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Formulation and Antibacterial Activity Of a Natural Deodorant Spray Containing Extracts Of Pandanus amaryllifolius (Roxb) and *Ocimum bacilicum* L. Against *Staphylococcus aureus*

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Abstrak

Bau badan merupakan masalah kebersihan diri yang berkaitan dengan aktivitas mikroorganisme kulit yang memetabolisme komponen keringat menjadi senyawa penghasil bau. Daun pandan dan daun kemangi memiliki potensi sebagai agen antibakteri. Penelitian ini bertujuan untuk memformulasikan sediaan semprotan deodoran alami yang mengandung kombinasi ekstrak daun pandan (*Pandanus amaryllifolius*) dan daun kemangi (*Ocimum basilicum* L.) serta mengevaluasi karakteristik fisik, stabilitas fisik, dan aktivitas antibakterinya terhadap *Staphylococcus aureus*. Penelitian eksperimental laboratorium ini menggunakan metode maserasi dengan pelarut etanol. Ekstrak diformulasikan menjadi sediaan semprotan deodoran dengan berbagai konsentrasi: F0 (kontrol), F1 (10%), F2 (20%), dan F3 (30%). Formulasi tersebut dievaluasi meliputi karakteristik organoleptik, homogenitas, pH, viskositas, daya sebar, waktu pengeringan, stabilitas fisik, dan aktivitas antibakteri menggunakan metode difusi cakram. Setiap evaluasi dilakukan dalam tiga kali pengulangan (n=3), dan data dianalisis secara deskriptif. Hasil penelitian menunjukkan bahwa seluruh formulasi memiliki karakteristik fisik yang dapat diterima dan tetap stabil selama periode pengamatan. Formula F3 menunjukkan aktivitas antibakteri tertinggi dengan zona hambat sebesar 39,8 mm, yang lebih besar dibandingkan dengan kontrol positif. Sebagai kesimpulan, kombinasi ekstrak Pandanus amaryllifolius dan Ocimum basilicum L. berpotensi untuk dikembangkan sebagai bahan alami dalam formulasi semprotan deodoran, karena menunjukkan karakteristik fisik yang dapat diterima, stabilitas fisik yang baik, serta aktivitas antibakteri terhadap Staphylococcus aureus.

Kata kunci: *Antibakteri, deodoran spray, Ocimum bacilicum L., Pandanus amaryllifolius, Staphylococcus aureus*

Abstract

Body odor is a personal hygiene concern associated with the activity of skin microorganisms that metabolize sweat components into odor producing compounds. Pandan and basil leaves have potential as antibacterial agents. This study aimed to formulate a natural deodorant spray containing a combination of pandan leaf (Pandanus amaryllifolius) and basil leaf (Ocimum bacilicum L.) extracts and to evaluate its physical characteristics, physical stability, and antibacterial activity against Staphylococcus aureus. This laboratory experimental study employed an ethanolic maceration method. The extracts were formulated into deodorant spray preparations at different concentrations: F0 (control), F1 (10%), F2 (20%), and F3 (30%). The formulations were evaluated for organoleptic characteristics, homogeneity, pH, viscosity, spreadability, drying time, physical stability, and antibacterial activity using the disk diffusion method. Each evaluation was performed in triplicate (n=3), and the data were analyzed descriptively. The results showed that all formulations exhibited acceptable physical characteristics and remained stable throughout the observation period. Formula F3 demonstrated the highest antibacterial activity, with an inhibition zone of 39.8 mm, which was larger than that of the positive control. In conclusion, the combination of Pandanus amaryllifolius and Ocimum bacilicum L. extracts has potential for development as a natural ingredient in deodorant spray formulations, exhibiting acceptable physical characteristics, good physical stability, and antibacterial activity against Staphylococcus aureus

Key words: *Antibacterial, deodorant spray, Ocimum bacilicum L., Pandanus amaryllifolius, Staphylococcus aureus*

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INTRODUCTION

Body odor is a common personal hygiene problem caused by bacterial activity on human sweat, particularly in moist areas such as the axilla. Sweat is essentially odorless, but when bacteria metabolize organic components of sweat, they produce volatile compounds that contribute to unpleasant body odor. One of the bacteria most frequently associated with this process is *Staphylococcus aureus* (Chang & Wang, 2023). Therefore, controlling bacterial growth is a key strategy in the development of effective deodorant products.

Synthetic deodorants are widely used to manage body odor and generally contain active compounds that function as antimicrobial or antiperspirant agents. Despite their effectiveness, the use of these products may cause adverse skin reactions, including skin irritation and allergic contact dermatitis, particularly in susceptible individuals (Zirwas & Moennich, 2008). These findings highlight the limitations and safety concerns associated with conventional deodorant formulations.

Indonesia is recognized for its abundant biodiversity including various plant species with potential applications as natural antibacterial agents. One of example is pandan leaf (*Pandanus amaryllifolius*), which is known to contain bioactive compounds such as flavonoids, saponins, and tannins (Sa'adah et al., 2023). Previous studies have demonstrated the antibacterial potential of *Pandanus amaryllifolius* leaf extract against *Staphylococcus aureus*, (Setiyanto et al., 2024) reported that a 70% ethanolic extract of pandan leaves inhibited the growth of methicillin-resistant *Staphylococcus aureus* (MRSA) in a concentration-dependent manner. The inhibition zones increased from 9.72 ± 0.92 mm at 20% extract concentration to 12.79 ± 1.24 mm at 40% and 14.37 ± 0.62 mm at 60%. Similarly with the result from Hasani et al., 2024 demonstrated that 96% ethanolic pandan leaf extract inhibited the growth of *Bacillus subtilis*, producing inhibition zones of 6.50 ± 0.16 mm, 7.64 ± 0.46 mm, and 10.63 ± 0.49 mm at concentrations of 30%, 40%, and 50%. These findings indicate that *P. amaryllifolius* leaf extract possesses promising concentration-dependent antibacterial activity and may have potential as a natural antibacterial ingredient for topical formulations.

Basil leaves (*Ocimum bacilicum* L.) are also widely recognized for their significant antibacterial properties due to the presence of active compounds such as eugenol, flavonoids, and essential oils. Basil leaves extract were formulated into liquid deodorant spray preparations with various concentrations. The inhibition zones produced by ethanol extract of basil leaves (*Ocimum basilicum* L.) were 5.25 mm at a concentration of 5%, 6.79 mm at 10%, and 8.43 mm at 15%. Meanwhile, the positive control exhibited an inhibition zone of 7.74 mm, whereas the negative control showed no inhibition zone. These findings indicate that the inhibition zone diameter varied depending on the concentration tested. Higher concentrations of the deodorant spray formulation resulted in larger inhibition zones, demonstrating an increased antibacterial effect (Chandra et al., 2023).

Although the antibacterial potential of pandan leaf extract and basil leaf extract has been reported individually, studies investigating their combined incorporation into a single deodorant formulation remain limited. Therefore, further research is needed to evaluate the potential of combining these two plant extracts in a deodorant spray formulation, particularly with regard to its physical characteristics, stability, and antibacterial activity against *Staphylococcus aureus*.

Therefore, this study aims to formulate and evaluate the antibacterial activity of a natural deodorant spray containing a combination of pandan leaf and basil leaf extracts. This article is expected to contribute to the scientific development of safe and effective plant-based cosmetic formulations and to enrich existing literature on the utilization of local plant extract combinations as antibacterial agents in personal care products.

RESEARCH METHODS

The materials used in this study included fresh pandan leaves and basil leaves. Botanical identification and determination of the plant materials were conducted at the School of Life Sciences and Technology (SITH), Institut Teknologi Bandung (ITB), Indonesia. The pandan leaves were identified as *Pandanus amaryllifolius*

Roxb., as documented in determination certificate No. 6780/ITI.C11.2/TA.00/2025, while the basil leaves were identified as *Ocimum basilicum* (L.), as documented in determination certificate No. 6781/ITI.C11.2/TA.00/2025. Other materials used in the formulation process included ethanol 96%, distilled water, propylene glycol, and other pharmaceutical-grade excipients. *Staphylococcus aureus* was used as the test microorganism, and nutrient agar was employed as the growth medium for antibacterial testing.

Extraction of Plant Materials

The dried powdered leaves of pandan (*Pandanus amaryllifolius* Roxb.) and basil (*Ocimum basilicum* (L.)) were extracted separately by maceration using 96% ethanol. For each plant, 500 g of powdered simplicia was macerated with 3,500 mL of ethanol at a 1:7 (w/v) ratio for 24 h, followed by filtration and remaceration with fresh solvent. The extraction was performed for three cycles, and all filtrates were combined and concentrated using a water bath at 50°C. The resulting extracts were weighed, yielding 218.4 g (43.68%) for pandan and 198.5 g (39.70%) for basil. The extracts were stored in airtight containers until further use.

Formulation of Deodorant Spray

The deodorant spray formulations were prepared using a spray base containing different concentrations of combined pandan and basil leaf extracts. Four formulations were developed: F0 (without extract), F1 (10% total extract concentration), F2 (20% total extract concentration), and F3 (30% total extract concentration) (Table 1). The combined extracts were incorporated at a 1:1 ratio of pandan leaf extract to basil leaf extract, corresponding to 5% :5% (F1), 10% : 10% (F2), and 15% : 15% (F3), respectively. All extract concentrations were expressed as % b/v. The extracts were incorporated into the spray base and mixed thoroughly under continuous stirring to ensure homogeneous distribution throughout the formulation.

Table 1. Deodorant Spray Formulation and Preparation

Material	Formulation (%)			
	F0	F1	F2	F3
Pandan leaf extract	-	5	10	15
Basil leaf extracts	-	5	10	15
Propilenglikol	5	5	5	5
Gliserin	5	5	5	5
Parfum	q.s	q.s	q.s	q.s
Aquadest ad	100	100	100	100

Evaluation of Physical Properties and Stability of *Deodorant Spray* Formulation

The physical characteristics and stability of the *deodorant spray* formulation were evaluated through several parameters, including organoleptic properties, pH, homogeneity, viscosity, sprayability, drying time, irritation potential, and stability testing. Each formulation was evaluated in three independent replicates (n = 3). Quantitative data were expressed as mean ± standard deviation (SD), with the mean calculated as the sum of the three measurements divided by three. The results were analyzed descriptively without inferential statistical testing; therefore, normality testing and statistical comparisons among F0–F3 and the positive control were not performed. The findings were presented in tables as descriptive values to compare the characteristics of each formulation. A significance level and statistical software were therefore not applicable.

The organoleptic evaluation was performed through visual observation of changes in color, odor, clarity, and physical appearance of the formulation during the storage period. This assessment aimed to identify potential degradation of active ingredients or microbial contamination during storage (Shella et al., 2025).

The pH measurement was conducted using a digital pH meter to evaluate formulation stability and ensure compatibility with the physiological pH range of human skin (4.5–6.5), thereby minimizing the potential risk of skin irritation (Sari et al., 2025).

Homogeneity testing was performed through visual inspection and texture evaluation to confirm the uniform distribution of active ingredients and other formulation components (Alti et al., 2025).

Viscosity measurement was carried out using a Brookfield Viscometer equipped with spindle No. 2 at a rotational speed of 30 rpm and a temperature of 25°C. The viscosity value was expressed in centipoise (cP) to characterize the flow properties of the formulation, which may influence spray performance and product distribution on the skin surface (Ramadhan, 2024).

Spray dispersion testing was performed by spraying the formulation onto a test surface from a distance of 10 cm. The spreading area of the spray was measured, and the test was repeated 3 times to obtain the average dispersion area. The diameter of the spray pattern was measured at its widest point, and the spray area was calculated assuming an approximately circular pattern using the formula $A = \pi r^2$, where A is the spray area and r is the radius of the spray pattern.

Drying time was evaluated by measuring the time required for the formulation to dry after application onto the skin surface, with an acceptable drying time of approximately 5 minutes (Ramadhan, 2024).

The physical stability of the deodorant spray formulations was evaluated under room-temperature storage conditions for four weeks. A 50 mL sample of each formulation was stored in its intended spray container and observed at weeks 0, 1, 2, 3, and 4. The evaluated parameters included organoleptic characteristics, pH, viscosity, homogeneity, and the presence of sedimentation or phase separation. The samples were stored at room temperature under normal laboratory conditions and protected from direct light. The formulations were considered physically stable if no noticeable changes in organoleptic characteristics, homogeneity, pH, viscosity, sedimentation, or phase separation were observed throughout the observation period.

Antibacterial Activity Evaluation

The antibacterial activity of the *deodorant spray* formulation was evaluated using the disc diffusion method against *Staphylococcus aureus*. The experimental procedures included sterilization of equipment and media, bacterial rejuvenation, preparation of bacterial suspension, antibacterial activity testing, and measurement of inhibition zones.

Sterilization of Equipment and Media

All glassware, including Petri dishes, test tubes, and pipettes, as well as Nutrient Agar (NA) media, were sterilized using an autoclave at a pressure of 15 psi and a temperature of 121°C for 15 minutes to ensure aseptic conditions during the experiment (Carroll & Pfaller, 2024).

Bacterial Rejuvenation

Bacterial rejuvenation was performed using a frozen stock culture of *Staphylococcus aureus* stored at −20°C. The bacterial inoculum was streaked onto NA slant agar using a sterile inoculating loop and incubated at 37°C for 18–24 hours. This process was conducted to obtain fresh and actively growing bacterial colonies prior to antibacterial testing (Tille, 2022).

Preparation of Agar Medium

Nutrient Agar (NA) powder (2.8 g) was dissolved in 100 mL of distilled water using an Erlenmeyer flask. The suspension was homogenized by heating on a water bath until boiling. Subsequently, 10 mL of the medium was transferred into three sterile test tubes, covered with aluminum foil, and sterilized using an autoclave at 121°C for 20 minutes. The tubes were then allowed to cool at room temperature for 30 minutes in a tilted position (approximately 30°) until the medium solidified. The prepared slant agar was used for bacterial inoculation (Carroll & Pfaller, 2024).

Preparation of Bacterial Suspension

Fresh bacterial colonies obtained from the rejuvenation process (18–24 hours old) were transferred into 5 mL of sterile physiological saline solution (0.9% NaCl). The suspension was homogenized using a vortex mixer until the turbidity reached the equivalent of a 0.5 McFarland standard. The bacterial suspension was subsequently used for antibacterial activity testing (Baker et al., 2021).

Disc Diffusion Assay

The antibacterial activity of the deodorant spray formulations was evaluated using the paper disc diffusion method, a suspension of *Staphylococcus aureus* was prepared and adjusted to a 0.5 McFarland turbidity standard before inoculation. A 200 µL aliquot of the

standardized bacterial suspension was evenly distributed onto the surface of Nutrient Agar (NA) to obtain a uniform bacterial lawn. Sterile paper discs (6 mm in diameter) were loaded with the test formulations and placed aseptically onto the inoculated agar surface. The plates were incubated at 37°C for 24 h. After incubation, the diameter of the inhibition zones was measured in millimeters. Each treatment was tested in three independent replicates (n = 3), and the results were expressed as mean ± standard deviation (Tampubolon et al., 2026).

Measurement of Inhibition Zone

Following incubation, the antibacterial activity was determined by measuring the diameter of the clear inhibition zones surrounding the paper discs using a caliper. The inhibition zone diameter was recorded in millimeters (mm), representing the sensitivity of *S. aureus* toward the tested extracts.

RESULTS AND DISCUSSION

Organoleptic Properties

The observations revealed that all formulations were clear liquid sprays without visible particles or sediment, indicating good physical compatibility among the formulation components. The primary differences were observed in color intensity, which increased proportionally with the concentration of combined plant extracts. The control formulation (F0) appeared colorless, whereas formulations containing plant extracts exhibited different shades of green. This color variation was attributed to the presence of natural pigments in pandan and basil leaf extracts. Notably, the color differences did not affect the clarity or homogeneity of the spray formulations.

Table 2. Organoleptic Evaluation

Parameter	F0 (Control)	F1 (10%)	F2 (20%)	F3 (30%)
Appearance	Clear liquid	Clear liquid	Clear liquid	Clear liquid
Color	Colorless	Light green	Green	Dark green
Odor	Neutral	Herbal characteristic	Herbal characteristic	Herbal characteristic

All extract containing formulations exhibited a characteristic herbal odor derived from the volatile compounds present in pandan and basil leaf extracts. The odor intensity slightly increased with increasing extract concentrations however, the aroma remained acceptable and did not produce any unpleasant odor. No rancid or undesirable odors were detected throughout the observation period, indicating good formulation stability. Overall, the organoleptic evaluation demonstrated that the incorporation of combined plant extracts did not adversely affect the physical appearance or sensory characteristics of the *deodorant spray* .

Homogeneity Evaluation

Homogeneity was evaluated visually by observing the presence or absence of coarse particles, sedimentation, or phase separation within the formulations. The results demonstrated that all *deodorant spray* formulations, including the control formulation (F0) and extract-containing formulations (F1, F2, and F3), exhibited good homogeneity. No visible particles, agglomerates, or phase separation were observed throughout the evaluation period.

pH Evaluation

The pH evaluation was conducted to determine the suitability of the *deodorant spray* formulations for topical application and to assess their compatibility with the skin. pH is an important quality parameter in cosmetic formulations because values outside the physiological skin pH range may potentially cause irritation, dryness, or discomfort during application.

Table 3. pH Values

Formulation	pH (Mean ± SD)				
	Day 0	Day 7	Day 14	Day 21	Day 28
F0 (0%)	6,2 ± 0.02	6,2± 0.03	5,7 ± 0.02	5,4 ± 0.05	5,4 ± 0.02
F1 (10%)	4,4 ± 0.03	4,4 ± 0.02	4,3 ± 0.07	4,2 ± 0.06	4,2± 0.02
F2 (20%)	4,3 ± 0.04	4,3 ± 0.07	4,2 ± 0.02	4,1 ± 0.02	4,1 ± 0.08
F3 (30%)	4,1 ± 0.05	4,1 ± 0.02	4,1 ± 0.03	4,1 ± 0.03	4,1 ± 0.02

The findings demonstrated that all *deodorant spray* formulations exhibited pH values within the acceptable range for topical cosmetic

products. A gradual decrease in pH values was observed with increasing concentrations of the combined plant extracts. This trend may be attributed to the presence of acidic phytochemical constituents, including phenolic compounds and flavonoids, naturally present in pandan and basil leaf extracts.

Despite the observed decrease in pH values, all formulations remained within the skin-compatible pH range (approximately 4.5–6.5), indicating their suitability for topical application. None of the formulations exhibited pH values that may potentially cause skin irritation. These findings demonstrate that the incorporation of pandan and basil leaf extracts at increasing concentrations did not adversely affect the pH stability of the *deodorant spray* formulations. Furthermore, the results suggest that the formulations maintained adequate chemical stability throughout the observation period, supporting their potential for further physicochemical and antibacterial evaluations.

Viscosity Evaluation

The viscosity of the deodorant spray formulations was evaluated to assess their flow characteristics and sprayability. Viscosity is an important physical parameter because it influences product application, spray performance, and consumer acceptability. Formulations with excessively low viscosity may flow too rapidly and be difficult to control during application, whereas formulations with excessively high viscosity may clog the spray mechanism and impair uniform distribution on the skin.

The results demonstrated that viscosity increased proportionally with increasing concentrations of the combined pandan and basil leaf extracts. The control formulation (F0) exhibited the lowest viscosity, whereas the formulation containing the highest extract concentration (F3) showed the highest viscosity. This increase in viscosity may be attributed to the higher solid content and the presence of phytochemical constituents in the extracts, which may enhance intermolecular interactions within the formulation.

Table 4. Viscosity of Deodorant Spray Formulations

Formulation	Viscosity (cPs)
F0 (Control)	18.6 ± 0.5
F1 (10%)	22.4 ± 0.7
F2 (20%)	26.9 ± 0.9
F3 (30%)	31.2 ± 1.1

Although viscosity increased with increasing extract concentration, all formulations remained within an acceptable range for sprayable preparations. None of the formulations exhibited excessive viscosity that could interfere with spray performance. During application testing, all formulations dispersed evenly without nozzle blockage or irregular droplet formation. These findings indicate that the incorporation of pandan and basil leaf extracts altered the rheological properties of the deodorant spray formulations without compromising their functional performance. The gradual increase in viscosity suggests that higher extract concentrations can be incorporated while maintaining acceptable physical characteristics and sprayability, which may support the potential use of these formulations for enhanced antibacterial activity.

Spreadability Evaluation

Spreadability testing was conducted to assess the ability of the deodorant spray formulations to disperse uniformly across the skin surface following application. Adequate spreadability is essential for topical preparations because it facilitates uniform distribution of the active ingredients, supports consistent antibacterial activity, and enhances user comfort. In this study, spreadability was evaluated by measuring the diameter of the spread following application under standardized conditions.

The results showed that all formulations exhibited adequate spreadability. However, a gradual decrease in the spread diameter was observed with increasing extract concentration. The control formulation (F0) exhibited the largest spread diameter, whereas the formulation containing the highest extract concentration (F3) showed the smallest spread diameter. This trend was consistent with the increase in viscosity observed in formulations containing higher concentrations of the combined extracts. The higher viscosity may have reduced the mobility

and flow of the formulations, thereby limiting their ability to spread across the skin surface.

Table 5. Spray Dispersion of Deodorant Spray Formulations

Formulation	Spray Dispersion (cm) ± SD				
	Day 0	Day 7	Day 14	Day 21	Day 28
F0 (0%)	9,8 ± 0.3	9,8 ± 0.5	9,9 ± 0.5	9,9± 0.4	9,9± 0.3
F1 (10%)	12,5 ± 0.4	12,5± 0.3	12,6± 0.3	12,6± 0.1	12,6± 0.3
F2 (20%)	13,5± 0.3	13,5± 0.3	13,6± 0.3	13,6± 0.3	13,6± 0.3
F3 (30%)	13,7± 0.3	13,7± 0.4	13,8± 0.3	13,8± 0.3	13,8± 0.3

The spray dispersion of the formulations remained within the previously reported optimal range of 5–7 cm for topical spray preparations (Wardani et al., 2019). In the present study, the decrease in spray dispersion observed with increasing extract concentration may be attributed to the corresponding increase in viscosity, which can limit the extent of spray dispersion across the skin surface. Despite this decrease, the formulations remained within the reported optimal range, indicating that the incorporation of combined pandan and basil leaf extracts did not substantially impair the spray ability or coverage of the formulations.

Drying Time Evaluation

Drying time was evaluated to determine the time required for the deodorant spray formulations to dry completely following application. This parameter is particularly important for deodorant preparations because prolonged drying may reduce user comfort and practicality during daily use. Drying time was measured from the moment of application until the formulation no longer produced a wet sensation on the skin surface.

The results showed that drying time increased slightly with increasing concentrations of the combined pandan and basil leaf extracts. The control formulation (F0) exhibited the shortest drying time, whereas the formulation containing the highest extract concentration (F3) required the longest time to dry. This trend may be associated with the increased viscosity and solid content of formulations containing higher concentrations of the combined extracts, which may reduce the rate of evaporation and dispersion of the formulation on the skin surface.

Table 6. Drying Time Evaluation

Formulation	Drying Time (Minute) ± SD				
	Day 0	Day 7	Day 14	Day 21	Day 28
F0 (0%)	1,39 ± 0.01	1,39± 0.02	1,40± 0.01	1,41± 0.02	1,41± 0.01
F1 (10%)	1,44± 0.01	1,44± 0.01	1,45± 0.01	1,46± 0.01	1, ± 0.0146
F2 (20%)	1,45± 0.01	1,45± 0.03	1,46± 0.01	1,47± 0.01	1,47± 0.01
F3 (30%)	1,53± 0.01	1,53± 0.01	1,54± 0.04	1,56± 0.04	1,56± 0.04

The drying time increased gradually with increasing extract concentration. All formulations dried within the 5 minute criterion previously reported for deodorant spray preparations (Dwi Djajanti & Agnia, 2021). This increase may be related to changes in the physical properties of the formulations following the incorporation of the plant extracts. Nevertheless, the drying times remained below the reported criterion, indicating that the incorporation of the combined pandan and basil leaf extracts did not substantially affect the practical usability of the formulations.
Antibacterial Activity of Deodorant Spray

The results demonstrated that all formulations containing the plant extracts exhibited clear antibacterial activity against *S. aureus*, whereas the control formulation (F0) produced no inhibition zone. A concentration-dependent increase in antibacterial activity was observed, with larger inhibition zones corresponding to higher concentrations of the combined extracts. This finding indicates that the antibacterial activity of the deodorant spray formulations was influenced by the concentration of the incorporated plant extracts, with higher extract concentrations producing greater inhibition of *S. aureus* growth.

Table 7. Inhibition Zone Diameter

Formulation	Inhibition Zone (mm) ± SD n=3
F0 (Control)	0.0 ± 0.0
F1 (10%)	37.8 ± 0.6
F2 (20%)	38.5 ± 0.7
F3 (30%)	39.8 ± 0.8
Positive Control (Commercial deodorant)	34.0 ± 0.5

F3 (30% total extract concentration) exhibited the largest mean inhibition zone among the tested formulations. The mean inhibition zones of F1, F2, and F3 were descriptively larger than that of the commercial deodorant used as the positive control. These results indicate that the deodorant spray formulations containing combined pandan and basil leaf extracts demonstrated antibacterial activity against *S. aureus* under the experimental conditions. However, because the data were analyzed descriptively without inferential statistical testing, the observed differences among F1, F2, F3, and the positive control should be interpreted as descriptive differences rather than statistically significant differences.

The strong antibacterial activity observed in the present study may be attributed to the phytochemical constituents of the pandan and basil leaf extracts. Flavonoids may exert antibacterial effects by disrupting bacterial cell integrity and interfering with nucleic acid synthesis, whereas tannins may precipitate bacterial proteins and alter membrane permeability. Saponins may increase membrane permeability, potentially leading to cellular leakage and lysis, while alkaloids may interfere with bacterial metabolic processes. The presence of these bioactive compounds in both pandan and basil leaf extracts may therefore contribute to the observed antibacterial activity through multiple complementary mechanisms.

Compared with previous reports on pandan or basil leaf extracts used individually, the present formulation showed larger inhibition zones. However, these findings should be interpreted cautiously because the experimental conditions differed among studies. The observed antibacterial activity may reflect the combined contribution of bioactive compounds from both plant extracts, but the extent to which their interaction contributes to the observed activity cannot be determined from the present data. Further investigation using individual-extract controls under identical experimental conditions and appropriate combination assays would be necessary to clarify the interaction between the two extracts. Nevertheless, the present findings demonstrate that the combined pandan and basil leaf extracts can be incorporated into a deodorant spray formulation with antibacterial activity against *S. aureus*.

CONCLUSION

This study demonstrated that a natural deodorant spray containing a combination of *Pandanus amaryllifolius* and *Ocimum bacilicum* L. leaf extracts can be formulated with satisfactory physical characteristics and antibacterial activity against Staphylococcus *aureus*. All formulations exhibited acceptable physical properties, including clarity, homogeneity, pH, viscosity, spreadability, drying time, and physical stability throughout the observation period. The antibacterial evaluation demonstrated a concentration-dependent inhibitory effect, with the formulation containing 30% combined extracts (F3) producing the largest inhibition zone against *S. aureus*. Notably, the extract containing formulations produced larger inhibition zones than the commercial deodorant used as the positive control under the experimental conditions. These findings support the potential of combined pandan and basil leaf extracts as plant based antibacterial ingredients for deodorant spray formulations.

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