characteristics of red shoot leaf extract (*Syzygium myrtifolium* Walp.)

The resulting extract was then further tested through specific and non-specific characteristic analyses to ensure its quality, stability, and safety. The resulting extract had a thick texture, dark brown color, and the distinctive aroma of red shoot leaves (*Syzygium myrtifolium* Walp.).

Figure 2. Organoleptic results of red pucuk leaf extract (*Syzygium myrtifolium* Walp.)

In addition, the results of non-specific testing showed that the test parameters were still within the limits according to the Indonesian Herbal Pharmacopoeia standards, so that the extract was declared to meet the applicable quality requirements.

Table 4. Characteristics of red pucuk leaf extract (*Syzygium myrtifolium* Walp.)

Parameter	Sign (%)	Standard (%)
Loss Due to Drying	8.387	≤10
Level Ash Total	5.1271	≤10
Level Sari Late Ethanol	25.4705	≥8
Level Water	10.0696	≤10

The drying loss results met the Ministry of Health (Kemenkes) 2000 standards, indicating good extract stability and shelf life. A drying loss value that is too high (≥10%) indicates excessive water content and can trigger growth (Farha, 2022). The low ash content also met the standards, indicating extract purity because it contains only a small amount of minerals (Sambode, 2022). Furthermore, the ethanol-soluble extract parameter of ≥8% indicated a high amount of soluble active compounds, which was influenced by the soaking time (Krisayadi, 2024). Meanwhile, the water content that slightly exceeded the standard (0.06%) was still within the appropriate range, taking into account variations that may occur during the extraction and drying processes.

Furthermore, the results of phytochemical screening aimed at detecting secondary metabolite compounds contained in red shoot leaf extract were obtained as follows.

Table 5. Phytochemical screening results of red pucuk leaf extract (*Syzygium myrtifolium* Walp.)

Reagent		Red Shoot Leaf Extract	Information
Alkaloid	Bouchardart	+	Brick Red Sediment
	Maeyer	+	Yellowish White Sediment
	Dragendorf	-	No Orange Deposit
Flavonoid	FeCl3	+	Black Colloid
	Mg+HCl	-	Doesn't Turn Pink
	NaoH 10%	+	Brownish Yellow Solution
Terpenoid	Liebermann-Bouchard	+	Blue-Green Solution
	Salkowsky	+	Red Solution
Steroid	Liebermann-Bouchard	+	Blue-Green Solution
	Salkowsky	+	Red Solution
Saponin	Aquadest	-	No Foaming
Tannin	FeCl3	+	Black Colloid

Several secondary metabolites such as alkaloids, flavonoids, steroids, triterpenoids, saponins, and tannins are used as antibacterial agents. The mechanism of action of alkaloids is by inhibiting the formation of peptidoglycan in the bacterial wall by nitrogen compounds in alkaloids and inhibiting the topoisomerase enzyme in protein synthesis, thus causing bacteria to experience lysis (rupture or damage to the cell membrane in bacteria that causes the release of bacterial cell organelles). The mechanism of action of flavonoids is that the OH compounds contained in flavonoids disrupt the peptidoglycan component in bacterial cells so that the wall layer does not form properly and causes bacterial cell death. The mechanism of action of steroids and terpenoids is by damaging the bacterial cell membrane by increasing cell permeability, resulting in cell leakage followed by the release of intracellular material. The mechanism of action of tannins is by inactivating bacterial cell adhesion and inactivating enzymes, as well as disrupting protein transport in the inner layer of the cell. Tannins damage cell

wall polypeptides so that bacterial cell wall formation becomes imperfect, thus causing bacterial cells to experience lysis (Nurjannah, 2022).

3.2 Gram staining *of Pseudomonas aeruginosa bacteria*

To support the analysis of antibacterial potential, Gram staining was also performed on the test bacteria to determine the basic characteristics of their cell walls. The Gram stain results indicated that *Pseudomonas aeruginosa* is gram-negative.

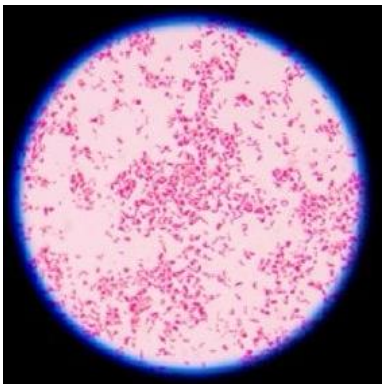

Figure 3. Gram staining results *of Pseudomonas aeruginosa bacteria*

Gram staining reveals that microscopically, the bacteria are rod-shaped and red or pink, characteristic of Gram-negative bacteria. Gram-negative bacteria have thinner cell walls than Gram-positive bacteria, so they cannot retain the purple dye (crystal violet) after decolorization.

3.3 Effectiveness of natural antiperspirant extract of pucuk merah leaves (*Syzygium Myrtifolium* Walp.) against *Psedomonas Aeruginosa bacteria*

The effectiveness of the antiperspirant product was tested using the disc diffusion method. Extract concentrations of 30% and 40% were chosen for the product formulation because after 20% extract concentration, increasing the dosage of the substance no longer resulted in a significant difference in antibacterial activity. Although the 20% concentration is considered potent and meets the Pharmacopoeia danger zone parameters, the 30% and 40% concentrations were chosen because they provided a more stable and consistent antibacterial effect while maintaining the efficiency of excess extract utilization. The results obtained are as follows **(**Table 6).

The formulation with a concentration of 30% produced an average inhibition zone diameter of 14.2 mm, while at a concentration of 40% produced an average of 14.3 mm against *Pseudomonas aeruginosa*. Both values are categorized as strong inhibition based on general criteria for measuring antibacterial activity and are in accordance with the Pharmacopoeia. However, increasing the concentration from 30% to 40% did not show a significant increase in the inhibition zone diameter. Based on the results of the antibacterial effectiveness test on antiperspirant products, it was found that the 30% concentration showed a slightly different inhibition zone diameter of 0.1 mm compared to the 40% concentration. The antibacterial effectiveness of a product is not only determined by the concentration of the extract, but is also influenced by the overall physicochemical properties of the product. These results indicate that the product formulation at a concentration of 30% is the same as 40%.

Table 6. Data from the effectiveness test results of natural antiperspirant extracts from red pucuk leaves (*Syzygium myrtifolium* Walp.) against *Pseudomonasa aeruginosa bacteria*

Concentration (%)	Bacterial Inhibition Zone *Pseudomonas aeruginosa bacteria*				Average Inhibition Zone	Criteria
	U1	U2	U3	U4		
Control (+)	19 mm	18.5 mm	20.25 mm	17.75 mm	18.8 mm	Strong
Control (-)	12.7 mm	12.9 mm	13.6 mm	12.3 mm	12.8 mm	Strong
30%	14.35 mm	14.6 mm	13.95 mm	14.05 mm	14.2 mm	Strong
40%	14.95 mm	14.1 mm	13.9 mm	14.6 mm	14.3 mm	Strong

Note: Positive Control (+) Conventional Antiperspirant**.** Negative Control (-) Without extract Red Shoot Leaf Extract (*Syzygium myrtifolium* Walp.). Concentrations of 30% and 40%.

According to [context needed] Rahman (2012), antibacterial effectiveness does not always increase significantly even when the concentration is increased. This relatively small difference is thought to be because the extract's inhibitory power is already near its maximum at a concentration of 30%, so adding the active compound at a concentration of 40% does not have a significant effect.

The inhibition zone data obtained were then analyzed using an ANOVA table. The results showed a significance value of 0.000 ($p < 0.05$). This value indicates effective results, so a Duncan Advanced Test was conducted with the following results.

Table 7. Duncan's advanced test data with bacterial inhibition zones against natural antiperspirant extract of red pucuk leaves (*Syzygium myrtifolium* Walp.)

Treatment	Average
Negative Control	12.87 ± 0.54^{a}
30%	14.23 ± 0.29^{b}
40%	14.38 ± 0.47^{b}
Positive Control	18.87 ± 1.05^{c}

Note: Data is the result of LSD testing. Data with different notations show significant differences ($P > 0.05$). Data was taken from the results of a natural antiperspirant test using red shoot leaf extract (*Syzygium myrtifolium* Walp.)

Based on product formulation analysis data and Duncan's further test results, the negative control showed a significant difference compared to the other groups. Meanwhile, the positive control showed a significant difference from all other groups, including the treatment group. These results indicate that treatments with 30% and 40% extract concentrations produced the same antibacterial effect (having the same letter notation), but both were significantly different from the negative control, indicating the presence of antibacterial activity. Meanwhile, the positive control showed the highest effectiveness in inhibiting bacterial growth. Thus, the 40% concentration

was chosen for further testing because it had a stable average inhibition zone even though it only differed by 0.1 between treatment groups, so it was considered the most optimal in representing the effectiveness of the extract.

3.10 Physical quality test results of antiperspirant preparations

Testing the characteristics of a natural antiperspirant product, red shoot leaf extract (*Syzygium myrtifolium* Walp.), produces a liquid texture with a reddish-brown color and the distinctive aroma of red shoot leaves (*Syzygium myrtifolium* Walp.).

Figure 4. Organoleptic properties of natural antiperspirants from red shoot leaf extract (*Syzygium myrtifolium* Walp.)

From the formulated product, it is known that the antiperspirant preparation of red shoot leaf extract (*Syzygium myrtifolium* Walp.) is liquid, reddish brown in color, and has a distinctive aroma of red shoot leaves (*Syzygium myrtifolium* Walp.). The conformity of the organoleptic results with the characteristics of the active ingredients shows that the formulation successfully maintains the visual and sensory stability of the red shoot leaf extract (*Syzygium myrtifolium* Walp.) (Roosevelt, 2019).

Other characteristics also show the results of a homogeneous antiperspirant product, characterized by the absence of coarse particles in the antiperspirant preparation and having a spray spread of 6 cm which has met the requirements for a good spread preparation. In addition, this antiperspirant product produced a good irritation test, characterized by the absence of irritation reactions on the skin that was sprayed with the antiperspirant preparation on 20 panelists. The antiperspirant product obtained a pH value of 4.07. According to SNI (Indonesian National Standard) 16-4951-1998 concerning deodorant and antiperspirant preparations, the preparation must meet the pH range of underarm skin, which is 3 - 7.5. These results indicate that the preparation made has met the requirements for underarm skin pH according to SNI. The viscosity results also showed a result of 1.3747 cp which means the preparation has a low viscosity, approaching the viscosity of water (1 cP at a temperature of 25°C).

Research by (Indritay, 2022), emphasized that low viscosity allows for rapid evaporation, which is in accordance with the characteristics of alcohol-based products or propellants in commercial spray antiperspirants. Furthermore, homogeneity testing resulted in the absence of coarse particles in the natural antiperspirant preparation of red shoot leaf extract (*Syzygium myrtifolium* Walp.), indicating that the antiperspirant preparation is homogeneous. Homogeneity is one of the parameters that can affect the physical quality of the preparation and impact changes in effectiveness due to differences in the level of absorption of the spray deodorant preparation on the skin. The preparation also has a spray spread of 6 cm and has met the requirements for good spread of 5-7 cm (Hidayati, 2024). The greater the spread provided, the wider the ability of the active substance to spread and come into contact with the skin. Good spread provides good release of drug substances. Furthermore, this

antiperspirant preparation also performed well in irritation tests, as evidenced by the absence of skin irritation on the skin sprayed with the antiperspirant preparation by any panelist. Irritation reactions are characterized by redness, itching, and swelling (Mulyono, 2023).

3.11 The effectiveness of natural antiperspirant red pucuk leaf extract on sweat production

Furthermore, the results of an antiperspirant effectiveness test conducted on 20 panelists, comparing the amount of sweat produced on treated skin areas with untreated areas, demonstrated effectiveness. The test results can be seen in Table 8 below.

Table 8. Observation results of natural antiperspirant tests of red shoot leaf extract

Panelist Code	With Antiperspirant		No antiperspirant	
	Initial weight (grams)	Final weight (grams)	Initial weight (grams)	Final weight (grams)
1	0.35	0.41	0.35	0.82
2	0.35	0.40	0.35	0.65
3	0.35	0.53	0.35	0.85
4	0.35	0.48	0.35	0.76
5	0.35	0.45	0.35	0.80
6	0.35	0.49	0.35	0.82
7	0.35	0.50	0.35	0.83
8	0.35	0.43	0.35	0.78
9	0.35	0.43	0.35	0.76
10	0.35	0.45	0.35	0.75
11	0.35	0.43	0.35	0.74
12	0.35	0.47	0.35	0.85
13	0.35	0.52	0.35	0.81
14	0.35	0.49	0.35	0.80
15	0.35	0.45	0.35	0.76
16	0.35	0.42	0.35	0.83
17	0.35	0.46	0.35	0.69
18	0.35	0.44	0.35	0.67
19	0.35	0.48	0.35	0.72
20	0.35	0.58	0.35	0.84
Average	**0.35**	**0.44**	**0.35**	**0.60**

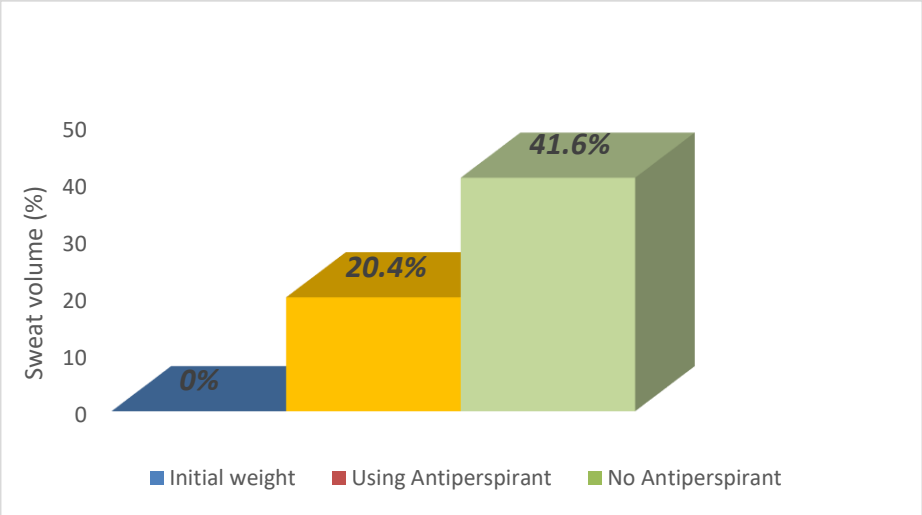

Figure 5. Percentage of sweat volume based on the results of the natural antiperspirant test of red Pucuk leaf extract (*Syzygium myrtifolium* Walp.)

Shrinking pores can help reduce sweat production locally. Although sweat production still occurs, the volume of sweat produced is reduced by up to 21.2%, indicating that the formulated antiperspirant is effective in inhibiting sweat production. According to the FDA (2021), a preparation can be categorized as having an antiperspirant effect if it can reduce sweat production by at least 20%. This is explained in the FDA's final monograph on antiperspirant drug products for non-prescription (OTC) human use. Therefore, the natural antiperspirant Pucuk Merah (*Syzygium myrtifolium* Walp.) leaf extract is said to still be effective in providing an antiperspirant effect.

4. CONCLUSION

Red shoot leaf extract (*Syzygium myrtifolium* Walp.) has been proven to have antibacterial effectiveness against *Pseudomonas aeruginosa*. Natural antiperspirant products formulated from red shoot leaf extract (*Syzygium myrtifolium* Walp.) have stable physical characteristics, as well as a pH that is suitable for the skin and are effective in inhibiting sweat production by up to 21.2%. The manufacture of natural antiperspirant products from red shoot leaf extract (*Syzygium myrtifolium* Walp.) shows that the antiperspirant product is effective in inhibiting the growth of *Pseudomonas aeruginosa bacteria* at a concentration of 40%. Thus, the use of natural ingredients can be a solution to overcome the causes of body odor and reduce the use of conventional antiperspirant products that contain chemicals that are harmful to health.

ACKNOWLEDGEMENT

The author would like to thank all parties who have provided support and contributions in the implementation of this research, especially the agencies and supervisors who have provided direction and guidance with full attention and responsibility.

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