Journal of Science and Technology Research for Pharmacy
Volume 5 Issue 1 Year 2025 Pages 14-26

E-ISSN 2776-0685
https://journal.unnes.ac.id/journals/JSTRP/index

Formulation and Antibacterial Activity Testing of Nanoemulsion Cream from Coriander Seed Extract (*Coriandrum sativum* L.) in Inhibiting Protein Synthesis of Staphylococcus aureus Bacteria

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Abstract: Bullous impetigo is a contagious skin infection caused by Staphylococcus aureus, characterized by the formation of fluid-filled bullae. The use of topical antibiotics for impetigo treatment has side effects, including the increased risk of bacterial resistance, leading to reduced efficacy. Natural alternatives such as coriander seeds (*Coriandrum sativum* L.) have the potential as antibacterial agents with fewer side effects. This study aimed to formulate and evaluate the antibacterial activity of a nanoemulsion cream containing coriander seed extract against Staphylococcus aureus. The extraction of coriander seeds was carried out using the maceration method with 96% ethanol to obtain a thick extract, followed by phytochemical screening to qualitatively identify bioactive compounds and a quantitative total flavonoid test, which resulted in a flavonoid content of 61.64 mg QE/g. The nanoemulsion was formulated using PEG 400 and VCO as the oil phase, while Tween 80, distilled water, and coriander seed extract at concentrations of 2.5%, 5%, and 7.5% were used as the aqueous phase. The nanoemulsion was then incorporated into a cream base containing stearic acid, cera alba, and white vaseline as the oil phase, and TEA, propylene glycol, methylparaben, and distilled water as the aqueous phase, heated in a water bath at 75°C. The resulting preparations were evaluated and tested for antibacterial activity using the well diffusion method. The bioactive compounds identified in coriander seed extract include alkaloids, saponins, tannins, terpenoids, and flavonoids, which exhibit antibacterial activity against *Staphylococcus aureus*. The antibacterial test results showed that the inhibition zones for F1 (2.5%), F2 (5%), and F3 (7.5%) were 15.00 mm, 22.00 mm, and 28.33 mm, respectively, while the positive control had an inhibition zone of 30.67 mm. The highest antibacterial activity was obtained at the F3 concentration (7.5%) with an inhibition zone diameter of 28.33 mm, classified as very strong.

Keywords: Antibakterial, *Coriandrum sativum* L, nanoemulsion cream, *Staphylococcus aureus.*

INTRODUCTION

Impetigo, a contagious bacterial skin infection often caused by *Staphylococcus aureus,* is divided into non-bullous impetigo and bullous impetigo. Bullous impetigo is characterized by blistering lesions that may develop into fluid-filled ulcers, common on the face and hands, while non-bullous impetigo is characterized by vesicles that rupture quickly to form crusts. The disease is prevalent in infants, children and individuals with low immunity, with a global prevalence of 11.2% by 2022, and most cases (70%) are bullous impetigo. In Indonesia, Staphylococcus aureus is the main cause of 19.96% of impetigo cases, and this bacteria is increasingly showing resistance to antibiotics which is a serious concern. The rapid transmission of bullous impetigo and the potential for serious complications, drives the need for more effective treatments.

Management of impetigo commonly uses topical antibiotics such as mupirocin, which effectively inhibits bacterial protein synthesis and minimizes systemic side effects. However, inappropriate use has increased bacterial resistance; 40% of Staphylococcus aureus are resistant to antibiotics, and more than 80% of Staphylococcus aureus infections show resistance to methicillin (MRSA). Mupirocin resistance is also frequently found. Therefore, the development of alternative therapies based on natural materials is urgently needed to reduce the level of antibiotic resistance and provide more sustainable treatment options.

Coriander seed *(Coriandrum sativum* L.*)* is one of the promising plants as an antibacterial source. The content of secondary metabolites such as flavonoids in coriander seeds has antibacterial activity with a mechanism similar to mupirocin, which inhibits bacterial protein synthesis, including *Staphylococcus aureus*. Previous research showed that coriander seed extract with 96% ethanol solvent had a moderate inhibition zone against *Staphylococus aureus* at a concentration of 4%. To increase effectiveness and overcome shortcomings such as color and pungent aroma, the development of preparations in the form of nanoemulsion creams is a new innovation. Nano technology can increase the bioavailability, efficiency, and antibacterial potential of the extract, as well as make the preparation more convenient to apply and easy to wash. Therefore, this study aims to develop and test nanoemulsion cream of coriander seed extract to inhibit *Staphylococcus aureus*, with the hope that it can be an alternative to natural antibiotics for bullous impetigo.

METHODS

Extraction

Simplices in glass containers were macerated using 96% ethanol solvent for 24 hours. During soaking, stirring was carried out every 6 hours for 5 minutes, then 3 changes of solvent were made with a time of 24 hours in a ratio of 1: 5 at room temperature. Simplisia that has been macerated is then separated between the filtrate and the residue using coarse filter paper, the filtrate obtained is then concentrated by evaporating the solvent using a rotary evaporator for 24 hours at 50˚C until a thick extract is obtained (Rodrigues *et al*, 2019). The thick extract obtained was evaluated from organoleptic test, yield calculation, phytochemical screening and total flavonoid test.

Phytochemical Screening

Flavonoid Test

A total of 1 mg of extract was put into a test tube, then 10 drops of ethyl acetate was added and homogenized. Then, 0.1 g of magnesium (Mg) and 4 drops of concentrated HCl were added to the mixture. A color change to yellow, blue, orange, or red indicates a positive result.

Alkaloid Test

A total of 1 gram of extract was dissolved in 10 ml of 96% ethanol, then the solution was divided into two tubes, each tube added 2-3 drops of Dragendorf reagent and Wagner reagent. Positive results in tubes containing Dragendorf reagent form an orange / orange precipitate and in Wagner's reagent there is a light brown / yellow color change.

Saponin Test

A total of 1 gram of extract was mixed with 20 ml of distilled water in a test tube, then stirred for 15 minutes. Positive results are characterized by the formation of foam.

Tanin Test

A total of 1 gram was dripped with 1 drop of $FeCl_3$ 1%. Positive results are marked by a change in color to blue-black.

Terpenoid and Steroid Test

A total of 1 gram of extract was dissolved in 10 mL of 96% ethanol then 5 ml extract was given 5 drops of Liebermann Burchard reagent. Positive results for terpenoids are indicated by the formation of brown or purple rings, while positive results for steroids are indicated by a change in color to bluish green.

Total Flavonoid Test

The total flavonoid test was carried out following the method by Bakti *et al*. (2017) through the following steps:

First, reagent solutions were prepared, including 10% $AlCl_3$ reagent, 5% acetic acid reagent, and 1000 ppm quercetin standard solution. Next, the maximum wavelength was determined by mixing 1 ml of 1000 ppm quercetin solution, 1 ml of 10% $AlCl_3$, and 8 ml of 5% acetic acid, then measured using UV-Vis spectrophotometry at a wavelength of 350-650 nm. The standard curve of quercetin was prepared from a series of 40-60 ppm solutions reacted with $AlCl_3$ and acetic acid, then measured the absorbance at the maximum wavelength after standing for 16 minutes. Finally, the determination of total flavonoids was carried out by mixing 1 ml of 1000 ppm extract solution with the same reagents, allowed to stand for 16 minutes, and measured the absorbance at the maximum wavelength using a UV-Vis spectrophotometer.

Nanoemulsion Formulation of Coriander Seed Extract

Nanoemulsion Formulation of Coriander Seed Extract Coriander seed extract nanoemulsion topical preparation formula consists of oil phase (PEG 400, VCO) and water phase (coriander seed extract, tween 80, aquadest). Coriander seed extract with concentrations of 2.5%; 5%; 7.5% and VCO were poured into a glass beaker and stirred using a magnetic stirrer for 30 minutes at a speed of 1000 rpm at 30°C, then added tween 80, PEG, and added little by little distilled water, the addition of distilled water was stopped after the volume added was 180 ml (b/v), Next, the mixture was homogenized again by increasing the stirring speed to 1250 rpm for 30 minutes. After all the ingredients were mixed, sonication was carried out for 1 hour while occasionally stirring at 30°C room temperature with a frequency of 54 kHz (Charoenkul & Phromyothin, 2017). The nanoemulsion formed will be clear in color, the nanoemulsion is stored at 5°C and the nanoemulsion preparation is stable within 14 days (Redhita *et al*., 2022).

Table 1. Nanoemulsion Formulation of Coriander Seed Extract

Material	Concentrarion				Function
	Negative Blank	F1	F2	F3	
Coriander Seed Extract	-	4,5 g	9 g	13,5 g	Active Ingredient
VCO	14,4 g	14,4 g	14,4 g	14,4 g	Oil Phase
Tween 80	72 g	72 g	72 g	72 g	Surfactant
PEG 400	36 g	36 g	36 g	36 g	Co Surfactant
Aquadest	add 180 ml	add 180 ml	add 180 ml	add 180 ml	Solvent

Formulation of Coriander Seed Extract Nanoemulsion Cream

Preparation of coriander seed ethanol extract cream refers to Wahyuningsih *et al*. (2023). Type m/a cream base was made by heating the oil phase (stearic acid, cera alba, white vaseline) and water phase (TEA, propylene glycol, methyl paraben, distilled water) separately to 75°C. The aqueous phase was then poured into a warm mortar, followed by the oil phase, stirring until homogeneous. Hot distilled water 60 ml was added gradually as a solvent until a creamy mass was formed. After cooling, the cream base was divided into four formulas (negative control; 2.5%; 5%; and 7.5%). Ketumbar seeds nanoemulsion was added to each base in the ratio of 3:1. The cream was then put into a container and can be stored at 25°C for 14 days (Arianto & Cindy, 2019).

Evaluation of Coriander Seed Extract Nanoemulsion Cream Preparation

Evaluation of coriander seed ethanol extract nanoemulsion cream preparation includes six main tests. The organoleptic test confirmed the stability of shape, color, and odor. The pH test measures the acidity of the cream, with a safe range of 4.5-7.5 so as not to irritate the skin. Spreadability test to evaluate the ability of the cream to spread between 5-7 cm after application of a load. Adhesion test to measure the adhesion time of the cream on the surface, with a standard of more than 4 seconds. Homogeneity test to check the presence or absence of coarse grains when the cream is applied. Finally, a cream type test using methylene blue to confirm the cream is oil-in-water (M/A) type if the blue color spreads evenly.

Table 2. Coriander Seed Extract Cream Formulation

Material	Formulation	Function
Stearic Acid	18 g	Emulsifiers
Triethanolamine (TEA)	1,8 g	Acidifying Agents
Cera Alba	2,4 g	Emulsion Stabilizers
Vaseline White	9,6 g	Cream Bases
Methyl Paraben	0,144 g	Preservatives
Propylene Glycol	9,6 g	Humectants
Fragrance	5 gtt	Fragrances
Aquadest	add 60 ml	Solvents

Antibacterial Activity Test of Coriander Seed Extract Nanoemulsion Cream

The antibacterial test of coriander seed extract nanoemulsion cream included several steps. First, tools and materials were sterilized to remove living organisms, using an autoclave at 121°C and 1 atm for 15 minutes, while rubber tools were soaked in 96% ethanol. Next, Nutrient Agar (NA) media was made to grow the test bacteria, by weighing 6 grams of NA powder into an erlenmeyer containing 200 ml of distilled water, heated until completely dissolved, then sterilized by autoclaving and poured into petri dishes until hardened. After that, rejuvenation of Staphylococcus aureus bacteria was carried out with the aim of maintaining optimal conditions, namely by scratching it using a cotton swab on a new NA sloping agar, then incubated at 37-38 ° C for 24 hours. Furthermore, the preparation of bacterial suspensions was carried out by suspending 2 cotton swabs of Staphylococcus aureus bacteria that had been inoculated into 5 ml of 0.9% NaCl, then incubated for 24 hours at 37°C until the turbidity was equivalent to Mc. Farland 0.5 standard (approximately 1.5 x 10^8 cfu/ml).

Next, the antibacterial activity test was carried out using the well diffusion method. NA media that had been inoculated with 100 µL of bacterial suspension evenly was allowed to solidify. Then, 5 wells with a diameter of 6 mm were made in the agar media to be filled with 0.1 g of preparations of various concentrations (2.5%, 5%, 7.5%), negative control (nanoemulsion cream base), and positive control (mupirocin). Petri dishes were incubated at 37°C for 24 hours. Finally, inhibition zone measurements were performed after 24 hours by observing and measuring the diameter (in millimeters) of the microbial growth inhibition area, including the hole diameter, using a caliper/ruler.

Each inhibition zone was measured three times from different directions to obtain accurate data, with a total of 3 replicates according to Federer's formula calculation.

RESULT AND DISCUSSION

Extraction

Coriander seeds that have become simplisia powder are extracted using the maceration method. This method was chosen because of its ease, simplicity, and ability to extract secondary metabolite compounds through soaking and stirring. A total of 450 grams of simplisia powder was soaked in 2500 mL of 96% ethanol for 24 hours at room temperature, with 3 repetitions of solvent changes every 24 hours and stirring every 6 hours. Stirring every 6 hours proved effective in increasing yield and bioactive compounds (Hakim *et al*., 2024). Ethanol was chosen as a universal solvent that effectively dissolves nonpolar and polar compounds, including flavonoids (Riwanti *et al*., 2020). The principle of maceration is "like dissolves like," ensuring compounds dissolve completely in solvents with similar levels of polarity (Wahyuningtyas *et al*., 2017).

Figure 1. Coriander Seed Viscous Extract

After maceration, the filtrate was separated from the residue, then concentrated using a rotary evaporator at 50˚C to separate the solvent and concentrated extract. This temperature is optimal for concentrating the extract without damaging the flavonoid content. The principle of a rotary evaporator is to convert liquid into vapor through heating and decreasing pressure, allowing the solvent to evaporate at low temperatures. The thick extract of coriander seeds produced was 50 grams from 450 grams of simplisia powder, giving a yield of 11.1%. Organoleptic tests show that the extract has a thick honey-like shape, blackish brown color (due to phenolic compounds, flavonoids, and tannins), and a distinctive odor that indicates the presence of volatile compounds such as flavonoids (Februyani *et al*., 2024). The 11.1% yield is influenced by the extraction method, type of solvent, duration, temperature, and sample characteristics (Februyani *et al*., 2024). The yield of not less than 10.8% shows that it meets the criteria of the Indonesian Pharmacopoeia. The greater the yield, the more the content of bioactive compounds (Riwanti *et al*., 2020).

Phytochemical Screening Results

Examination of the chemical content of coriander seed extract was carried out to identify the class of compounds. This simple method aims to detect biologically active compounds. In this study, flavonoids, alkaloids, saponins, tannins, terpenoids, and steroids were tested. The results of phytochemical screening can be seen in Table 3.

Table 3. Phytochemical Screening Results of Coriander Seed Extract

No	Compound	Reagen	Observation	Results
1.	Flavonoids	Ethyl acetate + Mg powder + concentrated HCl	Yellow color	+
2.	Alkaloids	Dragendrof, Mayer	Orange precipitate and brown color	+
3.	Saponins	Aquadest	Stable foam	+
4.	Tannins	$FeCl_3$ 1%	Blue-black	+
5.	Terpenoids/steroids	*Liebermann Burchard* (anhydrous acetic acid, concentrated H_2SO_4)	Brown ring	+

Flavonoid

Flavonoids were identified in coriander seed extract using ethyl acetate reagent, Mg powder, and concentrated HCl. This reaction reduces the benzopyrone nucleus of flavonoids to flavilium salts, characterized by a color change to yellow or orange (Illing *et al*., 2017; Pravita & Dhurhania, 2023). This positive result is consistent with previous studies characterized by a yellow color change (Putri *et al*., 2023).

Alkaloid Test

Alkaloids in coriander seed extract were tested using Dragendorff and Wagner reagents after being dissolved in 96% ethanol. Ethanol was chosen because of its ability to dissolve and separate alkaloids. Positive results were indicated by an orange precipitate in the Dragendorff test (Adhariani *et al*., 2018) and a brown precipitate in the Wagner test (Sangkal *et al*., 2020), in accordance with the findings of Putri *et al*. (2023).

Saponin Test

Saponins were identified in coriander seed extract through shaking with distilled water. Positive results are characterized by the formation of stable foam (Prabawa *et al*., 2019; Saputra *et al*., 2022). Coriander seed extract showed positive results, consistent with the study of Putri *et al*. (2023), where the foam indicates the presence of glycosides that form foam in water (Suleman *et al*., 2022).

Tanin Test

The presence of tannins in coriander seed extract is indicated by a change in the color of the solution to blue-black after the addition of 1% $FeCl_3$ reagent. This color change is caused by the formation of complexes between tannins and Fe ions (Khoiroh *et al*., 2018; Nurjannah *et al*., 2022). This positive result is also in accordance with the research of Putri *et al*. (2023).

Terpenoid and Steroid Test

Terpenoid and steroid tests were performed using Liebermann-Burchard reagents. Coriander seed extract showed positive (+) results for terpenoids, characterized by the formation of brown rings due to acetylation of hydroxyl groups (Asmara, 2017). However, the steroid test results were negative (-) because no bluish green color change occurred (Nurjannah *et al*., 2022). This finding is consistent with the research of Putri *et al*. (2023).

Flavonoid Total Test

Quantitative analysis of total flavonoids in ethanol extract of coriander seeds *(Coriandrum sativum* L.) was performed using UV-Vis spectrophotometry. This method was chosen because the conjugated aromatic system on flavonoids absorbs strongly in the UV-Vis area (Kumalasari *et al*., 2020). This test aims to determine the concentration of flavonoids, bioactive compounds with antioxidant, anti-inflammatory, and antimicrobial potential, to evaluate the therapeutic potential of coriander seeds (Februyani *et al*., 2024).

The test was conducted by colorimetric method using $AlCl_3$ reagent and 5% acetic acid, as well as quercetin standard. Quercetin was used because of its ability to form a color complex with $AlCl_3$ which produces a yellow solution, with the addition of acetic acid to keep the wavelength in the visible spectrum (Safarina *et al*., 2024).

The maximum wavelength was identified at 413 nm, which is slightly different from other studies (416 nm by Bakti *et al*., 2017). This difference indicates a hypsochromic shift (Dachriyanus, 2004). The standard concentrations of quercetin used were 40, 45, 50, 55, and 60 ppm, to make a standard curve with a linear regression equation $y = 0.003x - 0.0406$, with an R^2 value of 0.9568 and an r value of 0.978. The samples were incubated for 16 minutes to ensure complete reaction (Bakti *et al*., 2017).

Table 4. Total Flavonoid Assay Result of Coriander Seed Extract

Replicate	Absorbance	Total flavonoid content (mgQE/g extract)	Average total flavonoid content (mgQE/g extract)
1	0.173	71.2	61.53
2	0.139	59.86	
3	0.12	53.53	

The average total flavonoid content in coriander seed extract is 61.53 mg QE/g extract. This result is slightly different from the research of Siregar *et al*. (2017) which obtained 67.6 mg QE/g using n hexane solvent. This difference can be caused by the type of solvent, geographical plants, harvest time, fertilizer, and other factors. Flavonoids in coriander seeds are known to have antibacterial activity by inhibiting bacterial protein synthesis (Kodariah *et al*., 2024).

Characteristic of Coriander Seed Extract Nanoemulsion

The nanoemulsion of coriander seed extract was evaluated through a series of physical tests, showing that the addition of the extract affected the color of the preparation, with higher concentrations of the extract producing a more intense color (from pale yellow to brown). Despite this, all formulas remained homogeneous and odorless. The pH test showed that all formulations were within the safe range for the skin (pH 4.5-7), and the flavonoids and phenolic acids in the extracts contributed to stabilizing the pH close to the skin pH (Ma'arif *et al*., 2023; Widyastuti & Saryanti, 2023).

Furthermore, transmittance testing (Indalifiany *et al*., 2021; Sahumena & Suryani, 2023) showed that an increase in extract concentration led to a decrease in clarity and an increase in particle size, although nanoemulsion formation remained successful. This was confirmed by particle size tests (Gupta *et al*., 2016; Winarti *et al*., 2016), where F1 (185.3 nm) had a smaller size than F2 (406.7 nm) and F3 (410.2 nm), and the low polydispersity index in F1 and F2 indicated better particle uniformity (Adi *et al*., 2019; Maharini *et al*., 2018). Finally, all formulas were confirmed as oil-in-water (o/w) type emulsions thanks to their homogeneity with methylene blue and the use of Tween 80 as an emulsifying agent, making them suitable for topical application.

Evaluation of Coriander Seed Extract Nanoemulsion Cream Preparation

Evaluation of nanoemulsion cream preparation showed good results. Organoleptically, the color of the cream varied from white to yellowish white depending on the concentration of the extract, while the aroma remained fragrant and the consistency was semi-solid, indicating the nanoemulsion was able to reduce the characteristic aroma of the extract (Sari & Herdiana, 2018). The pH test showed an average value between 6.83-6.99, within the normal pH range of the skin (4.5-7.5), so it is safe to use even though the increase in extract concentration slightly lowers the pH due to the acidic nature of flavonoids and vitamin C (Februyani *et al*., 2024). The spreadability of the cream is very good (5-7 cm) and exceeds the standard (>5 cm) (Irianto *et al*., 2020), where the addition of extracts actually increases spreadability because it reduces viscosity. The adhesion of the cream also met the standard (>4 seconds) (Wahyuningsih *et al*., 2023), although higher extract concentrations slightly reduced the adhesion time, this is related to the consistency of the cream (Lumentut *et al*., 2020). All formulas showed good homogeneity without coarse grains (Sulastri *et al*., 2023), indicating an even distribution of active substances. Finally, the cream type test confirmed that all formulas were oil-in-water (M/A) type, characterized by complete dissolution of methylene blue (Kale & Deore, 2017; Lestario *et al*., 2024).

Antibacterial Activity Test of Coriander Seed Extract Nanoemulsion Cream

This study evaluated the antibacterial activity of coriander seed extract nanoemulsion cream preparation against Staphylococcus aureus bacteria, a common cause of skin infections in children. Coriander seed extract contains active compounds that can damage bacterial cell membranes, inhibit protein synthesis, and disrupt important metabolic pathways, thus effectively inhibiting bacterial growth. The test is performed using a simple but effective wells diffusion method, where the clear zone around the wells indicates the inhibition of the preparation (Bassy *et al*., 2023). Nutrient Agar (NA) medium is used for bacterial growth, providing essential nutrients such as carbon sources, nitrogen, amino acids, peptides, and maintaining osmotic pressure (Maharani *et al*., 2019).

Table 5. Results of Antibacterial Activity Testing of Seed Extract Nanoemulsion Cream Preparations

Cream formula	Inhibition Zone			
	Replication 1	Replication 2	Replication 3	Average
K+ (Mupirocin)	34 mm	29 mm	29 mm	30,67 mm
M0 (0%)	0 mm	0 mm	0 mm	0 mm
M1 (2,5%)	16 mm	15 mm	14 mm	15,00 mm**
M2 (5%)	24 mm	22 mm	20 mm	22,00 mm*
M3 (7,5%)	30 mm	28 mm	27 mm	28,33 mm *

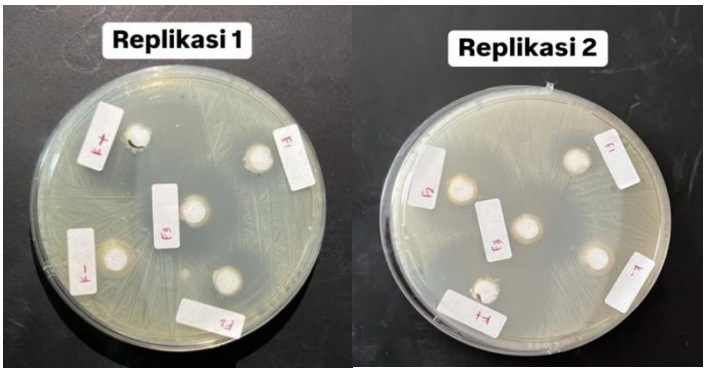
Keterangan :

* Significant difference to negative control (M0) ($p < 0,05$)

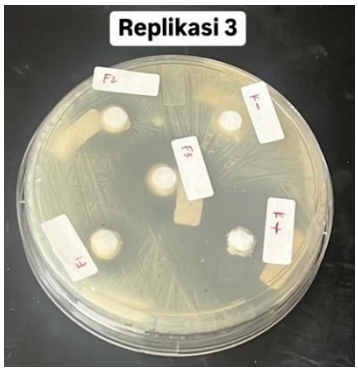
** Significant difference to positive control (K+) ($p < 0,05$)

The classification of antibacterial inhibition zones is divided into four categories: weak, moderate, strong, and very strong. If the inhibition zone diameter is less than 5 mm, it is classified as weak. A diameter of 5–10 mm is categorized as moderate, 10–20 mm is considered strong, and a diameter greater than 20 mm is categorized as very strong (Rahayu *et al*., 2019). Based on the results of antibacterial testing against Staphylococcus aureus, it was found that all nanoemulsion cream formulations containing coriander seed extract at concentrations of 2.5%, 5%, and 7.5% were able to form inhibition zones, indicating antibacterial activity. Formula M1 (2.5%) produced an average inhibition zone of 15.00 mm, which is classified as strong, and showed a significant difference compared to the positive control

(K+), namely mupirocin ($p < 0.05$). This result indicates that although M1 has good antibacterial activity, its effectiveness is still lower than the standard antibiotic. Formula M2 (5%) with an inhibition zone of 22.00 mm falls into the very strong category and showed a significant difference compared to the negative control (M0) ($p < 0.05$). This suggests that increasing the concentration of coriander seed extract from 2.5% to 5% can significantly enhance antibacterial activity. Formula M3 (7.5%) showed an average inhibition zone of 28.33 mm, which is also categorized as very strong, and demonstrated a significant difference compared to the negative control (M0) ($p < 0.05$). The antibacterial activity of M3 was very close to that of the positive control (mupirocin), which produced an inhibition zone of 30.67 mm. Meanwhile, the negative control (M0) did not show any inhibition zone (0 mm), confirming that the cream base without extract had no antibacterial effect against *Staphylococcus aureus*. The positive control (mupirocin) exhibited a clear inhibition zone with an average diameter of 30.67 mm, categorized as very strong antibacterial activity. The positive control served as a comparison to evaluate the inhibition diameter of mupirocin as a standard antibiotic against the coriander seed extract nanoemulsion cream formulation. In the negative control, no clear zone was found around the well, indicating that the base or excipients used in the formula did not possess antibacterial activity against Staphylococcus aureus.



(a) (b)



(c)

Figure 2. Antibacterial Activity Test Results (a) Replication 1 (b) Replication 2 (c) Replication 3

The test results (Table 4.) showed that all formulas containing coriander seed extract (F1, F2, F3) produced strong to very strong inhibition zones against *Staphylococcus aureus*. F1 (2.5% extract) had an average inhibition zone of 15.00 mm (strong), F2 (5% extract) 22.00 mm (very strong), and F3 (7.5% extract) 28.33 mm (very strong). The positive control mupirocin showed a very strong inhibition zone (30.67 mm), while the negative control showed no inhibition zone. An increase in extract concentration correlates with an increase in the zone of inhibition, supported by previous research that showed antibacterial activity of coriander seed extract against Propionibacterium acnes (Wahyuningsih *et al*., 2023). Statistical analysis using SPSS showed significant differences in antibacterial activity between formulas containing extracts with nanoemulsion base and between positive control and base.

CONCLUSION

Based on the results of the study, it can be concluded that the nanoemulsion cream preparation formulation of ethanol extract of coriander seeds (*Coriandrum sativum* L.) shows good physical characteristics, as evidenced by the organoleptic test, pH, spreadability, adhesiveness, homogeneity, and appropriate cream type. In addition, this

preparation also has significant antibacterial activity. Coriander seed extract concentration of 7.5% showed the greatest antibacterial activity against Staphylococcus aureus bacteria, with an average inhibition zone diameter of 28.33 mm, which was categorized as very strong.

ACKNOWLEDGMENTS

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CONFLICT OF INTEREST

We declare that we have no conflict of interest

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