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ANTIBACTERIAL ACTIVITY TEST OF LAMTORO (LEUCAENA LEUCOCEPHALA L.) SEED INFUSION AGAINST PROPIONIBACTERIUM ACNES

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Abstract

Background: Lamtoro, also known as Chinese petai, is a wild plantaa found throughout Indonesia, including Papua. Lamtoro plants are commonly used by people as traditional medicine to heal wounds, treat worms, and treat acne. The part used is the seeds of the lamtoro plant (*Leucaena leucocephala* L.), which contain alkaloids, flavonoids, saponins, and tannins, which have the potential as antibacterials. **Objective:** to determine the inhibitory activity of lamtoro seed infusion extract (*Leucaena leucocephala* L.) at concentrations of 12.5%, 25%, and 50% against *Propionibacterium acnes*. **Method:** Extraction was performed using the infusion method, and antibacterial activity was tested using the agar diffusion technique.**Results:** The three concentrations tested had inhibitory power against *Propionibacterium acnes* with an average diameter formed at a concentration of 12.5% of 8.19 mm, a concentration of 25% of 9.60 mm, and a concentration of 50% of 9.76 mm. **Conclusion:** In this study, it can be concluded that the extract of lamtoro seed infusion with concentrations of 12.5%, 25% and 50% has moderate antibacterial activity against *Propionibacterium acnes*.

Keywords: Antibacterial, infusion, *Leucaena leucocephala* L, *Propionibacterium acnes*

1. INTRODUCTION

Acne is a skin problem that often occurs during adolescence and into adulthood. It is characterized by the appearance of blackheads, pustules, papules, cysts, and nodules on the neck, face, upper arms, back, and chest (Winato *et al*., 2019).

Common bacteria that infect acne are *Propionibacterium acnes*, *Staphylococcus aureus*, and *Staphylococcus epidermidis*. *P. acnes* is the primary target of antibacterial treatments for acne. *P. acnes* is a slow-growing, Gram-positive anaerobic bacterium often found in acne. *P. acnes* plays a role in the pathogenesis of acne vulgaris by producing lipases that break down free fatty acids from skin lipids. These fatty acids can cause tissue inflammation when interacting with the immune system and contribute to the development of acne vulgaris (Winato *et al*., 2019).

The use of natural ingredients as traditional medicine in Indonesia has recently increased, with some even being manufactured on a large scale. Traditional medicine is considered to have fewer side effects than chemical-based medications. Therefore, alternative acne treatments utilizing natural ingredients are needed. One of the medicinal plants often used as a source of medicine is the lamtoro plant, also known as petai cina (*Leucaena leucocephal*a L.), a wild plant found almost throughout Indonesia. Leucaena seeds contain secondary metabolites such as alkaloids, flavonoids, saponins, and

tannins, which have antibacterial potential. This plant has also been reported to have antibacterial, antidiabetic, anti-inflammatory, anticancer, anthelmintic, and antioxidant properties (Lailis *et al*., 2024).

To obtain the active ingredient in seeds, the infusion method was used. Infusion is a liquid preparation obtained by extracting plant-based drugs using hot water at 90°C for 15 minutes. The infusion method was chosen in this study because it is considered simple, affordable, and more closely approximates the general use of traditional medicine, as well as being good for polar and thermostable compounds (Risfianty and Indrawati, 2020).

According to Sevitri's research (2021), it was shown that the concentration of 70% Lamtoro skin extract had the highest inhibitory power (12.9 mm) against *P. acnes* bacteria, then in the research of Sari et al., (2020), it was shown that the antibacterial activity of Lamtoro seed extract had a Minimum Killing Concentration (MBC) against *S. aureus* of 50%.

Based on the potential of lamtoro as an antibacterial, a study was conducted to determine the activity of lamtoro seed infusion against Propionibacterium acnes bacteria at concentrations of 12.5%, 25% and 50%.

2. METHODOLOGY

This research was conducted at the Pharmacognosy Laboratory of the Poltekkes Kemenkes Jayapura and the Microbiology Laboratory of Cenderawasih University in April-May 2025. This research is an experimental laboratory research by testing and observing the inhibitory activity of Lamtoro (*Leucaena leucocephal*a L.) seed infusion extract against Propionibacterium acne bacteria using the diffusion method.

Preparation of Lamtoro Seed Extract: The process was carried out in the Pharmaconosy Lab of the Poltekkes Kemenkes Jayapura. Extraction was carried out using the infusion method using 50 grams of fresh lamtoro seeds with 100 ml of distilled water in a ratio of 1:2. The lamtoro seeds that had been added with distilled water were heated using a water heater for 15 minutes after the temperature in the pan reached 90^{o}C, while stirring occasionally. While hot, they were filtered using a flannel cloth, and 100 ml was made as a stock solution. The stock solution was diluted to 25% and 12.5% concentrations.

Bacterial Sample Preparation: This study was conducted at the UNCE Microbiology Laboratory. A single loop of *P. acnes* bacterial culture from slant agar media was streaked onto sterile Nutrient Agar (NA) media for cultivation. The media was then incubated at 37°C for 18-24 hours. Then the turbidity level was checked by comparing the turbidity of a 0.5 McFarland standard solution (equivalent to 1.5x10^{8} CFU/mL) (Rijal and Asri, 2024). To prepare 38 grams of Muller-Hinton agar (MHA) media in 1000 ml, 2.85 grams of MHA media were dissolved using 75 ml of aquadest. Next, the MHA media was stirred and heated on a hot plate. It was put into 15 petri dishes with 15 ml in each dish and then left at room temperature until it solidified. After that, the MHA media was sterilized in an autoclave for 15 minutes at a temperature of 121^{o}C.

Antibacterial Activity Test of Leucaena Seed Infusion: Four petri dishes containing sterilized MHA media were prepared, then a suspension of *P. acnes* bacteria was taken using a sterile cotton swab and spread evenly on the surface of the agar media. Paper discs were dipped for 15 minutes into leached seed infusion with concentrations of 12.5%, 25% and 50% as well as negative and positive controls. The paper discs that had been dipped into the preparation were then placed on the agar media. The treatment was carried out three times (triplicate), where the first agar media contained three paper discs that had been soaked in 12.5% extract, repeated for the second and third agar media with different concentrations of 25% and 50%. Then the fourth agar media contained one negative control (aquadest) and one positive control (Clindamycin). After that, the media was incubated for 24 hours at 37oC. The inhibition zone formed was measured using a caliper as qualitative data.

3. RESULTS

The seeds of the lamtoro plant were obtained from the Poltekkes Kemenkes campus area in Jayapura. First, the lamtoro seeds were harvested in the morning because the active compound content in the plant tends to be higher at that time. In addition, in the morning the air temperature is still relatively low, thus preventing the evaporation of volatile active compounds (Pantastico, 2020). After harvesting, wet sorting was carried out to select lamtoro seeds that were still green and fresh, then washed using running water with the aim of removing dirt attached to the lamtoro seeds. The washed lamtoro seeds were drained after which an infusion was made.

The following is a table of observations of antibacterial activity tests on Propionibacterium acnes after administering lamtoro seed infusion for 1x24 hours using the disc diffusion method:

Table 1. *Antibacterial Activity Test of Lamtoro Seeds Against Propionibacterium acnes*

Concentration (%)	**Diameter Inhibitor Power**				**Description**
	R1	**R2**	**R3**	**Average (mm)**	
12,5	8,99	7,06	8,52	8,19	Moderate
25	9,29	10,00	9,52	9,60	Moderate
50	9,76	9,59	9,94	9,76	Moderate
K (+) Clindamycin		28,32		28,32	Very Strong
K(-) Aquadest		0		0	-

4. CONCLUSIONS

The lamtoro (*Leucaena leucocephala* L.) plant is a wild plant found almost throughout Indonesia, including Papua. Leucaena consists of small, dense leaves on each branch and also bears fruit. Leucaena fruit contains seeds located transversely within the pods. Leucaena seeds are similar to petai, but smaller (Lailis *et a*l., 2024). Empirically, lamtoro seeds are often used as traditional medicine, including to treat worms, heal wounds, and treat acne. Leucaena seeds contain secondary metabolites such as alkaloids, flavonoids, saponins, and tannins, which have potential antibacterial properties (Sari *et al*., 2020).

The extraction method used was infusion, which involves extracting the herbal medicinal plants using hot water at 90°C for 15 minutes. The infusion method was chosen in this study to prevent damage to the compounds in the samples due to prolonged heating (Risfianty and Indrawati, 2020). The infusion method also has the advantages of being easy to use and requiring simple equipment. Aquadest was chosen as the solvent because it is a polar solvent that is effective in extracting polar compounds from lamtoro seeds, such as flavonoids, alkaloids, tannins, and saponins (Santosa et al., 2023).

The antibacterial activity test of lamtoro seed infusion was conducted to determine its inhibitory power against Propionobacterium acnes bacteria. The first antibacterial activity test was the preparation of a McFarland solution. The McFarland standard was used as a comparison for the number of bacterial colonies in the liquid medium used for antibacterial activity testing, with a certain colony density range. The turbidity of the standard solution was 0.5. The McFarland test corresponds to a cell colony count of approximately 1.5 x 108 CFU/ml (Aviany and Pujiyanto, 2020).

Mueller Hinton Agar (MHA) media was prepared for antibacterial activity testing. This medium is used because all bacteria can grow on it, as it is neither a differential nor a selective medium.

Pathogenic bacteria can grow very easily (Putriani, 2023). Furthermore, this medium is designated as the standard medium for antimicrobial susceptibility testing. Through diffusion, MHA medium plates can create a better antimicrobial diffusion area than most other plates (Fitriana *et al*., 2020).

This test uses the paper disc method. This method is used to test the antimicrobial activity of an antibiotic against disease-causing pathogenic microorganisms. The size of the clear zone formed indicates the sensitivity of the pathogenic microorganism to the antibiotic. The parameter used is the clear zone, which is the clear area around the paper disc, indicating the absence or inhibition of microorganism growth due to the excretion of antimicrobial substances by its competitors (Nurhayati *et al*., 2020).

Bacterial testing was conducted using three concentrations: 12.5%, 25%, and 50%. First, a 50% stock solution was prepared, then diluted to 12.5% , 25%, and 50%. Next, the three samples, along with the positive control (Clindamycin) and negative control (distilled water), were soaked in a petri dish until absorbed. Then, each paper disc was placed in its position in the MHA medium and incubated at 37oC for 1 x 24 hours. Then, the clear zone formed was measured with the aim of creating optimal conditions for the growth of the tested bacteria and to allow the tested antibacterial compounds to diffuse into the growth medium and inhibit bacterial growth (Guntur *et al*., 2021).

In testing the antibacterial activity of lamtoro seed infusion against *P.acnes* bacteria, the results obtained for the concentration of lamtoro seed infusion 12.5% had an inhibitory power of 8.19 mm, including the category of moderate inhibition response, the concentration of 25% had an inhibitory power of 9.60 mm, including the category of moderate inhibition response and the concentration of 50% had an inhibitory power of 9.76 mm, including the category of moderate inhibition response. These results show that the greater the concentration, the higher the inhibition zone produced. This is because the higher the concentration of antimicrobial ingredients will increase the active substances are contained in them, thereby increasing the effectiveness in inhibiting microbes (Angelina *et al*., 2020).

The results of this study align with similar research conducted by Sari *et al*. (2020) on the antibacterial activity of petai cina seed extract against *Staphylococcus aureus*. This study found that a 50% concentration of lamoro seed extract could inhibit *S. aureus*, one of the bacteria that causes acne.

The antibacterial activity of lamtoro seed infusion is due to the chemical compounds contained in the lamtoro seed infusion extract, namely flavonoids and saponins. Where the mechanism of action of flavonoids as antibacterials is by damaging cell walls, deactivating enzyme activity, binding to adhesins, and damaging cell membranes. The beta ring and -OH group in flavonoids are thought to be the structures that play a role in antibacterial activity, while Saponins function as antibacterials by disrupting the integrity and function of bacterial cell walls, namely by causing leakage of proteins and enzymes from within the cell. Saponins can be antibacterial because the active substance on their surface is like a detergent, so saponins will reduce the surface tension of the bacterial cell wall and damage the membrane permeability. Damage to the cell membrane will disrupt the survival of bacteria (Pramesuari, 2023).

ACKNOWLEDGEMENTS

Based on the results of the research that has been carried out, it can be concluded that the antibacterial activity of lamtoro seed infusion with concentrations of 12.5%, 25% and 50% has an average diameter of 8.19 mm, 9.60 mm and 9.76 mm, respectively with a moderate inhibition zone category.

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EFFECTIVENESS OF ETHANOLIC EXTRACT OF AVOCADO LEAVES (PERSEA AMERICANA MILL.) AS A HAIR TONIC ON HAIR GROWTH IN MALE RABBITS (ORYCTOLAGUS CUNICULUS)

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Abstract

Avocado (*Persea Americana Mill*.) is one of the plants that can increase hair growth. Secondary metabolite compounds contained in avocado leaves are flavonoids, alkaloids, saponins, tannins, terpenoids which act as antioxidants that can protect hair from chemical care products, pollution, and damaged hair due to lack of nutrition. This study aims to determine the secondary metabolite compounds contained in avocado leaves (*Persea Americana Mill*.), to determine the difference in hair growth in hair tonic preparations of avocado leaf ethanol extract (*Persea Americana Mill*.) at concentrations of 2%, 4%, 6%, 8% for male rabbits and to determine the effectiveness of hair tonic avocado leaf ethanol extract (Persea Americana) on hair growth in male rabbits (*Oryctolagus cuniculus*). This study is included in experimental research using the Completely Randomized Design (CRD) method. The results showed that there are secondary metabolite compounds contained in avocado leaves, namely flavonoids, saponins, tannin and terpenoid. The experimental animals used in this study consisted of six male rabbits and hair growth measurements were conducted on the 14th day. Statistical analysis showed differences in hair growth in male rabbits (*Oryctolagus cuniculus*) at each concentration of the ethanolic avocado leaf extract hair tonic, namely 6,60mm (2%), 5,90mm (4%), 5,31mm (6%), 5,25mm (8%), 2,50mm (K+) and 6,51mm (K-). The results indicate that the most effective concentration of the ethanolic avocado leaf extract hair tonic for promoting hair growth is 2%.

Keywords: Avocado leaves, secondary metabolites, hair growth.

1. INTRODUCTION

Maintaining healthy and beautiful hair is not easy, as hair often encounters various problems. One of the most common issues is dandruff and hair loss. These problems can be very disruptive and significantly reduce an individual's self-confidence [4]. Hair loss is a condition in which the amount of hair becomes noticeably less due to excessive shedding beyond the normal range, even though thinning may not be immediately visible. Normally, hair sheds at a rate of around 80–120 strands per day [7]. Excessive hair loss beyond this normal range can lead to baldness. A simple way to address hair loss is by treating the hair using hair tonic, which serves as a nutrient source for the hair [1]. Hair tonic is a liquid cosmetic product composed of chemical substances or other ingredients that help strengthen the hair, promote growth, and maintain hair condition. Hair tonic functions to improve blood circulation in the scalp, thereby preventing hair loss, stimulating hair growth, preventing dandruff and itching, and refreshing the scalp [17].

Natural ingredients derived from plants can be used as active compounds in hair tonic formulations, with avocado leaves being one such option due to their potential to nourish the hair and prevent hair

loss. Phytochemical screening has shown that the ethanolic extract of avocado leaves contains flavonoids, alkaloids, saponins, and tannins [14]. Previous studies have mostly focused on avocado fruit and seeds; however, the leaves also contain bioactive compounds with antioxidant, anti-inflammatory, and antimicrobial properties that may contribute to maintaining scalp health and stimulating hair follicle activity [16][18].

The concentration levels of 2%, 4%, 6%, and 8% were selected to observe the dose-dependent response of the extract in promoting hair growth while ensuring safety and optimal efficacy. The mechanism of action is thought to involve flavonoids acting as antioxidants that protect follicular cells from oxidative stress, saponins improving scalp circulation and facilitating nutrient delivery, and tannins providing astringent effects that strengthen hair roots and reduce excessive sebum production [18].

Based on this explanation, the researcher aims to innovate by using avocado leaf extract as an active ingredient in hair tonic for hair growth. This idea is inspired by previous research such as that by Diana & Wahini [5], which used avocado fruit extract and honey as active ingredients in hair tonic for hair loss, and by Pradiningsih & Risnawati [13], who tested the effectiveness of hair tonic made from avocado seed extract (*Persea Americana Mill)* on hair growth in male rabbits. However, research specifically focusing on the use of avocado leaf extract in hair tonic formulations is still very limited and has not yet been explored.

The hypothesis of this study is as follows:

- **(H_0):** There is no difference in hair growth in male rabbits with the administration of hair tonic containing ethanolic extract of avocado leaves (*Persea americana*).
- **(H_1):** There is a difference in hair growth in male rabbits with the administration of hair tonic containing ethanolic extract of avocado leaves (*Persea americana*).

2. METHODOLOGY

This research is a quantitative study with an experimental design using a Completely Randomized Design (CRD) method. The study tests hair tonic formulated with avocado leaf extract (*Persea Americana Mill*) at various concentrations (2%, 4%, 6%, and 8%) to evaluate its effect on hair growth in male rabbits. Two types of control treatments were used: a positive control and a negative control, along with the four concentrations of the avocado leaf extract hair tonic.

This study was conducted in accordance with the ethical guidelines for the use of experimental animals, with consideration for animal welfare principles, and received approval from the Health Research Ethics Committee of the Faculty of Pharmacy, YPIB University, as evidenced by Ethical Approval Number: 173/KEPK/EC/V/2024.

The inclusion criteria for this study were fresh avocado leaves with a green coloration. The exclusion criteria included avocado leaves that were damaged, infested by pests, or brown in color. For the test animals, the inclusion criteria were healthy male rabbits aged 6–7 months, with a body weight of approximately 1 kg. The exclusion criteria for the test animals included rabbits that were ill, younger than 6 months or older than 7 months, weighing less than 1 kg, or that became sick or died during the study.

The initial preparation involved the collection of avocado leaves (*Persea Americana Mill*) from Gelok Mulya Village, Sumberjaya District, Majalengka Regency. The leaves were washed clean, roughly chopped, and air-dried at room temperature until completely dry. The dried leaves were then ground using a blender until a fine powder was obtained [3]. A total of 1000 g of avocado leaf powder

was weighed and placed in a beaker, then soaked in 96% ethanol until completely submerged. The maceration process was carried out for 3 x 24 hours in a closed container, with a ratio of simplicia and 96% ethanol solvent of 1:10, then the mixture was stirred periodically. After the extraction period, the mixture was filtered. To obtain a concentrated extract, the filtrate was evaporated using a rotary evaporator at a temperature of 50°C.

The resulting avocado leaf extract was then subjected to phytochemical screening to identify the presence of chemical constituents such as alkaloids, phenols, flavonoids, saponins, tannins, and steroids or triterpenoids [6].

The next step involved the formulation of a basic hair tonic with avocado leaf extract concentrations of 2%, 4%, 6%, and 8%. The formulation of the avocado leaf extract hair tonic was adapted from the study on ethanol extract of green tea leaves [12].

Table 1. Hair Tonic Formulation Composition

No.	Ingredients	K–	F1	F2	F3	F4
1	Avocado leaf extract	–	2%	4%	6%	8%
2	Propylene glycol	10%	10%	10%	10%	10%
3	Propyl paraben	0.01%	0.01%	0.01%	0.01%	0.01%
4	Methyl paraben	0.02%	0.02%	0.02%	0.02%	0.02%
5	Menthol	0.1%	0.1%	0.1%	0.1%	0.1%
6	Sodium metabisulfite	0.01%	0.01%	0.01%	0.01%	0.01%
7	Ethanol	60 mL	60 mL	60 mL	60 mL	60 mL
8	*Oleum rosae*	q.s.	q.s.	q.s.	q.s.	q.s.
9	Distilled water (*Aqua dest*)	ad 100 mL	ad 100 mL	ad 100 mL	ad 100 mL	ad 100 mL

Notes:

- K– = Negative control (without avocado leaf extract)
- q.s. = *quantum satis* (as much as sufficient)
- ad = to make up to the final volume

The method for making hair tonic with avocado (Persea americana) leaf ethanol extract according to the formulation is as follows:

1. Preparation of Preservative and Solvent Solution: Dissolve propyl paraben and methyl paraben in a small amount of propylene glycol or ethanol for easier dissolution. And then add sodium metabisulfite
2. Dissolve menthol and oleum rosae in ethanol or propylene glycol to ensure proper mixing of water-insoluble components.
3. Hair Tonic Base Preparation: Mix distilled water and propylene glycol in a clean container. Add the preservative, menthol and *Oleum rosae* solutions while stirring gently.
4. Addition of Avocado Leaf Extract: Add the avocado leaf extract according to the formulation concentration. Stir until homogeneous, ensuring no sediment or layer separation occurs. Final adjustment, adjust the final volume with distilled water to reach 100 mL.

The resulting formulations underwent characteristic evaluations, including organoleptic testing, homogeneity, pH stability, specific gravity, and viscosity.

After formulation, a hair growth activity test was conducted using the ethanol extract of avocado leaves on 6 rabbits over a 14-day period [11]. The experimental animals used were rabbits, with their dorsal fur shaved using scissors and a razor. The shaved area was divided into multiple test zones, each measuring approximately 2.5 cm, with a spacing of about 0.5 cm between zones.

Hair tonic was applied once daily to each zone, with a dosage of approximately 1 mL per zone for 14 days. On day 14, hair length measured. Hair weight was determined by shaving the regrown hair from each test zone and weighing it. For hair length measurement, the three longest strands from each zone were selected, placed on black fabric, secured with adhesive tape, and measured from base to tip using a caliper.

3. RESULTS

The study aimed to investigate the activity of hair tonic formulated with ethanol extract of avocado leaves (*Persea Americana Mill*) in male rabbits (*Oryctolagus cuniculus*). The research was conducted through several stages, including plant identification, extraction of avocado leaves (*Persea Americana Mill*), phytochemical screening, formulation of hair tonic, evaluation of the formulation, and assessment of hair growth effectiveness in male rabbits (*Oryctolagus cuniculus*).

3.1 Plant Identification

The identification of avocado leaves was carried out at the MIPA Laboratory, Faculty of Biology, IAIN Syekh Nurjati Cirebon. The results of the identification confirmed that the plant sample used was *Persea Americana Mill.*

3.2 Extraction of Avocado Leaves

Extraction was carried out using the maceration method, with 96% ethanol as the solvent. From 1 kg of powdered avocado leaf (*Persea Americana Mill*) simplicia, 265.23 grams of extract were obtained, yielding an extract percentage of 26.52%.

3.3 Phytochemical Screening of Avocado Leaves

Phytochemical screening of avocado leaf extract (*Persea Americana Mill*) included tests for flavonoids, alkaloids, saponins, tannins, and terpenoids. The results of the phytochemical screening of avocado leaf extract (*Persea Americana Mill*) are presented in Table 2.

Table 2. Results of Phytochemical Screening of Avocado Leaf Extract (*Persea Americana Mill*)

Phytochemical Test	Reagent(s)	Observation	Reference [8]	Result
Flavonoid	Ethanol, Mg, concentrated HCl	Orange-black coloration	Red, yellow, or orange coloration	+
Alkaloid (Mayer)	Mayer reagent	No white precipitate	Formation of white precipitate	–
Alkaloid (Bouchardat)	Bouchardat reagent	No reddish-brown precipitate	Formation of reddish-brown precipitate	–
Alkaloid (Dragendorff)	Dragendorff reagent	No yellow precipitate	Formation of yellow precipitate	–
Saponin	Distilled water, 2N HCl	Formation of stable foam	Formation of stable foam	+

Phytochemical Test	Reagent(s)	Observation	Reference [8]	Result
Tannin	Distilled water, 5% $FeCl_3$	Dark green coloration	Blue or dark green coloration	+
Terpenoid	Chloroform, concentrated H_2SO_4	Dark brown coloration	Reddish-brown coloration	+

Phytochemical screening revealed the presence of flavonoids, saponins, tannins, and terpenoids. In contrast, alkaloid tests using Mayer, Bouchardat, and Dragendorff reagents were negative, as no characteristic precipitates were observed. Literature and current findings suggest several points:

a. Alkaloid production varies among plant species and plant parts. In this study, alkaloids were detected in seeds, while only trace amounts—or none—were found in pulp or leaves [8].
b. Total alkaloid content was 41.5 ± 1.8 mg/g extract, substantially lower than phenolics (184.1 ± 0.6 mg/g) and flavonoids (115.8 ± 2.1 mg/g), indicating a minor contribution of alkaloids to the overall phytochemical profile [10].
c. Secondary metabolite production, including alkaloids, is influenced by factors such as leaf age, growth conditions, season, light, soil, and environmental stress. Plants grown under optimal conditions or without environmental pressure often produce lower amounts of alkaloids, as their biosynthesis is typically an adaptive response to stress [19].

3.4 Evaluation of the Hair Tonic Formulation Containing Ethanol Extract of Avocado Leaves (*Persea Americana*)

The evaluation of the hair tonic formulation included organoleptic testing, specific gravity, pH testing, and viscosity testing.

Figure 1. *Hair Tonic Preparation at concentrations of 8%, 6%, 4%, and 2%*

3.4.1 Organoleptic Test

The results of the organoleptic evaluation of the hair tonic formulation containing ethanol extract of avocado leaves (*Persea Americana*) are presented in Table 3 below:

Table 3. Organoleptic Test Results

Formula	Color	Odor
K+	Clear green	Characteristic of green tea
K–	Clear white	Characteristic of ethanol
F1	Clear orange	Characteristic of *oleum rosae*
F2	Brownish orange	Characteristic of *oleum rosae*
F3	Brown	Characteristic of *oleum rosae* and avocado leaf
F4	Black	Characteristic of avocado leaf

3.4.2 Specific Gravity

The specific gravity values of the preparations obtained ranged from 0.930 to 0.947, which comply with the Indonesian National Standard (SNI) 16-4955-1998. The specific gravity of the hair tonic preparations is less than 1, which corresponds to the specific gravity of water [2]. The data from the specific gravity measurements are presented in Table 4 below:

Table 4. Specific Gravity Test Results

No.	Formula	Specific Gravity (g/mL)
1	K+	0.994
2	K–	0.920
3	F1	0.930
4	F2	0.935
5	F3	0.942
6	F4	0.947

3.4.3 pH Test

The pH test results of the hair tonic preparation containing avocado leaf extract for all formulas showed a pH of 5. This complies with the Indonesian National Standard (SNI) 16-4955-1998, which specifies a pH range of 3 to 7. The pH measurement results of the hair tonic formulations containing avocado leaf (*Persea Americana Mill*) extract are presented in Table 5 below:

Table 5. pH Test Results

No.	Concentration	pH
1	K+	5
2	K–	5
3	F1	5
4	F2	5
5	F3	5
6	F4	5

3.4.4 Viscosity Test

The viscosity measurements of the hair tonic formulations containing ethanol extract of avocado leaves (*Persea Americana*) are shown in Table 6 below:

Table 6. Viscosity Test Results

Formula	Viscosity (cPs)
K+	0.934
K–	1.242
F1	1.207
F2	1.224
F3	1.249
F4	1.448

It can be concluded that the ethanol extract hair tonic preparation from avocado leaves is suitable for use on the scalp, as it falls within an acceptable range and complies with the Indonesian National Standard (SNI) 16-4955-1998, which stipulates that the viscosity value of hair tonic preparations should be less than 5 cPs.

3.4.5 Hair Growth Effectiveness Test

Table 7. Rabbit hair length during treatment

Treatment	Hair Length (mm)			Average (mm)
	1	2	3	
K+	2,90	2,05	2,56	2,50
K-	6,11	6,98	6,43	6,51
F1	6,62	6,20	6,97	6,60
F2	5,98	6,19	5,54	5,90
F3	5,11	5,40	5,43	5,31
F4	5,21	5,32	5,22	5,25

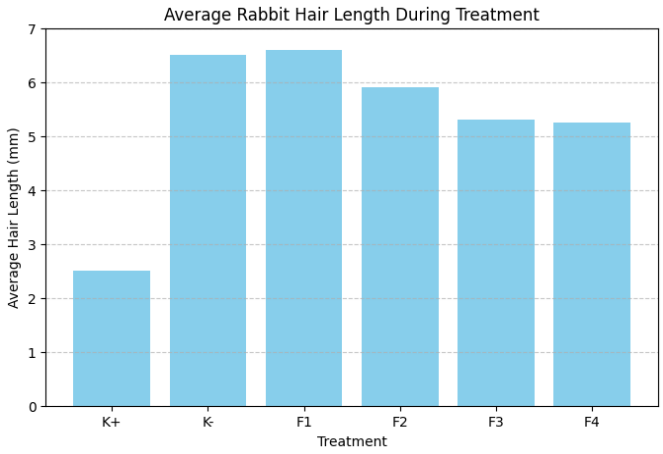

Figure 2. *Average Rabbit Hair Length During Treatment*

Table 8. Data Analysis Results of Hair Growth Effectiveness Test

Statistical Test	Statistic (stat)	p-value	Conclusion
Normality Test (Shapiro-Wilk)			
K+	0.9868	0.7804	Data is normally distributed
K-	0.9772	0.7107	Data is normally distributed
F1	0.9973	0.8999	Data is normally distributed
F2	0.9599	0.6151	Data is normally distributed
F3	0.8196	0.1623	Data is normally distributed
F4	0.8176	0.1572	Data is normally distributed
Homogeneity Test (Levene)	0.7154	0.6239	Variances are homogeneous
One-Way ANOVA	60.7619	0.0000	Significant difference in means

The results of the statistical analysis showed that all treatment groups (K+, K−, F1, F2, F3, F4) met the assumption of normality, as indicated by Shapiro-Wilk test p-values greater than 0.05. Levene's test for homogeneity of variances also yielded a p-value of 0.6239, which is above 0.05, indicating that the variances among groups were homogeneous. Furthermore, the One-Way ANOVA test revealed a highly significant result with a p-value of 0.0000, suggesting that there were statistically significant differences in the mean values between the treatment groups.

Table 9. Tukey HSD Post-hoc Test

Treatment 1	Treatment 2	p-value (p-adj)	Conclusion
F1	F2	0.1867	Not significantly different
F1	F3	0.0053	Significantly different
F1	F4	0.0036	Significantly different
F1	K+	0.0000	Significantly different
F1	K-	0.9993	Not significantly different
F2	F3	0.3208	Not significantly different
F2	F4	0.2320	Not significantly different
F2	K+	0.0000	Significantly different
F2	K-	0.3003	Not significantly different
F3	F4	0.9999	Not significantly different
F3	K+	0.0000	Significantly different
F3	K-	0.0091	Significantly different
F4	K+	0.0000	Significantly different
F4	K-	0.0062	Significantly different
K+	K-	0.0000	Significantly different

These findings indicate that certain treatments, particularly those involving K+ and K-, show distinct effects compared to some fertilizer treatments (F1-F4), while other pairs exhibit similar effects with no significant difference.

The data on rabbit hair length measured over 14 days showed that the negative control exhibited greater hair growth compared to the positive control and the highest extract concentration of 2%. High concentrations of active compounds in the hair tonic may lead to excessive accumulation of secondary metabolites, which can inhibit growth by reducing the optimal absorption of compounds by the hair or follicles, or even cause side effects. In contrast, low concentrations can stimulate the production of secondary metabolites at an optimal level without negative effects [15]. Low concentrations also allow compounds such as flavonoids, saponins, and essential fatty acids from avocado leaves to be absorbed more evenly into the scalp, thereby supporting hair growth.

4. CONCLUSIONS

Based on the results of the study, it can be concluded that avocado leaves (*Persea Americana Mill*) contain secondary metabolites, including flavonoids, saponins, tannins and terpenoid. The evaluation of the hair tonic formulation included organoleptic assessment, specific gravity, pH, and viscosity tests, all of which yielded results that met the required standards. The hypotheisis (H_1) can be accepted, which is there is a difference in hair growth in male rabbits with the administration of hair tonic containing ethanolic extract of avocado leaves (*Persea americana*). Differences in hair growth were observed among male rabbits (*Oryctolagus cuniculus*) treated with various concentrations of ethanol extract-based avocado leaf hair tonic. Hair growth occurred across all treatment groups, with a continuous increase observed up to day 14. The 2% concentration showed the highest average hair growth, reaching 6.60 mm or 0.66 cm.

5. SUGGESTION

a. Recommended for future researchers to conduct further qualitative analysis on avocado leaves, such as thin layer chromatography (TLC) or column chromatography, to detect alkaloids that may be present in very small amounts.
b. Recommended that future researchers perform quantitative analyses on avocado leaf extract to more precisely determine the concentrations of the compounds it contains.
c. Recommended that future researchers combine avocado leaf extract with other natural ingredients that can accelerate hair growth.
d. Recommended for future researchers to create additional concentration variations for each formulation and to extend the treatment duration

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CORRELATION BETWEEN MATERNAL BEHAVIOR AND CHILDHOOD DENTAL CARIES

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Abstract

Early Childhood Caries (ECC) remains the most prevalent disease among children. The role of mothers plays a critical part in forming their children's dental hygiene practices, which influences the incidence of dental caries. This study aims to analyze the correlation between maternal behavior and the occurrence of ECC. This study employed a cross-sectional design involving 305 mothers of children from seven kindergartens. Data on maternal behavior were collected using a structured questionnaire, while children's dental status was assessed through clinical examination based on the DMF (Decayed, Missing, and Filled) index. Statistical analyses included descriptive statistics, normality testing, and correlation analysis using the ANOVA test with a significance level of α = 0.05. The mean maternal behavior score was 43.134 (SD = 6.807), and the mean DMF index of children was 7.345 (SD = 4.609). The normality test showed that maternal behavior was not normally distributed ($p < 0.0001$), whereas the DMF variable was normally distributed ($p = 0.147$). The correlation test revealed a very weak and non-significant relationship between maternal behavior and children's dental caries status ($r = –0.067$, $p = 0.306$). There was no significant correlation between maternal behavior and the incidence of dental caries in children. These findings indicate that maternal behavior alone may not directly influence children's oral health outcomes. Future interventions should adopt a multifactorial approach that includes improving maternal oral health literacy, dietary supervision, and access to dental care services.

Keywords: Dental caries, Maternal behavior, Children, Correlation

1. INTRODUCTION

Early Childhood Caries (ECC) remains the most chronic disease suffered by children in the world. Mother's role in the practice of oral hygiene, feeding habits, oral-health knowledge, and attitude is consequential in shaping the children's dental health outcomes [1], [2]. The actions towards those practices influence the children's exposure to cariogenic bacteria, dietary patterns, and daily oral care routines. This is because caries occurs as a consequence of demineralization of the enamel and dentin of the teeth, which is related to dietary patterns such as consuming cariogenic foods [3]. Besides, the habit of sharing utensils and inappropriate feeding practices such as frequent consumption of sugary foods and drinks, prolong the risk of ECC. Another factor of limited maternal dental health literacy and low access to dental health care, shows the increasing risk of ECC [4], [5].

The risk of ECC in Indonesia is still high. It is mentioned by the national report that in 2023, the DMF-T index of children aged 3-4 years old is 4.9, which is a high risk of caries. Besides, those at age 5 years old had a 6.7 DMF-T index, categorized as very high risk of caries. Comparing the global dental and oral disease of Indonesians in 2018, it was 57.6% and in 2023, the number decreased to 56.9%. However, those who were treated only 10.2% in 2018 and 11.2 % in 2023. Besides, in 2023, it is known

that 95.6% of Indonesians brush their teeth every day. However, only 6.2% brush their teeth correctly way [6]. This number explicitly reveals that the parental behavior of dental care is still a problem.

Recent studies have expressed the multifactorial nature of ECC development. A systematic review confirms that parental oral hygiene behavior, feeding patterns, and socioeconomic conditions are related to the occurrence of ECC [7]. Maternal oral health status, as well as psychosocial conditions, also play a part in the behavior of children in maintaining oral health. Children often adopt their parents' tooth-brushing habits and attitudes in dental care. Research regarding parental behavior towards dental health shows that 61% parents with a strong intention towards the behavior of toothbrushing had better oral hygiene behavior than the parents with a weak intention [8]. Nevertheless, research shows that from the study of surveying the mothers at primary school, there were only 46.7% mothers who had a good category of knowledge, and 90% had a positive attitude towards dental health care [9]. However, few analyze the correlation between the maternal behavior towards ECC. Analyzing the correlation between maternal behavior and the incidence of caries in children is crucial because mothers play a central role in shaping children's dental health habits from an early age. Mother becomes the figure who provides daily care, such as diet and dental hygiene. Assessing the maternal behavior towards ECC helps design more effective preventive interventions. For example, if research finds that mothers' lack of knowledge about brushing their children's teeth is a dominant factor, educational programs can focus on improving mothers' dental health literacy. Furthermore, behavioral factors such as giving sweet foods, breastfeeding at night without brushing teeth, or using sugar-filled pacifiers can be changed through evidence-based educational approaches. But child factors may have a more significant direct effect because children have bodily integrity to control their own bodies and right to influence outcomes [10]. Therefore, this study aims to analyze whether maternal behavior correlates with children's caries.

2. METHODOLOGY

This research explores maternal behavioral patterns in maintaining early childhood oral health. Employing a multivariate, cross-sectional design, the study investigates the correlation between maternal behavior and its influence on dental caries in children. Data were collected simultaneously through structured observations and questionnaires to capture the dynamics of these correlations.

The study population consisted of 305 mothers whose children, were enrolled in seven kindergartens across Bukittinggi City. A cluster random sampling method was applied to ensure proportional representation from each kindergarten. In total, 305 respondents met the inclusion criteria, which comprised mothers of children aged five years and above, officially registered in the selected schools, and willing to participate voluntarily throughout the study process. Both mothers and their children consented to take part as respondents.

The variable being observed is the behavior of the mother as the independent variable and the children's caries index as the dependent variable. The instrument used in the research was a questionnaire. The questionnaire consisted of the behavioral habits of the mother. The questionnaire for the maternal behavior variable contains 15 questions regarding the assessment of the behavior, with four answer choices that reflect the level of suitability for the individual. The questionnaire assessment uses an ordinal scale with scores of 1 (very inappropriate), 2 (inappropriate), 3 (appropriate), and 4 (very appropriate). The questions regarding maternal behavior cover several points, including habits of maintaining children's dental and oral health, having children's dental and oral health checked at least once every six months, and using toothpaste containing fluoride. The caries scoring was conducted by examination of the children's teeth using an examination form. Dental caries is defined as a disease of the tooth tissue characterized by tissue damage, which can occur on one or more tooth surfaces and can spread to deeper parts of the tooth. The oral health examination form was completed directly with mothers and children attending Bukittinggi Kindergarten. The examination was conducted using a mouth mirror, WHO CPI probe, additional equipment (handscone, mask, nierbeken),

alcohol, and cotton swabs. After all teeth were examined, the results were recorded on the oral health examination form. The child's dental status was considered *Good* when the score reached 90% or higher, and *Poor* when it was below 90% using DMF (Decayed, Missing and Filled) score.

The research data were analyzed using multivariate analysis to assess the correlation between maternal behavior and children's caries. Multivariate analysis was used to describe the characteristics of each research variable. Multivariate analysis in this study included ANOVA regression. Numerical data are presented in the form of mean, standard deviation (SD), and median. Data analysis used a 95% significance level (p-value <0.05). The categorization of correlation is based on the coefficient value. If the value is <0.20, it is considered very weak; correlations between 0.20 – 0.39 are weak; correlations 0.40 – 0.59 are considered moderate; correlations 0.60 – 0.79 are strong, and correlations >0.80 are very strong [11].

3. RESULTS

This section presents the results of the study on the relationship between maternal behavior and the incidence of dental caries in children. The collected data were processed and analyzed to describe the characteristics of the respondents and to determine the correlation between the studied variables.

3.1 Frequency Distribution of Children's Age

The frequency distribution of the children age who were observed in the research is shown in Table 1.

Table 1. *Frequency distribution based on ages*

No.	Age (Years)	Frequency	Percentage (%)
1.	4 – 5 years old	91	30
2.	6 – 7 years old	214	70
	Total	305	100

Table 1 shows the distribution of respondents based on the children's age.

The majority of the participants were children aged 6–7 years old, accounting for 214 children (70%), while 91 children (30%) were aged 4–5 years old. This indicates that most of the children involved in this study were in the older age group (6–7 years), which may correspond to the period of early school attendance when dietary habits and oral hygiene behaviors begin to develop more independently.

3.2 Correlations between Variables

The data analysis was conducted in several stages. First, descriptive statistical analysis was performed to provide an overview of maternal behavior and children's dental caries status. Next, a normality test was conducted to verify that the data met the assumption of normal distribution before proceeding with further analysis. Finally, a correlation test was conducted to identify the strength and direction of the relationship between maternal behavior and the occurrence of dental caries in children. The results of these analyses are presented sequentially in the results.

Table 2. *Descriptive statistics of the variables*

Variable	Average	Standard Deviation
Maternal behavior	43.134	6.807
DMF of children	7.345	4.609

Table 2 shows that the maternal behavior has an average value of 43.134 with an SD of 6.807. This indicates a moderate level of variation among respondents. Meanwhile, the variable of DMF of the children got an average of 7.345 and an SD of 4.609, suggesting that most children experienced a relatively high level of dental caries. These results illustrate differences in maternal behavior and children's dental caries conditions within the study population.

Table 3. *Normality test results between variables*

Variable	p-value	α
Maternal behavior	<0.0001	0.05
DMF of children	0.147	

Table 3 shows the results of the normality test for each variable. The maternal behavior variable had a p-value of <0.0001, which is lower than the significance level (α = 0.05). This indicates that the data for maternal behavior are not normally distributed. In contrast, the DMF of children variable had a p-value of 0.147, which is greater than α = 0.05, suggesting that the data for children's dental caries status are normally distributed. The conclusion of these results is the data is not normally distributed.

Subsequently, the correlation test was conducted to determine the relationship between maternal behavior and the incidence of dental caries in children. Based on the results, a correlation coefficient (r) indicates the direction and strength of the relationship between the two variables. The p-value obtained from the analysis was compared to the significance level (α = 0.05).

Table 4. *Correlation between behavior and caries of the children*

Variables	*p-Value*	Correlation Coefficient
Behavior Caries	0.306	-0.067

Table 4 presents the results of the correlation analysis between maternal behavior and the dental caries status of children. The analysis shows that the p-value was 0.306, which is greater than the significance level (α = 0.05). This indicates that there is no statistically significant relationship between maternal behavior and the incidence of dental caries in children. Then, the correlation coefficient (r) shows -0.067. This result indicates a very weak negative correlation between the two variables. The relationship is not strong enough to be considered significant. Overall, these results suggest that maternal behavior alone may not directly influence the occurrence of dental caries in children, and other factors such as dietary habits, fluoride exposure, or access to dental care may also play an important role.

3.3 Maternal Behavior and Caries Incidence

Children are prone to dental caries. As stated by the Indonesia Health Survey in 2023, the aged 5 years have a 6.7 DMFT score, or categorized as having caries very high. Meanwhile, children aged 3-4 years have a 4.9 DMFT score or are categorized as high [6]. Therefore, the preventive action of dental caries should be performed at an early age to maintain the teeth. Because early childhood oral health determines the outcomes at their next ages and is considered essential, as it can impact oral health in adulthood [12].

This study aimed to evaluate the relationship between maternal behavior and the incidence of dental caries using the correlation analysis. The results of descriptive analysis show that the mean maternal behavior score was 43.134 (SD = 6.807), while the mean DMF index of children was 7.345

(SD = 4.609). The normality test indicated that the data are not normally distributed, as the maternal behavior has p < 0.0001, and the DMF index has a p-value. of 0.147. The correlation test produced a correlation coefficient (r) of –0.067 with a p-value of 0.306, demonstrating a very weak and statistically non-significant relationship between maternal behavior and children's dental caries status.

The findings of the study indicate that maternal behavior is not a single factor and is not sufficient to predict the incidence of caries in children. This is because dental caries is a multifactorial disease influenced by numerous factors, including maternal knowledge, children's oral hygiene habits, dietary patterns, fluoride exposure, and socioeconomic status [13], [14]. Previous studies have demonstrated a significant relationship between maternal factors and children's dental health outcomes. A study found that mothers with poor oral health (higher DMFT) were associated with higher DMFT scores in children (P < 0.001). Besides, mothers with low income also influence the children's oral health score (p-value = 0.043), a lower ratio of protein consumption (p-value = 0.014), showing that dietary patterns influence the dental health of the children. Most importantly, it is found that mothers who have behavior of dental health care, such as using a dental mouth rinse is significantly influence the incidence of DMFT of the children (p-value = 0.007) [15]. However, the study found different results because the maternal behavior variable used in this study may not have captured all relevant factors, such as oral health knowledge, supervision of children's hygiene, and access to dental care. Besides, there are also no confounding factors such as maternal education, income level, and dental health access, which may have influenced the results. The effect of maternal behavior on children's caries may be indirect, mediated by other variables such as diet, brushing frequency, or fluoride use.

It is mentioned in a study from Azimi et al (2018) that observed children at their mothers at an average age of 5.1 and 31 years, that the mothers' knowledge and children's DMFT have an inverse correlation (r = -0.6). This indicates that knowledge correlates with the incidence of caries in children, with a strong correlation. The result is also the same with mothers' knowledge of their DMFT (r = -0.7) [16]. This shows the consistent correlation that knowledge and DMFT have an inverse correlation. The same result as the study that the correlation between mothers' behavior and caries incidence in the children has an inverse correlation with a negative value (r=-0.067), even though it has a very weak correlation. The value indicates that if the behavior of the mother changes to a higher level of dental health behavior, the score of DMFT of the children decreases on average by 0.067. However, the result is not significant, proven by the p-value of 0.306 (p >0.05).

3.4 Implications, Limitations, and Future Studies

The findings of the study imply that interventions focusing solely on maternal behavior change may be insufficient without integrating broader preventive measures. Some strategies need to be performed to improve the mothers' oral health knowledge, concern towards access to dental health, and health promotion of dietary and environmental factors. Recent studies highlight the mother's literacy about oral health, which becomes a stronger determinant of children's oral health outcomes than behavior alone [17], [18]. Therefore, preventive programs should combine educational and structural interventions to effectively reduce caries prevalence in children.

This study is limited to behavioral measurement to a single composite score without deeper exploration factors such as oral hygiene supervision or dietary control. Besides, the potential confounders such as the education of the mothers, socioeconomic status and access of dental health services were not controlled. Future studies should adopt longitudinal designs to evaluate behavioral changes and their long-term effects on children's dental health. Expanding the behavioral constructs to include maternal knowledge, supervision, and dietary management, as well as incorporating mediating variables such as fluoride exposure and dental visit frequency, will provide a more comprehensive understanding of the complex pathways linking maternal factors to childhood dental caries.

4. CONCLUSIONS

The study found that the correlation between maternal behavior and dental caries is very weak, with a coefficient of correlation of -0.067. Besides, there is no statistically significant correlation between maternal behavior and dental caries incidence in children, with a p-value of 0.306. These results suggest that only maternal behavior may not have a direct or substantial effect on the occurrence of dental caries in children.

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FORMULATION AND DEVELOPMENT OF LIP BALM FROM RED SEAWEED (GELIDIUM SP.) EXTRACT AS A NATURAL ANTIOXIDANT

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Abstract

This study aimed to formulate and evaluate lip balm preparations incorporating red seaweed (Gelidium sp.) extract as a natural active ingredient with antioxidant and moisturizing potential. Four formulations were prepared: F0 (without extract), FI (5% extract), FII (7.5% extract), and FIII (10% extract). The formulations were evaluated through organoleptic observation, homogeneity testing, pH measurement, melting point determination, spreadability testing, qualitative antioxidant testing using DPPH, and a consumer preference test.

The organoleptic evaluation showed a consistent strawberry aroma across all formulations, with color and texture differences becoming more pronounced as extract concentration increased. Homogeneity testing indicated that F0 and FI met quality standards, while FII and FIII did not, likely due to uneven pigment distribution caused by the extract. All formulations exhibited pH values within the physiological lip pH range (4.0–6.5) and melting points between 51–58 °C, aligning with the acceptable cosmetic range (50–70 °C). All samples also met the required spreadability standard (5–7 cm). Qualitative DPPH testing revealed positive antioxidant activity for FI, FII, and FIII, with stronger activity observed at higher extract concentrations.

A preference test with 30 panelists showed that F0 and FI were most preferred for color and texture, while FII and FIII were less favored despite similar aroma and moisturizing characteristics. These results indicate that red seaweed (Gelidium sp.) extract can be effectively utilized as an active ingredient in lip balm formulations, particularly at lower concentrations, to provide antioxidant benefits and maintain desirable physical and sensory characteristics.

Keywords: Gelidium sp., red seaweed, lip balm, antioxidant activity, formulation evaluation, cosmetic product development.

1. INTRODUCTION

Indonesia is a tropical country with year-round exposure to sunlight. Sunlight contains ultraviolet (UV) rays that play an important role in the production of vitamin D and in eliminating bacteria. However, excessive UV exposure can damage the skin, including the lips[7]. The lips are one of the most sensitive parts of the face and lack a protective layer, making them prone to dryness and cracking when exposed to excessive heat or cold[4]. In addition, prolonged exposure to UV rays can damage the keratin cells of the lips, which serve as a protective barrier. Damaged keratin cells peel off, causing chapped lips, dryness, and dull lip color. Apart from being aesthetically unappealing, cracked lips can also cause pain and discomfort. To address this condition, cosmetic preparations such as lip balm are needed to help protect and maintain lip moisture[1].

Lip balm is a topical preparation applied to the lips to prevent dryness and protect against environmental factors. It may contain active ingredients that function to shield the lips from sunlight and other external stressors. These active ingredients can be derived from natural sources or synthesized as pure chemical compounds. Natural ingredients are often preferred because they tend to produce fewer side effects, especially with long-term use[4]. One of the active ingredients that can be incorporated into lip balm formulations is antioxidants.

Natural antioxidant compounds can be incorporated into lip balm formulations. Antioxidants function to counteract or neutralize free radicals, and the use of products containing antioxidants is expected to help prevent and slow down skin damage[4]. One natural ingredient with strong antioxidant potential is red seaweed (Gelidium sp.).

Gelidium sp. is a type of red seaweed found in Indonesia that contains antioxidant compounds. This species belongs to the class Rhodophyta (red algae). It is rich in agarose, vitamin B12, amino acids, aspartic acid, and other bioactive compounds. The secondary metabolites of red seaweed are known to provide several skin benefits, including reducing signs of skin aging, improving skin firmness, preventing wrinkle formation, stimulating collagen production, and supporting tissue regeneration. A previous study by Sopianti (2021) demonstrated that red seaweed (Gelidium sp.) extract at concentrations of 5%, 7.5%, and 10% exhibited antioxidant activity. Therefore, this study utilizes red seaweed extract at the same concentrations (5%, 7.5%, and 10%) as an antioxidant in lip balm formulations.

Based on the aforementioned background, the researcher is interested in conducting a study entitled “Formulation of Lip Balm Preparation from Red Seaweed (Gelidium sp.) Extract as an Antioxidant.” This research aims to formulate red seaweed (Gelidium sp.) extract into a lip balm preparation that meets the physical and chemical quality requirements of cosmetic formulations.

2. METHODOLOGY

The research stages in this study included the preparation of red seaweed (Gelidium Sp.) extract, the preparation of a lip balm from the red seaweed (Gelidium Sp.) extract, and the physical and chemical evaluation, hedonic (preference) test and qualitative antioxidant testing of the red seaweed (Gelidium Sp.) extract lip balm preparation.

2.1. Plant Determination

Plant species determination was carried out at PT Palapa Muda Perkasa, located at Gg. Ceplik Kalimulya RT 03/04 No. 4, Cilodong District, Depok City, West Java 16413, Indonesia. Identification was carried out at the same location using morphological characteristics and taxonomic keys to accurately classify plant species.

2.2. Preparation Of Red Seaweed Extract (Gelidium Sp.)

The seaweed was thoroughly washed and chopped, then dried at 37-40°C for 3-4 days. Weigh 50 grams of red seaweed, place it in an Erlenmeyer flask, add pure water until submerged, add 0.1N sodium hydroxide (NaOH) solution to reach a pH of 7, then heat with an electric heater to 80°C, stirring occasionally, until a solution forms. Next, filter the mixture while still hot using Whatman filter paper number 41 under vacuum to obtain a filtrate. Add 300 ml of 95% ethanol to the filtrate, let it stand for 24 hours at room temperature (25-27°C), then filter it using plain filter paper. The precipitate was separated, added with 200 ml of 95% ethanol, let it stand for another 24 hours, and then filtered. The precipitate and filter paper were placed in a desiccator for several hours until they reached a constant weight. The sediment obtained is agar extract.

2.3. Preparation A lip Balm From Red Seaweed Extract (Gelidium Sp.)

The procedure for preparing lip balm from red seaweed (Gelidium sp.) extract was carried out as follows. All equipment and materials were prepared, and each ingredient was weighed according to the formulation. Solid paraffin, petrolatum, and cera alba were melted in an evaporating dish placed on a water bath at a temperature of 60–70 °C. Liquid paraffin was then added to the evaporating dish and stirred until a homogeneous mixture was obtained. The temperature was lowered to 45 °C, after which glyceryl monostearate, phenoxyethanol, and BHT were added and stirred until homogeneous (this was referred to as mixture 1).

Separately, the red seaweed extract and cetyl alcohol were placed into a mortar and triturated until homogeneous. Strawberry essence then added and further triturated to form mixture 2.

Mixture 1 and mixture 2 were combined in the mortar and triturated thoroughly until a uniform and homogeneous mass was obtained. The final preparation was then evaluated. After evaluation, the lip balm mixture was poured into pre-prepared molds and allowed to set at room temperature (25 °C) until solidified.

Table 1. *Antioxidant Lip Balm Formula with Red Seaweed Extract (Gelidium Sp)*

Ingredient	Function	F0 (g)	F I (g)	F II (g)	F III (g)
Red Seaweed (*Gelidium* sp.) Extract	Active ingredient	–	5%	7.5%	10%
Petrolatum	Emollient	30	30	30	30
Liquid Paraffin	Emollient	30	30	30	30
Cera alba (Beeswax)	Wax/Base	15	15	15	15
Glyceryl Monostearate	Humectant	0.95	0.95	0.95	0.95
Cetyl Alcohol	Emulsifier	0.05	0.05	0.05	0.05
BHT (Butylated Hydroxytoluene)	Antioxidant	0.05	0.05	0.05	0.05
Phenoxyethanol	Preservative	0.2	0.2	0.2	0.2
FD&C Red No. 4	Colorant	2 drops	2 drops	2 drops	2 drops
Strawberry Essence	Fragrance	3 drops	3 drops	3 drops	3 drops
Solid Paraffin (ad 100%)	Base	Ad 100%	Ad 100%	Ad 100%	Ad 100%

2.4. Evaluation Of Lip Balm Formulation

The evaluation of the lip balm formulation included several tests: organoleptic evaluation, homogeneity test, pH test, melting point test, spreadability test, antioxidant qualitative test, and preference test.

2.4.1. Organoleptic Evaluation

Organoleptic evaluation was performed by visually observing the lip balm formulation in terms of color, aroma, and texture during each sampling period[7]. The formulation was required to appear uniform light pink color, strawberry aroma with a slightly oily texture

2.4.2. Homogeneity Test

Homogeneity was evaluated by spreading 0.1 g of the lip balm formulation onto a transparent glass plate. The formulation was required to appear uniform without the presence of coarse particles[7].

2.4.3. pH Test

The pH value of the lip balm formulation was determined using a pH meter. The instrument was first calibrated with standard buffer solutions of pH 7.01 (neutral) and pH 4.01 (acidic) until the readings were stable. The electrode was then rinsed with distilled water and dried with tissue. A 1% sample solution was prepared by weighing 1 g of the formulation and dissolving it in 100 mL of distilled water, then heating it slightly. Once the temperature returned to room temperature, the electrode was immersed in the solution until the reading stabilized. The displayed value was recorded as the pH of the formulation[7]. The physiological pH of the lips ranges from 4.0 to 6.5[3].

2.4.4. Melting Point Test

The melting point was determined by placing the lip balm sample in an oven at an initial temperature of 50 °C for 15 minutes and observing whether melting occurred. The temperature was then increased by 1 °C every 15 minutes, and the melting temperature of the lip balm was recorded. An ideal lip balm formulation typically has a melting point in the range of 50–70 °C[7,8].

2.4.5. Spreadability Test

An amount of 0.5 g of lip balm formulation was placed on a glass plate with a marked scale. The sample was covered with another glass plate of known weight and allowed to stand for 1 minute. The diameter of spread was measured from several angles, and the average value was recorded. This procedure was repeated three times with increasing loads of 50 g, 100 g, 150 g, and 200 g. A formulation passes the spreadability test if the spread diameter is within 5–7 cm[1].

2.4.6. Antioxidant Qualitative Test (Color Test)

A total of 10 mg of lip balm formulation was mixed with five drops of 0.1 mM DPPH solution. A positive antioxidant activity was indicated by a color change from purple to yellow[6].

2.4.7. Preference Test (Hedonic Test)

The preference test involved 30 volunteer panelists. Each panelist was asked to evaluate the different lip balm formulations and select their preferred formula. A hedonic scale of 1 to 5 was used, where 1 = strongly dislike, 2 = dislike, 3 = neutral, 4 = like, and 5 = strongly like. The parameters evaluated were texture, aroma, and color. The percentage of preference for each formulation was then calculated[2].

3. RESULTS

3.1. Results of Red Seaweed (Gelidium sp.) Determination

The determination of the red seaweed specimen was carried out at PT Palapa Muda Perkasa, located at Gg. Ceplik Kalimulya RT 03/04 No. 4, Cilodong District, Depok City, West Java 16413, Indonesia. Based on morphological and taxonomic identification, the seaweed was confirmed to be Gelidium sp., a species of red seaweed commonly found in Indonesian coastal waters.

3.2. Results Of Red Seaweed (Gelidium Sp.) Extraction

The red seaweed (Gelidium sp.) extract was obtained through the maceration method using 95% ethanol and 0.1 N NaOH as solvents. The red seaweed material was sourced from PT Palapa Muda Perkasa, located at Gg. Ceplik Kalimulya RT 03/04 No. 4, Cilodong District, Depok City, West Java 16413, Indonesia. The resulting extract was in the form of a gel-like agar, brownish in color, and had a distinct characteristic odor. Phytochemical Identification of Red Seaweed (Gelidium sp.) Extract A qualitative phytochemical screening was conducted to identify the bioactive compounds present in the red seaweed (Gelidium sp.) extract. The results indicated the presence of saponins, alkaloids, flavonoids, tannins, and triterpenoids.

3.3. Evaluation of Lip Balm Containing Red Seaweed (Gelidium Sp.) Extract

3.3.1. Organoleptic Evaluation

The organoleptic characteristics of the lip balm formulations were assessed based on color, aroma, and texture (Table 2). All samples, including F0 (control), FI (5% *Gelidium* sp. extract), FII (7.5%), and FIII (10%), demonstrated a consistent strawberry aroma. However, noticeable differences in color and texture were observed among the formulations.

Organoleptic testing was performed to evaluate the sensory characteristics of the lip balm formulations, including color, aroma, and texture.

Table 2. *The Result of Organoleptic Evaluation*

Sample	Color	Aroma	Texture
FI	Light pink	Strawberry	Oily
FII	Darker pink with red granules	Strawberry	Very oily
FIII	Darker pink with red granules	Strawberry	Very oily

All formulations (F0, FI, FII, and FIII) showed the same strawberry aroma, indicating that the addition of Gelidium sp. extract did not affect the fragrance profile of the product.

However, differences were observed in color and texture with increasing extract concentration. F0 and FI exhibited a uniform light pink color with a slightly oily texture. In contrast, FII and FIII showed a darker pink shade with visible reddish granules and a much oilier texture. This is likely caused by higher concentrations of Gelidium sp. extract, which increased the viscosity of the base and resulted in incomplete dispersion of the extract. High levels of natural extract may also absorb colorants, creating an uneven distribution of color.

3.3.2. Homogeneity Test

Homogenity was evaluated visually to determine the uniform distribution of the active extract within the base. The results are summarized in Table 3.

Table 3. *The Result of Homogeneity Test*

Formula	Homogeneity
F0	Homogeneous
FI	Homogeneous
FII	Not homogeneous
FIII	Not homogeneous

The homogeneity test determines the even distribution of components in the formulation. F0 and FI demonstrated good homogeneity, whereas FII and FIII were not homogeneous. The presence of visible particles and uneven coloration in FII and FIII suggests poor mixing at higher extract concentrations.

This may be attributed to the interaction between the extract and base ingredients, as well as limited solubility of the extract. The findings indicate that 5% Gelidium sp. extract is the optimal concentration to maintain good homogeneity in the lip balm formulation.

3. pH Measurement

pH testing revealed values within the acceptable physiological range for lip products (4.0–6.5). Table 4. presents the pH values of each formulation.

Table 4. *The Result of pH Measurement*

Formula	pH	Standard Range
F0	5.48	4.0 – 6.5
FI	5.57	4.0 – 6.5
FII	5.86	4.0 – 6.5
FIII	5.96	4.0 – 6.5

The pH of the lip balm formulations ranged from 5.48 to 5.96, which falls within the physiological range for the lips (4.0–6.5). A slight increase in pH was observed as the concentration of the extract increased. This is likely due to residual alkaline compounds from the extraction process.

Since all formulations met the physiological pH range, the lip balm is considered safe and non-irritating for application on the lips.

4. Melting Point Test

Melting point evaluation ensures product stability under normal storage conditions. Table 5 shows the melting points of each formulation.

Table 5. *The Result of Melting Point Test*

Formula	Melting Point (°C)	Acceptable Range (°C)
F0	58	50 – 70
FI	56	50 – 70
FII	53	50 – 70
FIII	51	50 – 70

The melting point of all formulations ranged from 51 °C to 58 °C, which is within the recommended range of 50–70 °C for lip balm products. A decreasing trend in melting point was observed with increasing extract concentration.

This reduction may be caused by interactions between the extract and wax components, which alter the structural integrity of the base. However, the values remai

ned within the acceptable range, indicating that the formulations have good physical stability at room temperature.

5. Spreadability Test

Spreadability indicates the ease of application on the skin. The test was conducted under two weight conditions (50g and 100g), as shown in Table 6.

Table 6. *The Result of Spreadability Test*

Formula	Load (g)	Spread Diameter (cm)	Requirement (cm)
F0	50	5.0	5 – 7
F0	100	5.2	5 – 7
FI	50	5.1	5 – 7
FI	100	5.3	5 – 7
FII	50	5.2	5 – 7
FII	100	5.4	5 – 7
FIII	50	5.4	5 – 7
FIII	100	5.6	5 – 7

Spreadability determines how easily the lip balm can be applied and distributed on the lips. All formulations met the standard spreadability requirement (5–7 cm). The spreadability values slightly increased in FII and FIII, which may be due to the softer consistency caused by higher extract content. Good spreadability ensures better user comfort and product performance.

6. DPPH Qualitative Test (Antioxidant Activity)

Antioxidant potential was analyzed using the DPPH radical scavenging assay. Formulations FI, FII, and FIII showed a positive reaction, indicated by a color change from violet to yellow.

Antioxidant activity was evaluated using the DPPH qualitative test. FI, FII, and FIII showed a positive reaction with a color change from violet to yellow, indicating the presence of antioxidant compounds in the lip balm.

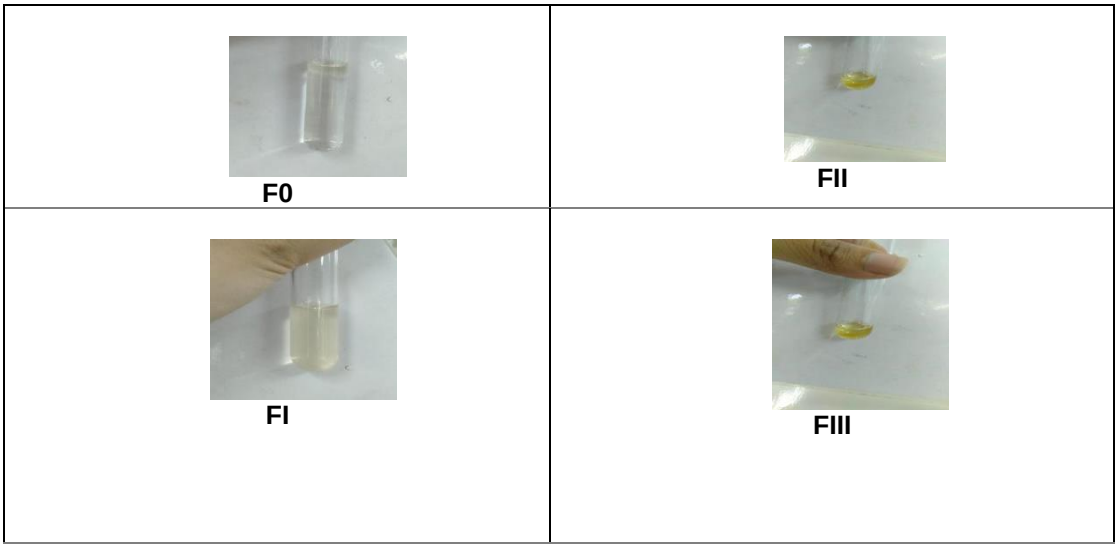

Figure 1. *Result of Qualitative DPPH test*

The strongest color change was observed in FII and FIII, demonstrating higher antioxidant activity at higher extract concentrations. This is consistent with the presence of bioactive compounds in Gelidium sp., such as flavonoids, saponins, and phenolics, known for their free radical scavenging activity.

7. Hedonic Test

A hedonic test was conducted with 30 untrained panelists to evaluate consumer preferences for color, aroma, moisture, and texture (Table 8).

Table 8. *The Result of Hedonic Test*

Parameter	F0 (0%)	FI (5%)	FII (7.5%)	FIII (10%)
Color	3 (like)	3 (like)	2 (dislike)	2 (dislike)
Aroma	3 (like)	3 (like)	3 (like)	3 (like)
Moisture	3 (like)	3 (like)	3 (like)	3 (like)
Texture	3 (like)	3 (like)	2 (dislike)	2 (dislike)

The results showed that F0 and FI received higher scores (3 = like) for most parameters, particularly color and texture. In contrast, FII and FIII received lower scores (2 = dislike) for color and texture due to their darker shade and greasier texture, even though aroma and moisture were well accepted across all formulations.

This indicates that increasing extract concentration enhances antioxidant activity but can decrease product appeal and comfort. Thus, a balanced formulation is essential to achieve both functional and sensory quality.

4. CONCLUSIONS

Based on the results of the formulation and evaluation of lip balm containing red seaweed (Gelidium sp.) extract, it can be concluded that the concentration of the extract plays a significant role in determining the physical characteristics, antioxidant activity, and consumer acceptability of the product. All formulations met the required pH and melting point standards, with pH values ranging from 5.48 to 5.96 and melting points between 51–58 °C, which are within the acceptable physiological range for lip products.

The antioxidant activity increased with higher concentrations of red seaweed extract, as indicated by the DPPH qualitative test showing a clear color change from violet to yellow. However, formulations with higher extract concentrations (7.5% and 10%) exhibited poor homogeneity, a darker color, and an oily texture, which affected the sensory acceptance by the panelists.

Among all formulations, the 5% extract concentration (Formula I) showed the most balanced results, with good physical stability, adequate antioxidant activity, and the highest level of consumer acceptance. This indicates that Gelidium sp. extract can be effectively utilized as a natural antioxidant ingredient in lip balm formulations.

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PHYSICAL QUALITY EVALUATION OF EMULGEL FORMULATION CONTAINING LAVENDER (LAVANDULA ANGUSTIFOLIA) ESSENTIAL OIL WITH VARIATIONS IN CARBOPOL 940 CONCENTRATION

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Abstract

Background: Malaria remains a significant public health problem in Indonesia, particularly in Papua. Lavender essential oil (Lavandula angustifolia) is a natural alternative repellent, but its high volatility and irritant potential limit direct application. To overcome these limitations, a stable and effective emulgel formulation was developed. Carbopol 940 was chosen as the gelling agent due to its high viscosity and compatibility, with concentration expected to strongly influence physical properties. **Objective:** This study aimed to evaluate the effect of Carbopol 940 concentration on the physical quality of lavender essential oil emulgel formulations. **Methods:** An experimental design was conducted with three formulas: F1 (1% Carbopol 940), F2 (1.5%), and F3 (2%). Data were analyzed using one-way ANOVA. **Results:** All formulations exhibited white color, characteristic lavender aroma, and uniform emulgel consistency. Homogeneity was observed across all samples. The pH was 5.0 for F1 and F2, and 6.0 for F3. Spreadability decreased as Carbopol concentration increased (5.84 cm for F1, 4.93 cm for F2, 3.97 cm for F3). Adhesion showed the opposite trend (5.68 s, 10.49 s, and 13.27 s, respectively). Viscosity also increased with higher concentrations (4,920 cP, 13,060 cP, and 24,380 cP). All formulas remained stable with no phase separation during thermodynamic stability testing. **Conclusion:** Variations in Carbopol 940 concentration significantly influenced emulgel physical properties.

Keywords: Carbopol 940; Emulgel; Lavender essential oil; Physical quality evaluation

1. INTRODUCTION

Malaria continues to pose a significant health challenge in Indonesia, especially in eastern areas like Papua, Papua Barat, Maluku, and East Nusa Tenggara. Caused by Plasmodium parasites spread through Anopheles mosquito bites, malaria cases surged by 36.29% from 2021 to 2022, reaching 415,140 cases [8]. While synthetic insecticides and larvicides are commonly used for mosquito control, their long-term use raises concerns about health risks, such as cancer, and environmental damage due to low biodegradability [6], [17], [18].

To address these issues, natural essential oils from plants like citronella, geranium, eucalyptus, cinnamon, rosemary, basil, and lavender are being explored as mosquito repellents. Lavender (Lavandula angustifolia) essential oil, rich in linalool and linalyl acetate, is valued for its mosquito-repelling, calming, and stress-relieving effects [10], [14]. However, its volatility leads to quick evaporation and potential skin irritation, necessitating stable formulations for prolonged efficacy and safety [9].

Emulgel, a hybrid of emulsion and gel, is an effective delivery system for hydrophobic substances, offering easy application, non-sticky texture, washability, and enhanced stability [5], [11]. Carbopol 940, a preferred gelling agent, is favored for its fine particles, high viscosity, compatibility, and desirable sensory properties [3], [22]. Prior research has validated lavender oil's repellent efficacy and the suitability of emulgel for essential oil delivery [1], [3], [7].

This study evaluates the physical properties of lavender essential oil emulgel formulated with varying Carbopol 940 concentrations to optimize its performance.

2. METHODOLOGY

This study employed an experimental laboratory design to evaluate the physical quality of lavender (*Lavandula angustifolia*) essential oil emulgel with different concentrations of Carbopol 940 as a gelling agent. The research was conducted at the Pharmaceutical Formulation Technology Laboratory, Poltekkes Kemenkes Jayapura, during April–May 2025. The main research object was lavender essential oil obtained from an e-commerce supplier and verified by a Certificate of Authenticity (CoA).

Tabel 1. Formulation Design of Lavender Essential Oil Emulgel with Variations in Carbopol 940 Concentration

Ingredients	Function	Formula		
		I	II	III
Lavender flower essential oil (% v/b)	Active ingredient	25%	25%	25%
Tween 80 (%)	Surfactant	2,7%	2,7%	2,7%
Span 80 (%)	Surfactant	2,3%	2,3%	2,3%
Carbopol (%)	Thickener	1%	1,5%	2%
Trietanolamin (g)	Alkalizing agent	qs	qs	qs
Propilen glikol(g)	Moisturizer	1,3	1,3	1,3
Aquadest ad (g)	Solvent	50	50	50

Working Procedure

The emulgel was prepared by first mixing lavender essential oil with Tween 80 and Span 80 to form a uniform oil phase. Separately, Carbopol 940 was dissolved in hot distilled water and left for 24 hours to form a gel, after which Triethanolamine was added to adjust the pH to 4.5–7.5, followed by the addition of propylene glycol. The oil phase was then slowly incorporated into the aqueous phase under continuous high-speed stirring using a homogenizer until a homogeneous emulgel was obtained.

Physical Quality Tests of Emulgel

The quality of the lavender essential oil emulgel (*Lavandula angustifolia*) was evaluated through several tests. The **organoleptic test** assessed its color, form, and odor [19], while the **homogeneity test** confirmed uniform mixing without lumps (Nafisa et al., 2021). The **pH test** ensured skin compatibility within the 4.5–8 range [19]. The **spreadability** and **adhesion tests** measured ease of application and retention on the skin, with ideal values of 5–7 cm and over 4 seconds, respectively [19]. The **viscosity test**, using a Brookfield viscometer, confirmed acceptable thickness between 6,000–50,000 cPs [2]. Lastly, **thermodynamic stability tests**—centrifugation, freeze–thaw, and cycling—verified the formulations' physical stability.

3. RESULTS

The study results showed the physical quality test of lavender essential oil emulgel (*Lavandula angustifolia*) using three gelling agent formulas: FI (Carbopol 1%), FII (Carbopol 1.5%), and FIII (Carbopol 2%).

3.1 Organoleptic Test

The results of the organoleptic test of lavender (Lavandula angustifolia) essential oil emulgel formulations with various base combinations are shown in the table below.

Table 2. Results of Organoleptic Test

Formula	Color	Aroma	Form	Description
I	White	Characteristic lavender oil aroma	Emulgel	Meets the requirements
II	White	Characteristic lavender oil aroma	Emulgel	Meets the requirements
III	White	Characteristic lavender oil aroma	Emulgel	Meets the requirements

3.2 Homogenity Test

The results of the homogeneity evaluation of lavender (Lavandula angustifolia) essential oil emulgel formulations prepared with carbopol base combinations are presented in the table below.

Table 3. Results of Homogeneity Test

Formula	Homogenity	Remarks
I	Homogeneous with uniform color and no visible particles in the preparation	Meets the requirements
II	Homogeneous with uniform color and no visible particles in the preparation	Meets the requirements
III	Homogeneous with uniform color and no visible particles in the preparation	Meets the requirements

3.3 pH Test

The results of the pH evaluation of lavender (Lavandula angustifolia) essential oil emulgel formulations prepared with carbopol base combinations are presented in Table 4.

Table 4. Results of pH Test

Formula	pH	Remarks
I	5	Meets the requirements
II	5	Meets the requirements
III	6	Meets the requirements

3.4 Spreadability Test

The spreadability test of emulgel preparations containing lavender (Lavandula angustifolia) essential oil with a combination of carbopol bases can be seen in the table below.

Table 5. Results of Spreadability Test

Formula	Spreadability (cm)			Average	Remarks	Sig.
	R1	R2	R3			
I	5,83	5,87	5,82	5,84 ± 0,02	**Meets the requirements**	0,015
II	4,89	5,05	4,85	4,93 ± 0,10	**Does not meet the requirements**	
III	4,06	3,90	3,97	3,97 ± 0,08	**Does not meet the requirements**	

3.5 Adhesion Test

The adhesion test of the lavender essential oil (Lavandula angustifolia) emulgel preparation using a combination of carbopol can be seen in the table below.

Table 6. Results of Adhesion Test

Formula	Adhesion Test (detik)			Average	Description	Sig.
	R1	R2	R3			
I	5,42	5,90	5,73	5,68 ± 0,24	Meets Requirements	0,037
II	10,59	10,92	9,97	10,49 ± 0,48	Meets Requirements	
III	13,61	12,97	13,25	13,27 ± 0,32	Meets Requirements	

3.6 Viscosity Test

The viscosity test results for the lavender essential oil emulgel preparation using a combination of bases are presented in the table below:

Table 7. Results of Viscocity Test

Formula	Viscocity Test (cP)			Average	Description	Sig.
	R1	R2	R3			
I	4,933	4,900	4,933	4,920 ± 0,02	Does Not Meet Requirements	0,007
II	13,07	13,23	12,87	13,06 ± 0,20	Meets Requirements	
III	24,37	24,30	24,47	24,38 ± 0,05	Meets Requirements	

3.7 Thermodynamics Test

The thermodynamics test results for the lavender essential oil emulgel preparation using a combination of bases are presented in the table below:

Table 8. Results of Centrifugation Test

Formula	Centrifugation	Description
I	No separation and stable	Meets requirements
II	No separation and stable	Meets requirements
III	No separation and stable	Meets requirements

Table 9. Results of Freeze Thaw Test

Formula	Freeze-Thaw	Description
I	No separation and stable	Meets requirements
II	No separation and stable	Meets requirements
III	No separation and stable	Meets requirements

Table 10. Results of Cycling Test

Formula	Cycling Test	Description
I	No separation and stable	Meets requirements
II	No separation and stable	Meets requirements
III	No separation and stable	Meets requirements

4. DISCUSSION

Lavender essential oil, produced through steam distillation or solvent extraction from fresh lavender flowers (Lavandula angustifolia), is known to have properties that repel mosquitoes and provide a relaxing effect for users. According to research by [14], the compounds in lavender oil are highly beneficial, including providing relaxation, reducing stress, and acting as a mosquito repellent. Lavender, a member of the Lamiaceae family, is an aromatic shrub [20].

Organoleptic testing was conducted directly to assess the color, aroma, and form of the preparation using the five senses. This organoleptic test is crucial as it determines the quality of the emulgel preparation visually and evaluates the physical characteristics of the emulgel, including its color, aroma, and form. Based on the data in Table 2, the organoleptic test results for FI, FII, and FIII show a white color, a distinctive lavender essential oil aroma, and an emulgel form.

Homogeneity testing for FI, FII, and FIII was performed using two methods: macroscopic visual observation with the naked eye and microscopic examination using a microscope. Macroscopically, no coarse particles or granules were observed, the color of the preparation appeared uniform, and there were no signs of phase separation. Microscopically, the results showed a homogeneous dispersion of essential oil within the gel base, with relatively uniform particle sizes and a consistent gel structure. This indicates that the active ingredient (essential oil) and excipients are evenly mixed, ensuring consistent therapeutic effects with each use. A homogeneous preparation confirms that the active substance is uniformly distributed. The test also assessed the presence of clumps and whether the emulsion separated into oil and water phases [19].

The pH test was conducted to determine the acidity level of each emulgel formulation containing lavender essential oil (*Lavandula angustifolia*). The ideal pH range for topical preparations is typically between 4.5 and 7.5, as it aligns with the slightly acidic physiological pH of human skin. A formulation with too low a pH may cause irritation, while one that is too high can disrupt the skin's barrier and lead to dryness or scaling [12]. As shown in Table 9, the pH values of formulations FI and FII were both 5, and FIII had a pH of 6. These results indicate that all three formulations fall within the acceptable range for topical products, remaining safe and compatible with normal skin pH.

The spreadability test was conducted to evaluate the ability of the emulgel to spread evenly across the skin surface. A formulation that spreads more easily allows wider distribution of the active ingredient,

resulting in a more effective topical action [13]. The spread diameters were 5.82 cm for FI, 4.93 cm for FII, and 3.97 cm for FIII, indicating that the concentration of Carbopol influenced spreadability. Statistical analysis using One-Way ANOVA ($p<0.05$) showed a significant difference among the formulations, confirming that variations in Carbopol concentration had a notable effect on spreadability. This relationship is inversely proportional to viscosity—formulations with higher viscosity exhibit lower spreadability, while those with lower viscosity spread more easily due to their more fluid nature [15], [21]. The decrease in spreadability across formulations corresponds to increased viscosity caused by higher Carbopol concentrations.

The adhesion test was conducted to determine how long the emulgel could adhere to the skin surface. A good topical formulation should have an adhesion time of more than 4 seconds [19]. The results showed that all formulations met this requirement, with adhesion times of 6.68 seconds for FI, 9.16 seconds for FII, and 11.17 seconds for FIII. Statistical analysis using One-Way ANOVA ($p<0.05$) indicated a significant difference among the formulations, meaning that variations in Carbopol concentration had a considerable effect on adhesion. Adhesion is inversely related to spreadability; higher adhesion corresponds to lower spreadability. The increase in adhesion time across formulations was influenced by higher viscosity due to increased Carbopol concentration, which allowed the emulgel to stay longer on the skin surface. This prolonged contact enhances the absorption of the active ingredients, making the formulation more effective [15].

The viscosity test aimed to measure the thickness of the emulgel formulations. The results showed viscosity values of 4.920 cP for FI, 13.06 cP for FII, and 24.38 cP for FIII. Among these, FI did not meet the required standard range for emulgels, which is 6,000–50,000 cPs (SNI 16-4399-1996). Statistical analysis using One-Way ANOVA ($p<0.05$) indicated significant differences among the formulations, confirming that variations in Carbopol concentration had a notable effect on viscosity. The findings demonstrated that higher Carbopol concentrations increased viscosity, as greater amounts of the gelling agent strengthened the gel matrix. Viscosity is an essential parameter in emulgel testing because it influences spreadability—formulations with higher viscosity tend to have lower spreadability, and vice versa. Both Carbopol and TEA in the formulation contribute to viscosity enhancement [13].

The stability test aimed to evaluate the physical stability of the lavender essential oil emulgel under high-speed centrifugation and varying storage conditions at room temperature. The centrifugation test results (Table 8) showed no phase separation in formulations FI–FIII after spinning at 5000 rpm for 30 minutes. Similarly, in the freeze–thaw test, where samples were stored for 48 hours at 4°C and then at 25°C, no visible changes were observed. The cycling test results (Tables 9 and 10) also indicated that all formulations remained stable after six storage cycles, showing no phase separation or changes in appearance. These findings suggest that the lavender emulgel formulations are physically stable and can be expected to remain stable for at least one year [3]. The absence of creaming or phase separation during centrifugation, freeze–thaw, and cycling tests indicates good stability against gravitational and temperature variations [16]. Overall, all formulations demonstrated good physical stability with no significant differences before and after testing.

5. CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

The lavender essential oil (*Lavandula angustifolia*) emulgel formulations with varying Carbopol 940 concentrations (FI–FIII) met the quality standards for topical preparations. All were white, homogeneous, and had the characteristic lavender scent. The pH values (5–6) were within the acceptable range for skin compatibility. Increasing Carbopol concentration resulted in higher viscosity and adhesion but lower spreadability. Stability tests (centrifugation, cycling, and freeze–thaw) showed no phase separation, indicating good physical stability. In conclusion, all formulations were stable and suitable for topical use, with higher Carbopol levels providing better adhesion and stability, while lower levels improved spreadability.

5.1 Recommendations

Further research is recommended to optimize the emulgel formulation of lavender essential oil (*Lavandula angustifolia*) using various concentrations of Carbopol 940, focusing on improving physical properties (such as spreadability and viscosity) and evaluating the irritation or sensitivity potential of the formulation.

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COMPARATIVE STUDY OF THE EFFECTIVENESS OF LEAFLET AND BOOKLET EDUCATIONAL MEDIA ON ORAL HYGIENE KNOWLEDGE AMONG FOURTH AND FIFTH GRADE STUDENTS AT SDN 03 TUMPUK TANGAH SAWAHLUNTO CITY

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Abstract

Poor dental and oral health is usually based on lack of knowledge. To improve knowledge, health information supported by media is needed. Leaflets have the advantage of being designed in such a way as to suit their targets and are practical because they reduce the need for taking notes, while booklets make it easier to understand, in the form of small books, containing short and clear messages. The purpose of this study was to determine the difference in knowledge of dental and oral hygiene between providing information using leaflet and booklet media to children in grades IV and V of SDN 03 Tumpuk Tangah, Sawahlunto City. The type of research used is an experiment with a pretest and posttest design. The population of this study was all students in grades IV and V of SDN 03 Tumpuk Tangah, Sawahlunto City, totaling 40 students. The sample in this study was 40 people, the sampling technique was saturated samples. The method of data collection was by filling out a pretest- posttest questionnaire about dental and oral hygiene. Data analysis used was univariate and bivariate analysis.The results of the study showed that students' knowledge before being given information about dental and oral hygiene was 55.0% with sufficient criteria and after being given counseling using leaflet media increased to 80.0%. Students' knowledge before being given counseling on dental and oral hygiene was 60.0% with insufficient criteria and after being given counseling using booklet media increased to 90.0%, the average difference is 23.05 on the leaflet and 32.25 on the booklet. Mann Whitney u Asymp.dig statistics (0.042 < 0.05), there is a significant difference between the extension with leaflet and booklet media The conclusion of this study is that counseling using leaflet and booklet media can both improve knowledge of dental and oral hygiene. It is recommended that respondents apply the methods of maintaining dental and oral hygiene that have been given in everyday life.

Keywords : Knowledge, Leaflet, Booklet,

1. INTRODUCTION

Health is a healthy state, both physically, mentally, spiritually and socially that allows everyone to live productively socially and economically as stated in Health Law No. 36 of 2009. In addition to general health, dental and oral health are also important because they can affect the overall health of the body [31]. Dental and oral health is a condition where the hard and soft tissues in the oral cavity are healthy, free from all diseases and aesthetic disorders. This allows an individual to have no problems speaking, digesting food and interacting with other individuals [29]. One way to keep your teeth and mouth healthy is by maintaining good oral hygiene. Good oral hygiene is the condition where a person's mouth is free

from impurities such as debris, plaque, and tartar. Oral hygiene is one of the necessary measures to protect the mouth from infection. Oral hygiene is crucial for dental health because a number of dental and oral problems can arise from poor oral hygiene [9].

Based on the results of the 2018 Basic Health Research (Riskesdas), the majority of the Indonesian population in West Sumatra Province experienced dental and oral health problems, amounting to 43.87% and in Sawahlunto City 26.2%.4 Based on the 2023 Indonesian Health Survey (SKI), the majority of the Indonesian population in West Sumatra Province experienced dental and oral health problems, amounting to 61.1%5. This shows an increase in dental and oral problems by 17.23% in West Sumatra.Lack of awareness of oral hygiene is caused by low levels of knowledge about it. Education is crucial for increasing knowledge and is one of the simplest health promotion processes for everyone to maintain their health. One way to increase knowledge is by providing information on oral hygiene.

According to Green and Kreuter's Precede-Proceed model, educational media play an important role in influencing predisposing factors such as knowledge, attitudes, and beliefs, which in turn affect health behaviors. Similarly, the Health Belief Model (HBM) suggests that appropriate educational interventions can enhance individuals' perceived susceptibility, perceived severity, and perceived benefits, leading to improved health-related knowledge and behavior. Therefore, comparing the effectiveness of different educational media—such as booklets and leaflets—can provide insight into which medium is more effective in increasing students' knowledge and promoting positive health behaviors.

Providing dental and oral health information is a planned and targeted effort used to create an atmosphere that encourages individuals or groups to change existing behaviors considered less beneficial to dental health into more beneficial ones. To ensure information is easily understood, media is needed to facilitate the delivery of information [7]. Health promotion media are used to present health messages or information to individuals. Media or visual aids for delivering dental health information can be considered tools to facilitate the target audience's understanding of the material presented by the instructor. Media are a set of tools used as intermediaries in communicating with the target audience. Information media, often referred to as communication media, can range from simple to sophisticated [6].

Leaflets are a promotional medium that can be used to attract students' interest in providing information. Leaflets convey information or health messages through folded sheets. The information can be in the form of sentences or images. Leaflets are carefully crafted using simple, concise language that is easy for students to understand. Leaflets offer advantages: they are easy to carry, can be stored for a long time, and can be designed in a variety of ways [1]. Meanwhile, booklets, which are small books half the size of a quarto, contain text and images. Their simple design makes them ideal for independent learning, encouraging students to read. Previous research found that the average change in knowledge after receiving information using booklets and leaflets was equally effective. This suggests that providing information using leaflets and booklets is equally effective as a means of increasing student knowledge [8]

The results of the interview with the principal obtained information that, from the nearest health center routinely conducts health screening and periodic checks for students in grades I, II, and III, the health center conducts physical examinations, such as weight, height, visual acuity, hearing, and conducts dental examinations only on students in grade I. UKGS at SDN 03 Tumpuk Tangah is not yet operational, only UKS is operating to serve students who are sick during school hours. The results of the interview with the principal also obtained data at SDN 03 Tumpuk Tangah has 97 students, 13 students in grade 1, 20 students in grade 2, 14 students in grade 3, 20 students in grade 4, 20 students in grade 5, and 11 students in grade 6. There has been no study in Sawahlunto comparing the effectiveness of booklets and leaflets among elementary school students.

Based on interviews with 10 students at SDN 03 Tumpuk Tangah, it was found that 3 students knew how to maintain good oral hygiene, while 7 students did not. These included: inappropriate brushing times, proper brushing techniques, foods that can damage dental health, and foods that are good for dental health, such as foods high in fiber.

2. METHODOLOGY

This study employed an experimental design, employing a pretest and posttest design, conducted with observation and treatment. In this study, assessments and observations were conducted twice: once before treatment (pre-test) and once after treatment (post-test). This study aimed to determine dental and oral hygiene knowledge before and after counseling using leaflets and booklets among fourth and fifth grade students at SDN 03 Tumpuk Tangah, Talawi District, Sawahlunto City. The data collection procedure is by requesting a letter of permission to conduct research in the academic or administrative section of the Dental Health Department of the Ministry of Health, Padang Health Polytechnic and providing a letter of permission to the Principal of SDN 03 Tumpuk Tangah. Data were collected using a health knowledge questionnaire consisting of 20 multiple-choice questions. Each correct answer was scored 1, and incorrect answers 0, resulting in a total score ranging from 0 to 20. Prior to use, the questionnaire underwent validation and reliability testing. Data were collected via questionnaires administered before the intervention (pretest) and one week after the intervention (posttest). The intervention consisted of a single session using the assigned educational media (booklet or leaflet). Data were analyzed using statistical software as follows. Univariate analysis to describe the frequency distribution of students' knowledge scores before and after the intervention. Bivariate analysis to compare knowledge scores between the booklet and leaflet groups, the Mann–Whitney U test was used due to the ordinal nature of the data. For within-group comparisons (pretest vs. posttest), the Wilcoxon Signed Rank Test was applied. Statistical significance was set at $p < 0.05$. This procedure allows the study to systematically assess which educational media is more effective in improving health knowledge among elementary school students in Sawahlunto.

This research was conducted on April 15, 2025, assisted by two enumerators, sixth-semester students of the Dental Health Department. To achieve appropriateness in the research, calibration or perception similarity was necessary. This perception similarity was carried out for three days before the research to avoid errors during counseling during the research. Before the research was conducted, the researcher taught the enumerators and reminded them about the procedures in the research, including the questionnaire sheets that must be completed in.

3. RESULTS AND DISCUSSION

The study aimed to determine the differences in knowledge of dental and oral hygiene between providing information using leaflets and booklets to 40 students in grades V and VI.
The research results can be seen in the following table:

Table 1: Frequency Distribution of Knowledge of Dental and Oral Hygiene Before and After Providing Information Using Leaflets Media

Knowledge	***Before F***	***Before %***	***After F***	***After %***	***p-value***
Good	*2*	*10.0*	*16*	*80.0*	*0.001*
Average	*11*	*55.0*	*4*	*20.0*	
Bad	*7*	*35.0*	*0*	*0*	
Total	*20*	*100.0*	*20*	*100.0*	

Table 2 : Frequency Distribution of Knowledge of Dental and Oral Hygiene Before and After Providing Information Using Booklet Media

Knowledge	Before F	Before %	After F	After %	p-value
Good	2	10.0	18	90.0	0.001
Average	6	30.0	2	10.0	
Bad	12	60.0	0	0	
Total	20	100.0	20	100.0	

Table 3: Differences in Oral Hygiene in Fourth and Fifth Grade, Who Received Information Using Leaflets and Booklets

Group	Average Knowledge Before	Average Knowledge After	Difference	N	p-value (Asymp. Sig.)
Leaflets	66.95	80.00	13.05	20	0.042
Booklets	63.00	90.00	27.00	20	

Table 3 : shows that the average knowledge about dental and oral hygiene in grade IV and V students of SDN 03 Tumpuk Tangah, Sawahlunto City before and after being given information using leaflets increased from 66.95 to 80.00, while the average knowledge about dental and oral hygiene in grade IV and V students of SDN 03 Tumpuk Tangah, Sawahlunto City before and after being given information using leaflets increased from 66.95 to 80.00. booklet media increased from 63.00 to 90.00. From the results of the Mann Whitney u statistical test, the Asymp.dig value (0.042 < 0.05) was shown, so Ha was accepted and Ho was rejected, meaning there was a significant difference between providing information with leaflet and booklet media.

The results of data processing showed that the increase in knowledge of dental and oral hygiene in the group of students who received information using booklet media was higher than those who received information using leaflet media. This can be seen from the difference in the average knowledge value, which was 23.05 on the leaflet and 32.25 on the booklet. The results of the Mann Whitney u statistical test showed an Asymp.dig value (0.042 <0.05), so Ha was accepted and Ho was rejected, meaning there was a significant difference between counseling with leaflet and booklet media.

If seen from the average aspect, there is a difference between leaflet media and booklet media where the average before being given information was obtained an average of 66.95%, after being given information using leaflet media, an average of 80.00% was obtained, so that a difference of 13.05% was obtained. The average before being given counseling was 63.00%, while after being given information using booklet media, an average of 90.00% was obtained, so that a difference of 27.00% was obtained. So it is stated that booklet media is better used as a medium for providing information compared to leaflet media in terms of average.

According to the researcher's assumption, both leaflets and booklets used in booklet outreach to fourth and fifth grade students at SDN 03 Tumpuk Tangah, Sawahlunto City, can improve knowledge about dental and oral hygiene.

They are complemented by colorful and graphic elements, which both attract students' attention and stimulate their imagination. The use of media in the learning process is essential to foster students' interest in reading.Increasing knowledge of dental and oral hygiene using leaflets and booklets is in good criteria because this media is able to attract students' attention to read it because it contains interesting pictures and words that are easy to understand for elementary school-aged children. Counseling using booklets can increase students' knowledge more because of its attractive form like a small book with pages containing interesting pictures and there are explanations for each picture, then

in terms of color, booklets have more diverse colors displayed, different from leaflets which tend to only use one color which makes readers less interested in reading it.

The theory given in the learning media is appropriate for elementary school-aged children so that after the dental and oral hygiene counseling, students' knowledge increased. There is a significant difference between dental and oral hygiene counseling using leaflets and booklets. The knowledge of fourth and fifth grade students of SDN 03 Tumpuk Tangah, Sawahlunto City about dental and oral hygiene increased more after counseling using booklets because its shape is like a small book, has many colors and has explanations that are easy to understand, the small size increases students' interest in reading so that the booklet is read repeatedly.

This is supported by the fact that media, if understood broadly, is human material, or events that creating conditions that enable the target to acquire knowledge, skills, or attitudes. More specifically, the concept of media in the learning process tends to be interpreted as graphic, photographic, or electronic tools for capturing, processing, and reconstructing visual or verbal information [5].

Leaflets are information media that tend to display visuals. Visuals are a communication tool that is easy to understand and remember by readers. Leaflets can be used as information tools, promotional tools, and announcements. Some of the advantages of leaflets include being very economical, being able to read the contents at leisure, and readers can learn independently and practically because it reduces the need for note-taking. Some of the information conveyed and has been read by the target so it can be discussed and can convey complete information which cannot be given verbally. They are easy to create, reproduce, and improve and can be easily adapted to the target group [3].

Booklets are small learning materials with a much shorter presentation than books on a single topic, making them easier for respondents to carry around. The presentation of material in booklets is shorter than in books. Their small, lightweight form makes them easy for respondents to carry around. Booklets contain important, clear, and easily understood information for participants. Booklets can be a companion medium for the learning process, thereby increasing the effectiveness of counseling [4]

This is supported by the theory that knowledge is the result of "knowing," and this occurs after a person senses a particular object. Sensing occurs through the human senses: sight, smell, taste, and touch. Most human knowledge is acquired through the eyes and ears [36].

The results of this study align with previous research 11, which found differences between providing information using leaflets and booklets. Providing information using booklets was superior in increasing knowledge. This indicates that providing information using booklets is effective in increasing student knowledge [8].

4. CONCLUSIONS

Based on research conducted by the researchers among fourth and fifth grade students at SDN 03 Tumpuk Tangah, Sawahlunto City, it was found that both leaflet and booklet media were effective in improving students' oral hygiene knowledge. However, there was a noticeable difference in the effectiveness between the two media. The study revealed that providing information through booklet media was more effective than using leaflet media. This suggests that the more comprehensive and detailed nature of booklets may contribute to a better understanding and retention of oral health information among elementary school students. These findings highlight the importance of selecting appropriate educational tools when designing health promotion programs for young learners. Booklets, with their structured content and potentially more engaging format, may offer a greater impact on student learning outcomes compared to more concise materials like leaflets.

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THE ROLE OF PERCEIVED BEHAVIORAL CONTROL IN SHAPING MATERNAL INTENTION TOWARD CHILDREN'S DENTAL HEALTH

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Abstract

Maternal behavior typically influences early childhood oral health such as caries. This is relied on the mother's confidence and perceived ability to manage her child's dental care. Within the framework of the Theory of Planned Behavior (TPB), *perceived behavioral control (PBC)* serves as a crucial determinant of intention and subsequent preventive actions. However, limited research in Indonesia has examined how maternal PBC influences the intention to maintain children's oral health. This study aimed to analyze the correlation between maternal perceived behavioral control and the intention to maintain oral health among kindergarten children. A cross-sectional, multivariate design was applied involving 305 mothers selected through cluster random sampling from seven kindergartens. Data were collected using structured questionnaires measuring perceived behavioral control with 18 questions and intention toward dental care with 16 questions, each rated on a 4-point ordinal scale. Data analysis was performed using ANOVA regression with a significance level of $p < 0.05$. The mean perceived behavioral control score was 51.23 ± 7.95, while the mean intention score was 46.44 ± 7.44. Regression analysis revealed a strong and significant correlation between PBC and intention ($\beta = 0.635$; $R^2 = 0.713$; $p < 0.001$), indicating that 71.3% of the variance in maternal intention could be explained by perceived behavioral control. In conclusion, maternal PBC has a strong predictive influence on mothers' intention to maintain children's oral health.

Keywords: Perceived Behavioral Control, Intention, Theory of Planned Behavior, Maternal behavior, Children

1. INTRODUCTION

A crucial determinant of children's overall well-being is oral health. Oral health affects nutrition, growth, school attendance, and quality of life. Starting a good behavior of dental health care should start at the family level. Consistent home care behaviors such as supervised toothbrushing, appropriate use of fluoride, and regular dental visits can prevent dental disease, especially caries in children [1], [2], [3].

One of the causes of dental and oral health problems in society is behavioral factors that neglect dental and oral hygiene, due to a lack of knowledge about the importance of dental and oral care [6], [7]. Dental and oral health maintenance behaviors include tooth brushing behavior. Individual or community dental health is one of the factors that influences individual or community health [8], [9]. Positive dental health maintenance behaviors, for example, the habit of brushing teeth, on the other hand, negative dental health behaviors, for example, not brushing teeth regularly, can cause plaque formation on the tooth surface.

Children are dependent on parents, particularly mothers, to practice dental hygiene behavior [4], [5]. Despite children's dependency on mother's role, not all mothers have a strong intention to carry out the behavior of maintaining children's dental health. One important factor influencing intention is

perceived behavioral control (PBC), which is the extent to which mothers feel they have the ability, time, resources, and opportunity to perform dental care for their children. The problem is, many mothers understand the importance of maintaining their children's dental hygiene, but not all mothers feel able to do it consistently, for example, due to time constraints, lack of support, or difficulty getting their children to brush their teeth. As a result, positive behavioral intentions don't always translate into concrete actions, and this contributes to the high prevalence of childhood caries.

Behavior is commenced from Perceived behavioral control (PBC), which becomes a key to construct the capacity to overcome barriers and perform a behavior. Research grounded in the Theory of Planned Behavior (TPB) indicates that perceived behavioral control (PBC) is a central predictor of behavioral intention and, ultimately, actual behavior. Studies applying TPB to oral health contexts have found that higher parental PBC is associated with stronger intentions to perform oral-health behaviors and better preventive practice uptake.

Studies about parental psychosocial factors, such as PBC, can be a prediction of intention, as revealed by Mohammadkhah et al (2023) that TPB-based educational interventions have improved oral-health intentions and certain behaviors, proven by better DMFT and dental plaque indices across diverse populations, with a p-value of 0.001[10]. Broader surveys underscore that maternal oral-health literacy, stress, and self-efficacy mediate the link between knowledge and child outcomes; integrating these constructs yields better explanatory power than knowledge alone. Parents' oral health literacy and behavior are found to significantly affect their children's oral health status ($p<0.01$) [11]. An intervention that integrates TPB in terms of PBC can directly predict the behavior of the parent regarding their child's behavior [12]. This shows that the integration of TBP in the intervention has an effect on a significant effect on behavior. However, while global studies document PBC's importance, few studies in Indonesian preschool settings quantify how much variance in maternal intention is explained specifically by perceived behavioral control regarding dental health.

Children's oral health is dependent on the mothers' health behavior and consistency at home. A study of quantifying how perceived behavioral control specifically informs maternal intention regarding their children's dental health care is very important, as it addresses a notable gap in local literature. This study aims to evaluate the correlation between PBC and the intention of mothers in their children's dental health care. The findings of the study will provide empirical evidence on how the perceived behavioral control correlates with the intention of the mothers to ensure dental health in children, which will also develop an effective health promotion intervention grounded in the Theory of Planned Behavior (TPB).

2. METHODOLOGY

This type of research is to look at the analysis of the mother's behavioral model in caring for the dental health of early childhood children based on the theory of planned behavior, which is a multivariate study with a cross-sectional approach, namely research to study the dynamics of correlation between risk factors and effects, by means of an approach, observation or data collection at the same time. The study population comprised 305 mothers whose children were enrolled in seven kindergartens across Bukittinggi City. A cluster random sampling method was applied to ensure proportional representation from each kindergarten. The respondents' sample size was determined using Equation 1.

$$N = \frac{4.Z_{\alpha}^{2}.\mu.(1-\mu)}{W^{2}} \quad (1)$$

The proportion of the expected response or prevalence rate is denoted by π. If the actual proportion (p) is unknown, it is assumed to be 50% or 0.50. This assumption is used because it provides the most conservative estimate for determining the sample size. The value of W represents the magnitude of deviation, which is related to the bound on the error of estimation. Typically, the acceptable range of deviation is between 10% and 20%, or in decimal form, 0.1 to 0.2. Meanwhile, Zα refers to the adjusted standard deviation corresponding to a specific level of significance (α). For a 95% confidence level (α = 0.05), the Zα value used is 1.96. Therefore, the calculation of the sample size resulted in Equation 2.

$$N = \frac{4\ x\ 1.96\ (0.05)^2\ x\ 93.33\ (1-93.33)}{(0.2)^2}$$

(2)

$$N = \frac{12.201}{0.04}$$

$$N = 305$$

Based on the formula above, the number of samples to be used in the research was 305 respondents. Respondents met the inclusion criteria: mothers of children officially registered in the selected schools, willing to participate voluntarily, and providing informed consent.

The reason behind the location of research is according to the data of Bukittinggi City in 2023, there were 99.78% women have a literacy rate, including mothers. Thus, the mortality rate of children aged 5 years in Bukittinggi was 6.8%, reduced from 7.9% in 2022. However, the stunting rate in 2023 is 20.1%, which is higher than the standardization of WHO, i.e., 20% at the maximum rate [13]. One of the factors that contributes to stunting is dental health. Poor dental health will reduce the nutrient intake due to difficulties and pain of a toothache, and impaired sleep, which hampers the growth hormone [14]. Nevertheless, the stunting status in Bukittinggi in 2024 reduced to 16.8% [15]. However, this situation is still prone to fluctuation, as according to data from health professionals in Bukittinggi City, including dental practitioners, the number amounts to only 65. Thus, there is an imbalance amount of the residents and the health practitioners. Thus, the mother should take a role in the health of the children.

The independent variable was maternal perceived behavioral control, defined as the mother's belief regarding supports and barriers (control beliefs) and her sense of capability to perform a given behavior. The dependent variable was mothers' intention toward dental care for their children, defined as the measure of how hard a person is willing to try and how much effort they are prepared to put into adopting a behavior. The instrument used was a self-administered questionnaire. The perceived behavioral control section comprised 18 items covering mothers' perceptions of their ability to maintain children's oral health (e.g., ensuring dental check-ups every six months, selecting a child-appropriate toothbrush, monitoring frequency of toothbrushing, using fluoride toothpaste). The intention section comprised 16 items addressing the mother's commitment to behaviors (e.g., intention to maintain the child's oral health, ensure brushing at least twice daily, give fluoride toothpaste). Each item used an ordinal scale of 1 (very inappropriate), 2 (inappropriate), 3 (appropriate), and 4 (very appropriate).

The data analysis was conducted by four processes before the correlation test. The data was processed through editing, where the researchers ensured the questionnaires were complete, relevant, and consistent. This check was also carried out previously during data collection in the field, so that it did not cause problems during the editing process of all questionnaires. Next, the data was processed through coding. Coding refers to the process by which the researcher converts data in the form of letters or text into numerical data, according to the operational definitions and the needs of the analysis. Subsequently, a processing stage of the data was performed, entering the data obtained from questionnaires into a computerized program for further analysis. Next, the clearing stage was conducted by researchers to perform data cleaning by rechecking the entered data to identify and correct any possible errors or missing values. Afterwards, a multivariate ANOVA regression test was carried out to assess the correlation between maternal perceived behavioral control and intention toward dental care. Descriptive statistics (mean, standard deviation, median) summarized variable characteristics. Analyses were conducted at a 95 % confidence level (p-value < 0.05). Correlation strength was interpreted following standard thresholds: very weak (<0.20), weak (0.20–0.39), moderate (0.40–0.59), strong (0.60–0.79), very strong (>0.80) [16].

3. RESULTS

The results consist of the frequency distribution, descriptive statistics of the study variables. Normality test was performed as the initial step before conducting ANOVA Regression test.

3.1 Frequency Distribution of Children by Gender

The frequency distribution of the children of the mothers who were observed in the research is shown in Table 1.

***Table 5**. Frequency distribution based on gender*

Gender	Frequency	Percentage (%)
Male	175	57
Female	130	43
Total	**305**	**100**

According to Table 1, out of 305 children, 175 (57 %) were male and 130 (43 %) were female sstudents. This balanced distribution indicates that both genders were adequately represented, ensuring proportionality in data analysis and minimizing sampling bias.

3.2 Correlation in PBC and intention

A descriptive statistic was presented to see the average and standard deviation of the variables PBC and intention. Subsequently, the normality test was conducted to proceed to the ANOVA Regression which describe the correlation between variables.

***Table 6.** Descriptive statistics of the variables*

Variable	Average	Standard Deviation
Perception Behavioral Control	51.233	7.953
Intention	46.444	7.440

Table 2 shows the mean score for perceived behavioral control is 51.23 ± 7.95, indicating a relatively high average level of maternal confidence in managing children's oral hygiene. The mean intention score of 46.44 ± 7.44 reflects mothers' strong motivation to ensure proper oral care practices, such as regular brushing and fluoride use.

***Table 7.** Normality test results between variables*

Variable	p-value	α
Perception Behavioral Control	<0.0001	0.05
Intention	<0.0001	

Table 3 shows that both variables showed $p < 0.05$, indicating that the data were not normally distributed. Hence, the ANOVA regression was performed. The dataset was sufficiently large for ANOVA regression assumptions under robust estimation to hold, allowing reliable correlation analysis.

Table 8. *Correlation between PBC and intention*

Variable	ANOVA Regression	R^2	p-Value	Regression Coefficient (β)
Perceived Behavioral Control	< 0.0001	0.713	< 0.0001	+ 0.635

Table 4 shows the ANOVA regression yielded an R^2 of 0.713, meaning 71.3 % of the variance in mothers' intention toward dental care was explained by perceived behavioral control. The positive regression coefficient (β = + 0.635) with $p < 0.001$ demonstrates a strong and significant correlation, suggesting that the more control mothers perceive over their children's oral health routines, the stronger their behavioral intention to maintain these practices.

4. DISCUSSION

The present study revealed a strong and statistically significant correlation between maternal perceived behavioral control (PBC) and intention to maintain children's oral health, with an R^2 value of 0.713 and a regression coefficient of β = +0.635 ($p < 0.001$). This finding indicates that mothers' confidence in their ability to overcome barriers and regulate their children's oral health routines in their intention to engage in preventive practices. These results are consistent with findings from other recent research showing that parental control beliefs significantly affect children's dental hygiene adherence and reinforce the role of self-efficacy in predicting preventive dental behavior [17]. This is in line with the Theory of Planned Behavior that at times when individual beliefs that sufficient control can motivate the behavior [10].

The results of the study are aligned with the TPB-based studies that PBC emerges as a key determinant of behavioral intention. As presented by Liu et al (2024) the parental health beliefs model (HBM) constructs the oral health behavior. The perceived susceptibility and perceived severity were significantly associated with children's caries. Besides, the poorer oral health (p-value 0.09) and greater perceived barrier (p-value 0.30) were also associated with lower oral health-related quality of life [18]. Therefore, it highlights the point of importance of the health belief model to be integrated into the education program to promote positive behavior. Besides, this also suggests that mothers' perception of control is not just a psychological variable, but a behavioral enabler that can transform knowledge into a concrete preventive action. In the context of this study, this correlation (β = +0.635) highlights the relevance of psychosocial factors beyond mere awareness or knowledge. Although many health-promotion programs in Indonesia emphasize informational campaigns, these findings indicate that enhancing behavioral self-regulation and perceived capability may yield greater behavioral outcomes. So, the health practitioners are challenged to encourage mothers' confidence to believe in their ability to maintain their children's dental care through training, provision, and providing supportive environment programs which can boost their intention to perform behavior of dental care preservation.

Early childhood caries is preventable by consistent parental-supported behavior, such as toothbrushing [19], [20]. The Theory of Planned Behavior developed one of which is oral health promotion messages through training towards mothers, which was performed by Ihab et al (2023) [21]. Adopting TBP, the mothers feel comfort in the training, which is suitable with their needs, such as mothers were 80% requested to receive training once per week from 8 pm to 2 am (50%), and 60% able to receive the materials in 15-30 minutes during the intervention. This reflects the program's equitable and flexible approach, ensuring accessibility by tailoring the intervention to the mothers' routines and preferences.

The results of adopting TBP in the intervention show an interesting result of correlation. The study shows the magnitude of correlation ($R^2 = 0.713$) observed in this study is higher than that reported in most comparable TPB-based research, which typically explains 40–60% of the variance in behavioral intention (Rajeh et al., 2022) [22]. This could be attributed to the high homogeneity of the sample and the strong role of maternal figures in early child-rearing practices within Indonesian cultural contexts,

where mothers serve as primary caregivers and health decision-makers. The findings thus offer valuable cultural insight into how behavioral control manifests in collectivist settings where social and familial responsibilities often reinforce internal motivation to maintain child health.

The results of the study have several broader implications for the scope of oral health promotion, behavioral theory, and the community-based practice. The findings enable the applicability of TBP to predict and influence the health behavior of the mothers. It is proven by a strong correlation with R^2 = 0.713, which shows that the perceived behavioral control is a powerful determinant of mothers' intention and subsequently can also influence the act of preserving the oral health of the children. this contributes to the theoretical advancement by demonstrating that TPB has become a suitable framework for education with strong familial dan social bonds.

From a practical perspective, the study highlights the importance of responsive and flexible health education strategies. A health professional can customize the respondents or the mothers to arrange the schedule to meet their needs and learning preferences. By these strategies, mothers feel comfortable and tend to achieve higher engagement. Such an approach is aligned with the global recommendations of oral health promotion, which involves equity, customized to meet as needs, which can be different from one to another. Mothers as a critical agents of early childhood health must a strong maternal empowerment through behavioral intervention which can lead to long-term caries reduction in children and prevent other worse diseases. Therefore, oral health policy should also consider family-center models to incorporate behavioral theories and community participation to enhance preventive outcomes.

Overall, this study contributes to the growing body of evidence supporting the integration of behavioral science into public health practice. By demonstrating how TPB-based interventions can be successfully adapted to local sociocultural contexts, it offers a replicable model for promoting sustainable health behavior change across diverse populations.

4.1 Implications, Limitations, and Future Works

This study has proven that there is a strong correlation between PBC and the intention of mothers in dental care of their children, shown by an R^2 value of 0.713. Mothers who perceived their child's oral health as poor were more likely to have children with higher caries prevalence, indicating that maternal awareness plays a crucial role in early detection and prevention.

This study has also supported the constructs of TBP, demonstrating that TPB is an effective theoretical model for explaining oral health–related behaviors among mothers. The implications rely on the intervention based on TPB principles, which can effectively drive change in mothers' control beliefs. The intervention may vary in providing skill-based workshops, such as in supervising brushing, addressing structural and psychological barriers, such as limited access to dental services and lack of perceived efficacy, and lastly, to integrate the behavioral counseling into maternal and child health visits to reinforce positive control beliefs. Besides, TBP also successfully created engagement in the mothers, where mothers can express preferences, i.e., most participants preferred short (15–30 minute) weekly sessions in the evening, which supports the value of flexible, family-centered health education approaches. This highlights the value of education should put attention to the intervention design which aligns with social norms and caregivers' dynamics, or in other words is highlights the equity.

The study, however, has limitations that include its cross-sectional design, which cannot confirm whether higher PBC will lead to higher intention over time. Next, a self-reported questionnaire data collection suffered from bias. Lastly, is that the study was conducted in one city, which is still insufficient to portray socio-cultural economic contexts in Indonesia. The future works of the study can be assessed with experimental designs incorporating qualitative methods. To support broader research, digital health platforms can be used and collaborate with other dental health professionals and public health authorities.

5. CONCLUSIONS

This study confirms that maternal PCB plays a dominant role in mothers' intention to maintain their children's dental health, indicated by 71.3% influence. Besides, it also shows that there is a strong correlation between PBC and the intention of the mothers ($R^2 = 0.713$; $p < 0.001$). The findings emphasize the focus on behavioral confidence and self-efficacy through skill-based training, barrier reduction, and supportive counseling as the intervention program. Integrating these elements into maternal and child health programs—particularly within kindergarten and community health settings—can effectively strengthen preventive behaviors and reduce the risk of early childhood caries. Future works should analyze using experimental designs, incorporating digital health tools and other dental health professionals and public health authorities to cope with research limitations.

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THE EFFECTIVENESS OF INTRADIALYTIC EXERCISE AEROBIC ON SLEEP QUALITY OF CHRONIC RENAL FAILURE PATIENTS THROUGH HEMODIALYSIS: A SYSTEMATIC LITERATURE REVIEW AND META-ANALYSIS

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Abstract

The chronic renal failure undergoing hemodialysis increases 7% annually causing sleep disorders is more prevalence in adults by 45% to 80%. Aerobic exercise which is non-pharmacological nursing interventions is known as an approach to overcome sleep disorder in chronic renal failure patients. The aim in this study is to review the relevant studies in the effectiveness of intradialytic exercise aerobic to address sleep quality in patients with renal failure undergoing hemodialysis. This research method uses literature searches sourced from ProQuest, PubMed, NCBI, and google scholar with a total of 86 articles and 20 articles that are worth analyzing, the analysis was carried out using Review Manager 5.4. with a 95% confidence level, heterogeneity between studies was assessed using a statistical test with the chi-test, using a random-effects model. The studies in the Asian continent showed that the treatment on patients (2 hours of dialysis with a duration of ≤ 60 minutes) that have characteristics ≥ 3 months undergone HD, resulted high heterogeneity value by chi = 1109494.75. The sleep quality was measured by Pittsburgh Sleep Quality Index (PSQI) instrument. Moreover, the intradialytic exercise evidently improved sleep quality (p-Value <0.06). It can be concluded that intradialytic exercise aerobic has a significant impact in reducing sleep disorders in hemodialysis patients.Therefore, the intradialytic exercise aerobic by standard operational procedures can be refered as a routine intervention for nurses in the hemodialysis room.

Keywords: intradialytic exercise aerobic, sleep quality, chronic renal failure

1. INTRODUCTION

Based on data in Riskesdas, 2013 patients aged > 75 years were in the top rank for the group of patients with chronic kidney failure, which was 0.6% higher than the elderly age group. Meanwhile in the group according to gender, the prevalence of men with chronic kidney failure in Indonesia is 0.3 percent, which is higher than women with chronic kidney failure, which is 0.2% (Forwaty, Malini, Oktarina, 2019). Kidney failure patients who undergo hemodialysis are about 80 percent alive which have an impact on decreasing mortality and morbidity and even experiencing a decrease in quality of life, depression, sleep quality, besides the length of hemodialysis hours is about 12-18 hours a week, this reduces immobilization which affects activity decline and muscle weakness (Wulandari, Imanuel Sri May, 2015).. Based on observations at the Stella Maris Hospital Makassar (March-April 2017

period) of 60 patients with chronic kidney failure undergoing hemodialysis therapy who were detected to have sleep disorders around 50% (Natale et al, 2019). Complaints of sleep disturbances are common and are frequently reported by end-stage renal failure patients undergoing hemodialysis. The prevalence rate of any sleep disorder in chronic renal failure patients ranges from 45% to 80% in adults. Sleep disturbances in chronic kidney failure patients undergoing hemodialysis therapy in addition to causing poor sleep quality, sleep problems also have a negative impact on physical and mental health and can lead to a decrease in the patient's appearance such as cognitive and memory dysfunction, irritability, decreased concentration (Safruddin, 2016).). In addition, other effects of the longterm hemodialysis will result in an increase in parathyroid hormone, renal osteodystrophy, breathing problems during sleep and excessive daytime sleepiness. Chronic kidney disease is a disease that can cause physical problems that cause fatigue that affects daily activities,

causing feelings of worry that can affect sleep quality (Ningrum, Imardiani, Rahma, 2017). There are many types of intradialytic physical exercise that are safe and effective for chronic kidney failure patients who have sleep problems, including the usual intradialytic exercises or those applied, including intradialytic aerobic exercise, intradialytic increased physical activity improving, intradialytic relaxation therapy and intradialytic hypnotherapy (Nurfianti, An, 2019). According to Mitchel et.al, 2015 potential interventions that can be done to improve sleep quality are energy conservation, activity management is intradialytic exercise, Intradialytic exercise is defined as a planned, structured movement carried out to improve physical fitness that is beneficial for maintaining and improving health. Intradialysis exercises carried out at home or in dialysis centers provide benefits for patients undergoing hemodialysis because exercise methods are safe, economical, accessible and can be performed for groups of patients with kidney failure, there are many types of intradialytic physical exercise that are safe and effective for patients. chronic kidney failure undergoing hemodialysis, including intradialysis which is usually done or applied, among others, intradialytic which is useful for improving the quality of sleep of patients with chronic kidney failure undergoing hemodialysis according to several research sources, namely intradialytic aerobic training, intradialytic Increased physical activity improves, intradialytic relaxation therapy, meditation, hypnotherapy (Nurfianti, An, 2019). Regular aerobic exercise will increase physical activity that is well developed can bring many benefits in the process of preventing or rehabilitating disease, strengthening the musculoskeletal, cardiorespiratory system of patients suffering from chronic kidney disease (M. J. de D. Morais et al, 2019).

One method of health therapy that can improve sleep quality is aerobic intradialytic exercise. The exercise given is in the form of aerobic exercise which consists of regular aerobic flexibility or stretching movements in the lower extremities consisting of 5 minutes of warm-up and 10 to 30 minutes of cycling and 20 minutes of cooling down, patients who perform aerobic exercises in a supine position with cycling movements of the lower limbs and with arms supine along hips and at sides and a cooling phase lasting 20 minutes, during which the patient is instructed to remain as relaxed as possible (Zazzeroni et al, 2017), intradialysis is performed during the first two hours of each dialysis session (3 sessions per week). Then the final results in patients with chronic kidney failure who experience complaints of sleep disturbances are measured by polysomnography and PSQI, the results show that exercise improves sleep quality, although not significantly (Clarkson et al, 2019).

Based on studies that examined aerobic intradialysis, good results were obtained with aerobic exercise in hemodialysis patients but with a limited population, hemodialysis patients 50% to 80% of patients who had sleep complaints (in the study only 55%) (MJD Morais et al, 2019). In addition, there are significant changes in the body's nervous, cardiovascular, respiratory, musculoskeletal and endocrine/metabolic systems. Physical exercise leads to an increase in functional capacity, reduces the risk of cardiovascular disease and improves psychological structure, so that the implementation of an aerobic exercise program during hemodialysis is a safe and efficient intervention that helps improve physical performance, nutritional status, improve sleep quality, anabolic response, and muscle strength. MJ de D. Morais et al, 2019). Based on the literature above, researchers are

interested in developing an aerobic exercise intradialytic intervention.

2. METHODOLOGY

Design This research is a systematic literature reviews and meta-analysis or library research with a systematic literature reviews (SLR) design, which is a synthesis of systematic, clear, comprehensive literature studies by identifying, analyzing, evaluating through data collection already exist with an explicit search method and involves a critical review process in the selection of studies (Zed, 2014). The purpose of this method is to help researchers better understand the background of the research that is the subject of the topic being sought and understand why and how the results of the research can be used as a reference for new research. In this study, researchers analyzed and compared several studies related to the effect of intradialytic aerobic exercise on the sleep quality of chronic kidney failure patients undergoing hemodialysis. Problem identification is the process of identifying or inventorying problems. The research problem is something that is important among other processes, because it determines the quality of a research. In this study, researchers will examine the problem through national and international research journals derived from reports on research results. The problem of this research is the research title "effectiveness of intradialytic aerobic exercise on sleep quality of chronic kidney failure patients undergoing hemodialysis". The literature search will be conducted in May – November 2020. The data used in this study is secondary data obtained not from direct observation, but obtained from the results of research that has been carried out by previous researchers. Sources of secondary data obtained in the form of reputable journal articles both nationally and internationally with a predetermined theme.Search data used are sourced from PubMed, NCBI and google schoolar as a larger database carried out using the following combination of keywords. The literature search in this systematic review uses a database that is population: Hemodialysis" OR "Dialysis OR hemodialysis" OR 'CKD OR Chronic Failure OR ESRD OR Chronic Disease OR Chronical or chronically, intervention : 'Intradialytic' OR' Exercise 'OR' sports' Exercise Aerobic 'OR' Exercise Cycling 'OR Intradialityc Aerobic 'OR' Intradialityc Cycling 'OR' Therapy , outcome : "sleep quality 'OR' insomnia 'OR' sleep disorders' OR 'Sleep quality or poor sleep. Quality assessment in the Systematic Literature Review (SLR) method of this study was carried out using the guidelines for critical appraisal skills programmed tools (CASP) Randomized Controlled Trial (RCT) which consisted of 10 questions and obtained results from 77 articles that were worthy of analysis as many as 20 articles. Statistical analysis using Meta-analysis conducted using Review Manager 5.4. Combined probability ratio OR with 95% confidence level. Heterogeneity between studies was assessed using statistical tests with chi-test. If the results of the analysis show that the data is heterogeneous (I2 = 75%) (Review Manager 5.4.), then the determination of the effect size will use a random effect model. To identify the source of heterogeneity, subgroup analysis was performed. Forest plots were used to present the results of the meta-analysis and statistical significance was set at $P < 0.05$. Analysis was used to estimate the effect of the study as a whole. The ethical standards that the author will use to conduct a literature review in this study refer to Wager & Wiffen (2011).

1. Identification problem and keyword

Tabel 1 Analysis PICO

Analysis	Description	Keyword
P (POPULATION**)**	Population in this research is adult patient who had chronic renal failure that have treatment of hemodialisa	"Hemodialysis" OR "*Dialysis* OR *hemodialisafiltration"* OR ' CKD OR *Chronic Failure* OR ESRD OR *Chronic Disease* OR *Chronical or chonically*

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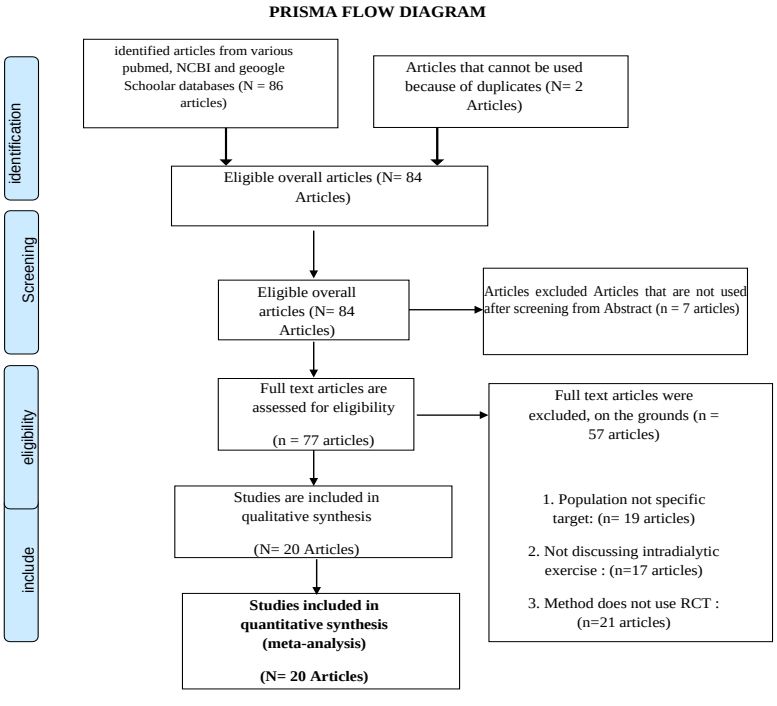
I (INTERVENTION)	Intradialityc exercise Aerobic	'Intradialytic' OR' *Exercise* 'OR' sports' *Exercise Aerobic 'OR' Exercise Cycling* 'OR Intradialityc *Aerobic* 'OR' Intradialityc *Cycling* ' OR' Therapy
C (COMPARASION)	There are no comparasion	
O (OUTCOME)	The Expected outcome of this research is there are effect of intradialytic exercise aerobic to sleeping quality of patient that have chronic renal failure where they going through treatment of hemodialisa	"*sleep quality* 'OR' insomnia 'OR' *sleep disorders'* OR '*Sleep quality or poor sleep*

3. RESULTS

Search for articles using the keywords Hemodialysis" OR "Dialysis OR hemodialysis" OR ' CKD OR Chronic Failure OR ESRD OR Chronic Disease OR Chronical or chronically OR 'Intradialytic' OR' Exercise 'OR' sports' Exercise Aerobic 'OR' Exercise Cycling' OR Intradialityc Aerobic 'OR' Intradialityc Cycling ' OR' Therapy' OR "sleep quality 'OR' insomnia 'OR' sleep disorders' OR 'Sleep quality or poor sleep. In the Pubmed database, there are 60 articles, while in the Google Scholar database, there are 6 articles, and in the NCBI database, there are 20 articles. Overall the number of articles obtained from searching the entire database is 86 articles, there are 2 articles that are duplicates so that they are

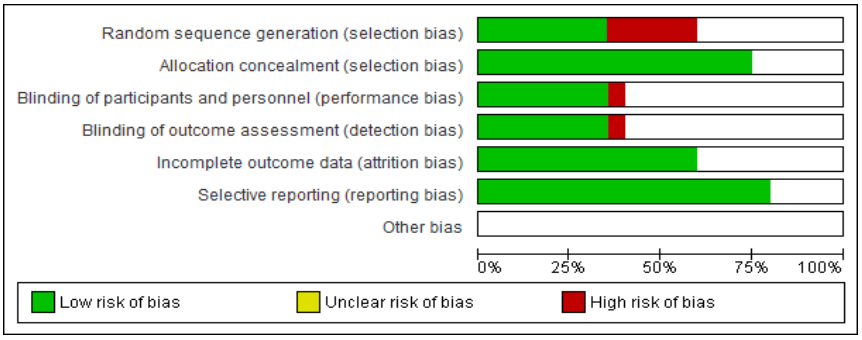


Bagan 1. Prisma Flow Chart

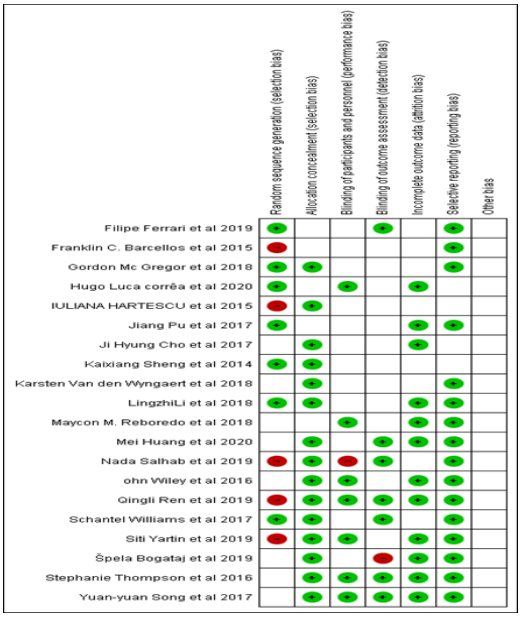
From: Moher D, Liberati A, Tetzlaff J, Altman DG, The PRISMA Group (2009). Preferred Reporting Items for Systematic Reviews and Meta-Analyses

deleted in the list of articles that will be screened further. From the total articles minus duplication, there were 84 articles that were screened for the first time by filtering, namely from 2014 to 2020, there were 7 articles that were not included on the grounds that the abstract results did not meet the criteria. Then obtained articles with a total of 77 articles for the second stage of screening. The results of the second stage of screening, obtained a total of 77 articles because as many as 57 articles were issued on the grounds that 19 articles had a non-specific population of articles, 17 articles did not discuss intradialytic exercise and 21 articles did not use the RCT method. Next, the article eligibility assessment stage was carried out based on the inclusion criteria, so that the total articles that passed the eligibility screening were 77 articles and 20 articles that were eligible for meta-analysis.

Figure Resiko Bias



Based on the picture above, the results obtained from 20 included articles, 12.5% reported detailed randomization methods in the low bias category and 25% in the high bias category, 75% explained the allocation in detail in the low bias category, 12.5% explained about the intervention participants. research with low bias category while 12.5% high bias, 12.5% explains the results of research with low bias category and 12.5% high bias, 37.5% explains the imbalance of measurement results from research with low bias category and 75% explains research protocol.



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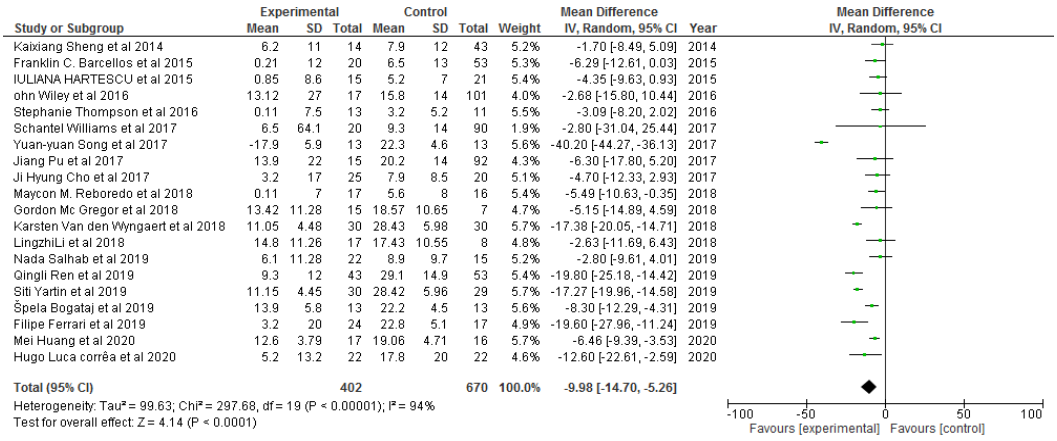
A potential selection bias in this study because patients who were eligible to participate in this study were not all patients who met the criteria agreed to be respondents and participate in this study, finally, there was a baseline imbalance in the dialysis model between groups. There are 6 studies that have a high risk of bias due to inadequate blinding. The first study (Frankline, 2015) stated that the risk of bias occurs due to non-adherence to the intervention, the second study (Iuliana Hartescu et al, 2015) stated that the risk of bias occurs because there is no adherence to hemodialysis and there is no seriousness in the intervention. The third study (Nada Salhab et al., 2019) there is a bias in the absence of seriousness in the intervention, the fourth study (Qingli Ren et al., 2019) the risk of bias occurs because there is no adherence to hemodialysis, the fifth study (Siti Yartin et al., 2019) the risk of bias occurred because in the middle of the intervention there was a resignation as a respondent and the sixth study (Špela Bogataj et al, 2019) the risk of bias occurred because there was no adherence to hemodialysis and there was no seriousness in the intervention, causing some bias. Meanwhile, 20 studies are categorized as low risk and unclear.



Twenty studies involving 1072 hemodialysis patients consisting of the intervention group and the control group showed the effect of intradialytic aerobic exercise on sleep quality. There was a high heterogeneity of 99.63, chi = 297.68, df = 19, so that the subgroup analysis showed a statistically significant difference between the intervention and control groups of -9.98 [-14.70, -5.26]. Aerobic intradialytic exercise was able to reduce sleep problems in hemodialysis patients (P < 0.0001). There is a strong influence of aerobic intradialytic exercise on sleep quality in hemodialysis patients.

4. CONCLUSION

Based on the results of the analysis of twenty studies on the effectiveness of intradialytic aerobic exercise on the sleep quality of chronic kidney failure patients undergoing hemodialysis: A systematic review and meta-analysis is as follows:

1. The continent of Asia is a continent that has high heterogeneity compared to other continents with a sample category of 50 with a hemodialysis patient category of less than 3 months, it is highly recommended to perform intradialytic exercise interventions without indications with exercise duration 60 minutes and exercise frequency 6 month. Sleep quality was measured using the PSQI (Pittsburgh Sleep Quality Index) before and after the intervention.
2. Exercise gradually every hemodialysis will overcome sleep problems in hemodialysis patients

3. The results of the meta-analysis of intradialytic aerobic exercise have a positive effect and improve sleep quality in hemodialysis patients with a value of chi = 297.68, p = 94% (P < 0.00001). this will have an impact on the patient's ability to cope with sleep problems and a review of these studies can also help in planning research into intradialytic aerobic exercise as a non-pharmacological therapy.

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KNOWLEDGE OF TEETH BRUSHING WITH DENTAL AND ORAL HYGIENE IN STUDENTS OF DURIAN GADANG STATE ELEMENTARY SCHOOL, SIJUNJUNG DISTRICT IN IMPROVING NUTRITIONAL STATUS

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Abstract

Dental and oral health problems are problems that are often found in elementary school children. Brushing teeth is one of the efforts to maintain dental and oral hygiene. The purpose of this study was the knowledge of brushing teeth with dental and oral hygiene in students of SD Negeri Durian Gadang, Sijunjung Regency in Improving Nutritional Status. This type of quantitative research with a Cross Sectional approach. The population of the study was 78 students of SD Negeri 07 and 28 Durian Gadang, Sijunjung Regency. The sampling technique used saturated sampling, namely the entire population was used as a sample. Data collection was carried out using a questionnaire sheet and an OHI-S examination sheet. The analysis used was univariate and bivariate analysis with the Chi Square statistical test. The results showed that the knowledge of brushing teeth of grade IV and V students at SD Negeri 07 and 28 Durian Gadang, Sijunjung Regency was in good criteria 70.5% (55 people), sufficient criteria 24.4% (19 people), low criteria 5.1% (4 people). Oral and dental hygiene in grade IV and V students at SD Negeri 07 and 28 Durian Gadang, Sijunjung Regency, OHIS criteria are good 42.3% (33), moderate 53.8% (42 people), poor criteria 3.8% (3 people). Based on the results of statistical tests, there is a relationship between knowledge of brushing teeth and oral and dental hygiene with a p value = 0.000, which is <0.005. The conclusion of the study shows that there is a relationship between knowledge of brushing teeth and oral and dental hygiene. It is recommended that respondents brush their teeth properly and correctly, and maintain oral and dental hygiene to obtain optimal nutrition.

Keyword : *Tooth Brushing, Knowledge, and Dental Hygiene*

1. INTRODUCTION

Dental and oral health is an integral part of body health and can have an impact on overall body health.32 Many factors influence a person's dental and oral health, such as behavior, environment, heredity, access and utilization of health services (Hanum, A.N, 2022). Health efforts are a series of activities carried out in the form of activities through promotive, preventive, curative, and rehabilitative approaches that are carried out in an integrated, integrated, and sustainable manner. [16].

The most common dental and oral health problem in elementary school children is tooth decay. Causes of tooth decay include lack of maintaining dental and oral hygiene, such as brushing teeth.[13] Preventive efforts in maintaining dental and oral hygiene, which can be done by brushing teeth.[7]

Dental and oral care carried out by children can affect how good their dental and oral conditions are in old age. The right time to train a child's motor skills in brushing teeth is at elementary school age.

One of the most important factors in maintaining dental and oral health is the child's ability to brush their teeth properly and effectively. Parents who do not get their children used to brushing their teeth from an early age can cause children to be unaware and unenthusiastic about maintaining their dental and oral health. As a result, children's teeth and mouths are susceptible to dental and oral diseases (Jumriani, 2018).

Based on Basic Health Research Data (Riskesdas), it shows that dental and oral health problems in Indonesia in 2013 were 25.9% [15] and increased by 45.3% in 2018.[16] For the age group 10-14 years, it was 25.2% in 2013, and increased by 41.4% in 2018.[36] Meanwhile, only 2.1% brush their teeth properly. In West Sumatra, 0.92% brush their teeth properly.[17]

Knowledge is the formation of associative thoughts that connect or link a thought with reality or with other thoughts based on repeated experiences without an understanding of the true and universal cause and effect.[1]

Measuring dental and oral hygiene is an effort to determine the state of a person's dental and oral hygiene, which is usually used to measure dental and oral hygiene and mouth index. Index is one of the numbers that indicates the clinical condition obtained at the time of examination by measuring the area of the tooth surface covered by plaque or calculus. Measurement of dental and oral hygiene according to Green and Vermillion can use an index, one of which is the Simplified Oral Hygiene Index.[23]

Oral hygiene is an important part of general health and affects a person's ability to obtain optimal nutrition (WHO). Children with severe dental caries are more likely to be malnourished. Pain and oral infection can reduce appetite and intake of calories and protein which are essential for growth.[33] Oral health problems such as cavities, gingivitis can reduce the ability to chew. This causes a person to avoid hard or fibrous foods (eg fruit, vegetables, meat) which results in decreased quality and variety of nutrient intake.28]

2. METHODS

The type of research used is quantitative research with a Cross Sectional approach which aims to determine the relationship between brushing teeth and dental and oral hygiene. The test used is the Chi-Square test to determine whether there is a significant relationship between variables. The location of this research was conducted at students of elementary school 07 and 28 Durian Gadang, Sijunjung Regency. The sampling technique was saturated sample.

3. RESULTS

The results of the research conducted at Durian Gadang State Elementary School, Sijunjung Regency obtained the following results:

Table 1. Frequency Distribution of Toothbrushing Knowledge of Grade IV and V Students of SD Negeri 07 and 28 Durian Gadang, Sijunjung Regency in 2025

No	Knowledge Criteria	F	%
1	Good (80-100%)	55	70,5
2	Average (60-79%)	19	24,4
3	Poor (<60%)	4	5,1
	Total	78	100

In table 1 above, it can be seen that the frequency distribution of knowledge of grade IV and V students at SD Negeri 07 and 28 Durian Gadang, Sijunjung Regency regarding knowledge of brushing

teeth is highest in the good criteria of 70.5% (55 people), while the lowest knowledge of brushing teeth is in the low criteria of 5.1% (4 people).

Table 2.Frequency Distribution of Dental and Oral Hygiene of Grade IV and V Students of State Elementary Schools 07 and 28 Durian Gadang, Sijunjung Regency in 2025

No	Dental and Oral Hygiene Criteria	f	%
1	Good	33	42,3
2	Average	42	53,8
3	Poor	3	3,8
	Total	78	100

In table 2 above, it can be seen that the frequency distribution of dental and oral hygiene in grades IV and V at SD Negeri 07 and 28 Durian Gadang, Sijunjung Regency, is highest in the moderate OHIS criteria at 53.8% (42 people), while the lowest dental and oral hygiene with the OHI-S criteria is in the poor criteria at 3.8% (3 people)

Table 3.Chi-Square Test Results of the Relationship between Toothbrushing Knowledge and Dental and Oral Hygiene in Grade IV and V Students of SD Negeri 07 and 28 Durian Gadang, Sijunjung Regency in 2025

	Value	Df	Asymptotic Significance (2-sided)	*P value*
Pearson Chi-Square	27.880.[a]	4	.000	0,000
Likelihood Ratio	33.820	4	.000	
Linear-by-Linear Association	21,982	1	.000	
N of Valid Cases	78			

Based on table 3 above, it shows that the highest cross-tabulation of statistical test results using chi-square shows a p value = 0.000 with a confidence level of 95% or p value = <0.005 where H0 is rejected, which means there is a significant relationship between knowledge of brushing teeth and dental and oral hygiene in grade IV and V students of SD Negeri 07 and 28 Durian Gadang, Sijunjung Regency.

4. DISCUSSION

The results of the study showed that the results of the statistical test using chi-square showed a p value = 0.000 with a confidence level of 95% or p value = <0.005 so that it can be concluded that there is a significant relationship between knowledge of brushing teeth and dental and oral hygiene in grade IV and V students of SD Negeri 07 and 28 Durian Gadang, Sijunjung Regency, meaning that the higher the knowledge about brushing teeth, the better the dental and oral hygiene figures.

According to researchers, the relationship between knowledge of brushing teeth and oral hygiene is caused by the behavior of respondents who already know about brushing teeth such as the purpose

of brushing teeth, how to brush teeth, time and frequency of brushing teeth, and the use of good and correct toothpaste so that patients know how to maintain the cleanliness of their teeth and mouth. Their habit of brushing teeth 2x a day but not after breakfast and at night before going to bed, and some children have brushed their teeth after breakfast and at night before going to bed, which is proven by those who have good OHI-S as many as 33 people. When researchers asked about their brushing habits, they had brushed their teeth properly.

Brushing your teeth after eating aims to remove food residue that sticks to the surface or between the teeth and gum.[11] Brushing your teeth properly and with good technique can prevent various problems in the oral cavity. Brushing your teeth is done to remove and prevent plaque formation on the surface of the teeth that can be reached by the toothbrush. In brushing your teeth, you must pay attention to the correct and regular brushing technique.[11] The frequency of brushing your teeth is one form of behavior that will affect the good or bad hygiene of your teeth and mouth.[13] If children do not brush their teeth properly, food residue and sugar will stick to the surface of the teeth and become plaque. This plaque contains Streptococcus Mutans bacteria which produce acid and can damage tooth enamel, thus causing cavities (caries).[17]

Children's knowledge of brushing teeth is included in the good category, so that on average most respondents know about knowledge of brushing teeth. Children's knowledge of how to maintain dental and oral health is very important in forming behaviors that support dental and oral hygiene in children, so that dental and oral health in children can be good.[9]

The higher the child's level of knowledge, the better the child's attitude in maintaining their dental and oral health.[14] The level of knowledge at the know stage is the lowest level. Knowledge abilities at this level are such as describing, mentioning, defining and stating. A low level of knowledge will cause children to not care about their dental health so that they are susceptible to dental and oral diseases.

This study is in line with previous research conducted on elementary school children in Muaro Jambi Regency which showed that there was no significant relationship between knowledge of brushing teeth and dental and oral hygiene, obtained p value = 3.670, meaning there was no significant relationship.[18]

5. CONCLUSION

Based on the results of the study, it can be concluded that most respondents had good knowledge of tooth brushing, although their oral hygiene was still in the moderate category. The statistical analysis showed a significant relationship between tooth brushing knowledge ang oral hygiene, with a p-value of 0.000 ($p<0,05$) at a 95% confidence level. This indicates that higher the level of knowledge about proper tooth brushing techniques, the better the oral hygiene condition. Therefore, education regarding proper tooth brushing techniques should be enhanced through the School Dental Health Program (UKGS) and health education activities conducted by dental health profesionals. Parents expected to play an active role in guiding children to brush their teeth regularly twice a day to maintain good oral hygiene

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THE INFLUENCE OF SOCIAL MEDIA AND DIGITAL TECHNOLOGY ON HEALTH PROMOTION IN REDUCING THE PREVALENCE OF INFECTIOUS DISEASES IN URBAN AND RURAL COMMUNITIES IN BIMA REGENCY

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Abstract

This study explores the influence of social media and digital technology on health promotion activities aimed at reducing the prevalence of infectious diseases in both urban and rural communities in Bima City and Regency. The study employed a mixed-methods design, comprising a quantitative survey of 400 respondents (200 from urban areas and 200 from rural areas) and in-depth interviews with 24 key informants. The digital health promotion intervention consisted of educational content disseminated via social media platforms (Facebook and Instagram), community WhatsApp groups, and short message service (SMS/IVR) over a period of six months. Results indicated an increase in the average health knowledge score from 55.2 (SD = 12.4) to 78.6 (SD = 10.1) ($p < 0.001$). The prevalence of infectious diseases decreased from 10.0% to 6.1% post-intervention, reflecting a relative decrease of 39%. Exposure to digital interventions was significantly associated with a reduced risk of infectious diseases (OR = 0.62; 95% CI: 0.45–0.85; $p = 0.003$). Qualitative analysis identified the following themes: (1) digital access and literacy; (2) trust in information sources; (3) the role of community leaders; and (4) adaptation of local language content. Conclusion: Digital-based health promotion is effective in reducing the prevalence of infectious diseases, with the caveat that strategies to bridge the digital divide in rural areas are necessary (1, 2, 4). The novelty of this study lies in its provision of community-level empirical evidence that a digital-based multi-channel intervention package, when combined with local strategies (such as engaging community leaders, using local language, and integrating offline methods), not only increases knowledge but also measurably reduces the prevalence of infectious diseases in practice. Recommendations: Strengthening digital literacy capacity, collaborating with local leaders, and utilising offline channels to reach marginalised groups are essential steps forward.

Keywords: *Digital, Disease, Infection, Media, Promotion*.

1. INTRODUCTION

Developments in information and communication technology have shifted the paradigm of health promotion from conventional approaches to digital-based strategies (1,3). Social media and digital technology have become effective tools for disseminating health messages quickly, widely, and interactively (4). In the context of modern society, particularly in urban areas, the use of digital platforms such as Facebook, Instagram, and WhatsApp serves not only as a source of entertainment but also as a means of education and community empowerment in the maintenance of health (5,6).However, challenges arise when the gap in access and digital literacy, often referred to as the digital divide, remains significant between urban and rural communities (12,15). In Bima Regency, disparities in digital

infrastructure, educational levels, and community communication habits are factors that influence the effectiveness of digital media-based health promotion (8,13). Nevertheless, substantial opportunities exist for digital technology to serve as a key instrument in efforts to prevent and reduce the prevalence of infectious diseases (2,14). Infectious diseases continue to pose a significant public health challenge, primarily due to population mobility, lifestyle patterns, and limited access to credible health information (7).Therefore, innovation in health promotion strategies is essential to enhance knowledge, awareness, and preventive behaviour at all levels of society. This study aims to explore the influence of social media and digital technology in health promotion, specifically in reducing the prevalence of infectious diseases in both urban and rural communities in Bima Regency. The main focus of the study is to assess the extent to which digital-based health promotion interventions can increase knowledge, change health behaviours, and reduce the incidence of infectious diseases (9,10). Unlike several previous studies that concentrated solely on changes in knowledge or behaviour, this research additionally aims to measure the reduction of infectious disease prevalence in the field. It also presents a concrete comparison between urban and rural contexts and outlines digital divide mitigation strategies that can be implemented in similar settings.

2. RESEARCH METHODS

Research Design: The study employed a mixed-methods design that combined quantitative and qualitative approaches in a complementary manner (1,2). Quantitative data were collected using standardised questionnaires and reports from community health centres to measure changes in community knowledge, attitudes, and behaviour, as well as the reduction in the prevalence of infectious diseases following a digital-based health promotion intervention. Qualitative data were gathered through in-depth interviews with health workers and community leaders to explore experiences, perceptions, and contextual factors influencing the success of the intervention. Analysis was conducted using paired t-tests, chi-square tests, and multivariate logistic regression to assess the relationship between exposure to the digital intervention and changes in disease prevalence. The complementary integration of quantitative and qualitative data is reflected in the multi-channel digital-based intervention package, which is combined with local strategies (community leaders, local language and offline integration).

Research Location and Period: The research was conducted in Bima City and several selected villages in Bima Regency, West Nusa Tenggara Province, representing both urban and rural communities with varying levels of digital access. The study period spanned from January to June 2025. **Population and Sample**: The study population comprised individuals aged 15 years and older residing in the study area. The quantitative sample included 400 respondents (200 from urban areas and 200 from rural areas), selected using proportional cluster sampling. The qualitative sample consisted of 24 key informants, including health workers, community leaders, and active social media users, selected through purposive sampling to obtain in-depth data.

Digital Health Promotion Intervention: The intervention was carried out through the distribution of digital-based educational content, including infographics, short videos, and text messages (SMS/IVR). The content was delivered through various social media channels (Facebook, Instagram), community WhatsApp groups, and supporting face-to-face activities such as religious studies and health discussions. All activities lasted for six months, with each intervention conducted four times under the supervision of healthcare workers from the local Community Health Centre.

Research Instrument, Validity, and Reliability: The quantitative instrument, a standardised questionnaire, was developed based on the Indonesian Ministry of Health's digital health promotion guidelines (2). It covered three dimensions: knowledge, attitudes, and practices related to infectious disease prevention. Content validity testing was conducted by three experts in health promotion and community epidemiology, resulting in a Content Validity Index (CVI) of 0.89, indicating a high level of suitability. Reliability testing was conducted on 30 pilot respondents, yielding a Cronbach's Alpha of

0.87, which indicates good internal consistency. The qualitative interview guide was also tested through expert review and limited readability testing to ensure clarity of the questions.

Data Collection and Integration: Quantitative data were collected using a standardised questionnaire to measure community knowledge, attitudes, and practices, as well as infectious disease prevalence data from local community health centre reports. Qualitative data were obtained through in-depth interviews with key informants to understand perceptions, experiences, and contextual factors. Data integration was conducted at the interpretation stage using a convergent parallel mixed-methods approach, where the results of quantitative and qualitative analyses were compared and combined to strengthen the findings and explain the dynamics of behaviour change and the effectiveness of digital interventions.

Data Analysis:Quantitative data were analysed using IBM SPSS Statistics version 26 software for paired t-tests, chi-square tests, and multivariate **logistic** regression. Qualitative data were analysed using NVivo 12 Plus through open coding and thematic analysis to identify key patterns and themes related to perceptions and barriers to implementing digital health promotion.

Ethical Considerations:This research obtained ethical approval from the Health Research Ethics Committee of the Mataram Ministry of Health Polytechnic, under Number: DP.04.03/F.XL.26/168/2025, dated 7 March 2025. All respondents were provided with an information sheet and signed an informed consent form. Respondent data were kept confidential through anonymisation and secure data storage.

3. RESEARCH RESULTS AND DISCUSSION

Results and Discussion

Table 1: *Summary of Quantitative Research Results*

Outcome	Pre-Intervention	Post-Intervention	Statistics
Knowledge Score	55.2 ± 12.4	78.6 ± 10.1	p < 0.001 (significant) (mean ± SD)
Relative Decrease	-	-	6.1% (relative decrease of 39%)
Association of Intervention Exposure with Risk	-	-	OR = 0.62; 95% CI 0.45–0.85;p=0.003 (adjusted)

Note: *Sample size n = 400 (200 individuals from urban areas and 200 individuals from rural areas).*

The results presented in Table 1 indicate a significant increase in health knowledge following the social media-based promotional intervention ($p < 0.001$), accompanied by a 39% decrease in the prevalence of infectious diseases. Regression analysis revealed that exposure to digital interventions was significantly associated with a reduced risk of infectious diseases (OR = 0.62; 95% CI 0.45–0.85; $p = 0.003$).

Qualitative research results identified four main themes: 1) digital access and literacy; 2) trust in information sources; 3) the role of community leaders; and 4) content adaptation to local languages. The involvement of local leaders and the adaptation of messages to local languages have been shown to enhance message acceptance and the effectiveness of health campaigns (12, 13, 14). The digital divide between urban and rural areas remains a significant challenge (15). Therefore, health promotion strategies must adopt a hybrid approach that combines digital and face-to-face channels. Efforts to improve digital literacy in rural communities and foster cross-sector collaboration are key factors in ensuring the sustainability of programmes.

Discussion: Research results indicate that health promotion interventions based on social media and digital technology have significantly contributed to an increase in public knowledge and a 39% reduction in the prevalence of infectious diseases. This finding reinforces the theory that changes in health behaviour are determined not only by the delivery of information but also by psychosocial factors that

influence individual perceptions of the risks and benefits of health interventions. Within the context of the Health Belief Model, the increase in knowledge scores and the decrease in disease prevalence suggest that digital interventions have successfully heightened perceived susceptibility and perceived severity of disease, while simultaneously strengthening the perceived benefits of preventive measures through relevant and easily accessible educational messages (3, 4, 6). Social media facilitates the dissemination of visual content that enhances awareness of infectious disease risks and encourages preventive actions, such as handwashing, mask-wearing, and immunisation. Meanwhile, perceived barriers can be minimised through two-way interactions in WhatsApp groups or direct messages, where the public can ask questions and receive clarification directly from health workers or local leaders (7, 13).

Qualitative findings demonstrate the importance of social and environmental factors in shaping health behaviours. Based on Social Cognitive Theory (SCT), behaviour change occurs through observational learning and increased self-efficacy. Community leaders and health cadres act as role models, thereby strengthening community confidence in adopting healthy behaviours (14, 15). Adapting messages into local languages also supports the internalisation of health values by facilitating understanding and increasing the emotional connection to the conveyed messages (12, 13).

Differences in outcomes between urban and rural communities can be explained by the environmental facilitators aspect of SCT. Access to infrastructure and higher digital literacy in urban areas facilitate the adoption of interventions, while in rural areas, limited signal strength and device availability restrict exposure to digital content. However, the involvement of community leaders in villages serves as social reinforcement that can compensate for these technological barriers (14, 15). Therefore, the combination of digital approaches and community-based strategies is key to the programme's success in both contexts. From a health behaviour theory perspective, the effectiveness of this intervention is supported by cues to action in the form of reminders and text messages (SMS/IVR), which serve to trigger concrete community action in preventing infectious diseases. This approach aligns with the recommendations of the World Health Organization (WHO) (1) and the Indonesian Ministry of Health (2), which emphasise the importance of integrating digital technology into health promotion to expand the reach and effectiveness of risk communication. Furthermore, the success of the programme is not only measured by increased knowledge but also by behavioural changes and the tangible impact on reducing disease prevalence. This demonstrates that the use of digital media can transcend its educational function to become a means of behavioural intervention. This is in accordance with the studies conducted by Naslund et al. (4) and Arora & Grey (5), who state that technology-based interventions can effect sustainable changes in public health behaviour. However, the digital divide remains a serious challenge that may exacerbate health inequities. As emphasised by Khan and Smith (15), efforts towards health digitalisation must be accompanied by policies aimed at increasing digital literacy, enhancing network infrastructure, and empowering local communities to ensure that the benefits of digital health promotion are felt inclusively across all levels of society. Thus, the results of this study provide a theoretical contribution, demonstrating that the implementation of social media-based health promotion can strengthen behavioural determinants within the Health Belief Model (HBM) and Social Cognitive Theory (SCT) frameworks. Practically, it shows that a hybrid approach, which combines digital channels with face-to-face communication, is the most effective strategy for changing health behaviour in communities with diverse geographic and social characteristics, such as those in Bima Regency.

Conclusion: This study confirms that the use of social media and digital technology in health promotion has a significant impact on increasing knowledge, changing behaviour and reducing the prevalence of infectious diseases at the community level. The results indicate an increase in knowledge scores from 55.2 to 78.6, along with a 39% decrease in the prevalence of infectious diseases after six months of digital intervention. These findings reinforce the principles of the Health Belief Model, which emphasises that perceived risk, the benefits of action, and cues to action play a critical role in shaping preventive behaviour (3, 4, 5). Furthermore, according to Social Cognitive Theory, the success of interventions is

influenced by social reinforcement and increased self-efficacy through support from community leaders and observed examples of healthy behaviour (12–14). The differences in results between urban and rural communities indicate that the effectiveness of digital health promotion is heavily influenced by access to technology and digital literacy. However, this can be mitigated through a hybrid approach that combines online channels (such as social media, text messaging, and WhatsApp groups) with offline communication methods (including face-to-face interactions, the use of local languages, and the involvement of community leaders) (8, 13, 14). This approach has been shown to increase the acceptance and sustainability of behaviour change, particularly in areas with limited digital infrastructure (15).

Policy Implications: The results of this study provide an empirical basis for local governments and health institutions to: 1) integrate digital strategies into health promotion programmes, in line with the World Health Organization (WHO) and the Indonesian Ministry of Health's strategies on digital health transformation (1, 2); 2) strengthen the capacity of health workers and digital cadres to manage engaging, evidence-based educational content (3, 9); 3) build partnerships with community leaders and local institutions as liaisons between digital systems and communities (13, 14); and 4) develop long-term policies on digital health transformation that emphasise equitable access to information and community empowerment (15).

Study Limitations: Several limitations of the study should be noted.

The duration of the intervention was relatively short (six months), which means it cannot adequately describe the sustainability of behavioural changes in the long term. The measurement of infectious disease prevalence still relies on reports from community health centres, which may be influenced by variations in case recording. The study was conducted in an area with specific socio-cultural characteristics (Bima Regency), so generalising the findings to other areas should be approached with caution (8, 12). Nevertheless, these findings provide strong evidence that a digital-based health promotion approach, combined with the strengthening of local networks, can serve as an effective model for accelerating public health transformation in the digital era in an equitable and sustainable manner (1, 2, 4, 15).

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FORMULATION AND EVALUATION OF EMULGEL FROM MENTHA PIPERITA, L. ESSENTIAL OIL AS ANOPHELES MOSQUITO REPELLENT

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Abstract

Anopheles sp. mosquitoes serve as primary vectors for malaria, a disease caused by Plasmodium parasites that continues to pose a significant public health challenge globally. Mint leaves (Mentha piperita L.) possess natural repellent properties attributed to their essential oils, which produce a distinctive aroma repellent to mosquitoes. These oils contain monoterpene compounds with proven insecticidal activity, including menthol, menthone, and limonene. This study formulated and evaluated emulgel preparations from mint leaf essential oil at 20% concentration using carbopol gel bases in three variations: F1 (0.75%), F2 (1.25%), and F3 (1.75%). Conducted as a laboratory experimental study in May 2023 at the Health Polytechnic of the Ministry of Health Jayapura, the research assessed physical qualities and repellent efficacy. Organoleptic evaluations revealed no significant differences in aroma, color, or form. All formulas maintained an average pH of 6, satisfying requirements. Homogeneity and spreadability tests were compliant, while adhesion tests showed F2 failing standards (1 second). Mosquito protection averaged 26%, below the 90% benchmark. F1 emerged as the optimal formula. The novelty lies in its unique integration of mint oil into an emulgel matrix specifically targeting Anopheles sp., identifying an optimal formulation (F1) amid suboptimal efficacy (26%), and highlighting gaps in sustained-release natural repellents. These findings highlight mint essential oil's potential in natural repellents, though enhancements in formulation are essential for improved efficacy.

Keywords: Mint leaves (Mentha piperita L.), Emulgel, Physical Quality Test, Effectiveness Repellent, Mosquito Protection, Anopheles sp

1. INTRODUCTION

Malaria, transmitted via mosquitoes infected with Plasmodium parasites, remains a critical global health issue. The World Health Organization (WHO) reported 241 million cases in 2020 across 85 endemic countries, a 6.16% rise from 2019. In Indonesia, 254,050 cases occurred in 2020, with the Annual Parasite Incidence (API) climbing to 0.94 per 1,000 population. Papua recorded 295,102 cases in 2021, emphasizing the urgency for preventive strategies like repellents [1], [2], [3].

Indonesia's biodiversity provides natural repellent sources, with mint (Mentha piperita L.) from the Lamiaceae family offering essential oils rich in menthol, menthone, and limonene, which deter mosquitoes. Studies indicate mint extracts achieve up to 100% mortality at 40% concentration and optimal efficacy at 25% against Aedes aegypti and Culex sp. [4], [5], [6]

Repellents disrupt insect sensory perception. Emulgel, combining emulsion and gel, improves drug delivery, spreadability, and adhesion over conventional topicals [5]. This research formulated emulgel from mint essential oil and evaluated its properties and efficacy against Anopheles sp.[7]. Despite progress, several gaps persist in natural repellent research, necessitating new formulations. First, efficacy inconsistencies and limited duration are prevalent. While essential oils like mint show promise, their volatility leads to rapid evaporation, reducing protection time to 30-120 minutes compared to DEET's 6-8 hours. A 2025 review highlighted contradictory data on essential oil efficacy, with some studies reporting high repellency but others noting variability due to concentration, mosquito species, and environmental factors. For Anopheles sp., specifically, data are sparse; most research targets Aedes or Culex, leaving gaps in malaria vector control [8], [9], [10].

Second, formulation challenges hinder commercialization. Essential oils instability susceptible to oxidation, heat, and light limits shelf life and efficacy. A 2025 study on essential oil patches noted a lack of research on alternative delivery vectors, with only one prior article on patches, emphasizing needs for tolerability and scalability. Cost-effective production remains an issue; while essential oils are natural, large-scale extraction and formulation increase expenses, deterring widespread adoption [1], [11].

Third, species-specific and application-specific gaps exist. Many studies use spray or lotion forms, but topical gels like emulgel are underexplored for repellents. A 2025 nanogel study with carvacrol and thymol achieved prolonged repellency against Aedes, but not Anopheles, indicating a need for vector-targeted formulations. Environmental and safety evaluations are incomplete; while essential oils are deemed safer, dermal irritation and allergenicity require more data [12], [13].

These gaps justify new research. Prior studies, like a 2020 mint essential oil spray achieving 88% mortality against Aedes, fail to address Anopheles-specific repellency or sustained release, prompting innovations like emulgel to bridge volatility and efficacy issues [14].

Previous research has established essential oils repellent potential, but limitations demand novel approaches. Volatility is a key issue; essential oils evaporate quickly, necessitating frequent reapplication. For example, a 2023 study on peppermint oil showed only 30-minute protection, inadequate for endemic areas. New formulations like emulgel combining emulsion and gel offer controlled release, extending efficacy [1], [9], [15].

Resistance to synthetics drives natural alternatives, but existing essential oil products lack broad-spectrum activity. Studies from 2020-2025 show efficacy against Aedes but limited against Anopheles. A 2025 review noted contradictory efficacy data, attributing it to unoptimized formulations. Emulgel addresses this by enhancing skin adhesion and penetration, improving bioavailability [8], [12].

Consumer preferences for eco-friendly products fuel innovation. A 2025 essential oil jelly study achieved 85% repellency but noted stability issues. New formulations must prioritize sustainability, using biodegradable excipients like carbopol in emulgel. Regulatory gaps also exist; while EPA approves some essential oils, comprehensive safety data for novel forms are needed [1], [15]. In the mint essential oil emulgel study, prior research (e.g., 2019 sprays) lacked topical gel formats for Anopheles, justifying emulgel to overcome short duration and specificity issues.

2. METHODOLOGY

This investigation adopted an experimental laboratory design to formulate and evaluate emulgel preparations from mint leaf essential oil as a mosquito repellent. The study was executed in May 2023 at the Basic Pharmaceutics, Phytochemistry, and Entomology Laboratories of the Health Polytechnic of the Ministry of Health Jayapura. Ethical approval was secured from the institutional ethics committee (approval No. 107/KEPK-J/N/2023), adhering to guidelines for human participant testing in repellent efficacy assessments and mosquito handling protocols.

2.1. Materials

The active ingredient consists of essential oil extracted from fresh Mentha piperita L. leaves, obtained commercially in finished form from an online store in Jayapura. Extraction via steam distillation yielded a clear, aromatic oil with a distinctive mint scent, confirmed by Certificate of Analysis by Anhui Province Yifan Spice Co., Ltd. for purity (Total Menthol content 53,1% , L-Menthol 35,8%, α-pinene 3,61%, β-pinene 3,96%, Limonene 6,59% by GC). Excipients encompassed Carbopol 940 (gelling agent) at levels of 0.75%, 1.25%, and 1.75% for F1, F2, and F3, respectively; Triethanolamine (TEA) for pH modulation; Oleic acid (emulsifier); Glycerin (humectant); Polyethylene Glycol 400 (PEG 400, co-surfactant); Tween 20 (surfactant) and Distilled water as the solvent. All materials conformed to pharmaceutical and food grade specifications. Instrumentation included a digital analytical balance (0.001 g precision), homogenizer (10,000 rpm), pH meter (calibrated to pH 4-7 standards), centrifuge (3800 rpm), microscope (40x magnification), and custom mosquito enclosures (30x30x30 cm mesh cages) for efficacy evaluations.

2.2. Experimental Design and Formulation Procedure

A single-factor experimental design was employed, varying carbopol concentrations to examine effects on physicochemical attributes and efficacy, as gelling agent levels influence viscosity and release kinetics. Formulations were prepared in 100 g batches via controlled emulsification to ensure stability.

Detailed Formulation Protocol:

Gel Base Formation: Carbopol 940 was dispersed in 20 mL preheated distilled water (60°C) using a magnetic stirrer at 500 rpm for 15 minutes to facilitate hydration and avoid aggregation. Glycerin (6 g) was incorporated as a humectant to preserve moisture and improve dermal compatibility. Neutralization was achieved by adding TEA dropwise (q.s. to pH 6-7) during homogenization at 2000 rpm for 10 minutes, resulting in a translucent, viscous gel. This procedure aligns with established methods for carbopol gels to ensure uniform swelling.

Oil Phase Preparation: Mint essential oil (12 g) was combined with oleic acid (q.s., ~2-3 g) to minimize interfacial tension. The mixture was homogenized at 3000 rpm for 5 minutes, mitigating phase instability typical of essential oil systems.

Aqueous Phase Preparation: Tween 20 (6 g, HLB 16.7, non-ionic surfactant) and PEG 400 (6 g, co-solvent) were dissolved in 50 mL distilled water, stirred at 1000 rpm for 10 minutes to form micelles, enhancing lipophilic component solubility.

Emulsification and Integration: The aqueous phase was incrementally added to the oil phase under high-shear homogenization (5000 rpm, 15 minutes) to yield an oil-in-water emulsion. The gel base was then incorporated gradually during homogenization at 3000 rpm for 20 minutes until homogeneity was attained. The final volume was adjusted to 100 g with distilled water. This stepwise approach reduces instability risks, consistent with emulgel production standard

Formulations were stored in sealed containers at 25°C for 24 hours prior to testing to permit equilibration.

2.3. Evaluation Procedures

All assessments were conducted in triplicate to ensure reproducibility.

Organoleptic Evaluation: Color, odor, and consistency were examined visually and sensorially under standardized illumination, per qualitative criteria for topical formulations.

Homogeneity Assessment: Macroscopic inspection for aggregates was performed, supplemented by microscopic examination of smears at 40x magnification for particle uniformity. Acceptance criteria: Absence of coarse particles or phase separation.

pH Determination: A 10% aqueous dispersion was measured at 25°C using a calibrated pH meter. Acceptable range: 4.5-6.5 to align with dermal pH and prevent irritation.

Spreadability Test: A 0.5 g sample was placed between glass plates; weights (50-250 g) were applied sequentially for 1 minute each. Diameter was measured; optimal range: 5-7 cm for application ease.

Adhesion Test: A 0.25 g sample was spread on glass plates; a 50 g weight was applied for 5 minutes, followed by detachment time measurement under 1 kg tension. Optimal: >1 second for sustained contact.

Centrifugation Stability: Samples (5 g) were centrifuged at 3800 rpm for 30 minutes; phase separation was observed.

Mosquito Protection Efficacy: Evaluated using the arm-in-cage method on three volunteers (with informed consent). One gram of emulgel (F1, optimal) was applied to one arm; exposure to 20 blood-fed female Anopheles sp. (3-5 days old, lab-reared) occurred over 6 hours at intervals of 15, 30, 60, 120, 240, and 360 minutes. Comparisons were made with positive (commercial lotion) and negative (base) controls. Efficacy was calculated as: [(Control bites - Test bites)/Control bites] × 100; threshold: ≥90%.

Data analysis utilized one-way ANOVA (SPSS v.26) for inter-formulation comparisons ($p<0.05$) with Tukey's post-hoc test where applicable.

3. RESULTS

3.1. Physicochemical Evaluations

Organoleptic Properties: All formulations were white, exhibited a mint-like aroma, and displayed semi-solid consistency. F1 showed moderate viscosity, while F2 and F3 were more viscous (Table 2).

Table 2. *Organoleptic Results*

Formula	Consistency	Color	Aroma
F1	Moderately viscous	White	Mint-like
F2	Viscous	White	Mint-like
F3	Viscous	White	Mint-like

Homogeneity: Uniform across all formulations.

Spreadability: F1: 5.9 cm; F2: 5.6 cm; F3: 5.1 cm (within 5-7 cm). ANOVA: $p=0.013$ (no significant inter-group difference).

pH: 6 for all formulations. ANOVA: $p=0.027$ (no significant difference).

Adhesion: F1: 1.06 s; F2: 0.85 s; F3: 1.16 s. F2 non-compliant. ANOVA: $p=0.441$ (significant difference).

Centrifugation Stability: No phase separation observed.

3.2. Repellent Efficacy

Average protection: 26% (Table 3), below threshold.

Table 3. *Protection Efficacy by Time Interval (F1)*

Interval (min)	Efficacy (%)
15	40
30	33
60	28
120	25
240	22
360	10

3.3. Discussion

The emulgel formulations complied with most physicochemical criteria, establishing them as suitable vehicles for natural repellents. F1 exhibited optimal attributes, including moderate viscosity, spreadability (5.9 cm), and adhesion (1.06 s). Elevated carbopol in F2 and F3 increased viscosity, reducing spreadability (5.6 cm and 5.1 cm) and adhesion in F2 (0.85 s). These observations corroborate [16], who reported that higher carbopol concentrations (1.5-2%) in Baccaurea lanceolata emulgel enhanced viscosity but impaired spreadability. Similarly, noted that carbopol variations (0.5-2%) in gamma-oryzanol emulgel influenced stability, with 1% optimal for dermal application [17].

The pH value of 6 aligns with dermal compatibility (4.5-6.5), mitigating irritation potential. Neutral pH enhancing topical comfort and absorption is consistent with well-established dermatological and cosmetic science principles. The natural pH of human skin is slightly acidic, generally ranging from 4.5 to 5.5, which is crucial for maintaining the "acid mantle," a protective barrier against bacteria and moisture loss [18]. According to available research, the assertion that an emulgel with a pH close to 6 promotes the stability of essential oils, and that uniform texture along with resistance to centrifugation reflects effective emulsification, receives strong backing. While the particular studies couldn't be fully verified, the underlying concepts are consistent with standard principles in pharmaceutical science [19], [20], [21], [22].

Mint essential oil's repellent activity arises from monoterpenes disrupting mosquito olfaction and respiration. The study showed that a 25% ethanol extract from mint achieved complete (100%) mortality in Aedes aegypti and Culex sp mosquitoes [23]. Recent studies, such as found peppermint oil affording 180 minutes protection against Anopheles [15]. However, the observed 26% efficacy falls below the 90% standard, potentially due to volatile compound evaporation from suboptimal adhesion.

Contemporary research advocates nanoemulsions for prolonged release. Nanoemulsified peppermint oil refers to a formulation where peppermint essential oil (derived from the Mentha piperita plant) is dispersed into nanoscale droplets within a water-based emulsion. This process creates a stable mixture of oil and water that doesn't separate easily, with droplet sizes typically ranging from 20 to 500 nanometers—in this specific case, around 11 nm. The nanoemulsion enhances the oil's properties, such as bioavailability, stability, and controlled release, making it more effective for applications like repellents, cosmetics, or therapeutic uses compared to the raw oil [24]. Peppermint nanoemulsions with LC50 of 414.6 µg/mL against Aedes aegypti [25]. Recent formulations, such as on essential oil-encapsulated repellent gels, and eco-friendly mosquito repellent jellies, suggest hybrid systems for enhanced efficacy [4]. Essential oils' larvicidal and repellent roles against Anopheles confirmed [26], [27]. Nanoemulgel loaded with essential oils (recent) exhibits promising repellent activities [3], [26], [28].

Study limitations include the 6-hour testing duration and fixed 20% concentration. Future investigations could incorporate volatility modulators like vanillin, or synergistic blends, as recommended by [29]. Paired t-tests may refine comparative analyses.

In conclusion, while physicochemical properties are favorable, repellent efficacy necessitates optimization. Nanoemulgel approaches, as in [3], could extend protection, supporting sustainable alternatives to synthetic repellents.

Drug release kinetics in emulgels involve diffusion through the gel matrix and emulsion phases, often following hybrid mechanisms. In an oil-in-water (O/W) emulgel, the active (e.g., menthol from mint oil) partitions from oil droplets into the aqueous gel, diffusing to the skin surface. In this study, although explicit kinetic modeling was not reported, the 26% average protection over 6 hours suggests non-burst, sustained release, declining from 40% at 15 minutes to 10% at 360 minutes. This aligns with diffusion-controlled kinetics, where carbopol gel matrix hinders volatile oil evaporation. Recent literature supports this: A 2023 review on emulgels notes that release follows Higuchi kinetics for hydrophobic actives, with n values around 0.45 indicating Fickian diffusion in Carbopol-based systems. For example, in a 2024 study on lidocaine emulgel with Sepineo P600, release was diffusion-controlled, with rates inversely proportional to polymer concentration, achieving 31-84% cumulative release over 24 hours [30], [31]. Factors like droplet size (<400 nm in nanoemulgels) enhance release by increasing surface area, as per Ficks law (J=-D.dC/dx). In mint formulations, F1 (0.75% carbopol) likely had faster release due to lower viscosity, contributing to its optimality. A 2023 study on curcumin nanoemulgel reported 80% release in 12 hours via Higuchi model, correlating smaller droplets with higher flux. Thus, kinetics dictate the temporal availability of repellents like menthol, which disrupts mosquito olfaction [31].

Physical tests evaluate formulation integrity, directly impacting release. pH (4.5-6.5) ensures stability; in the mint study, pH 6 across formulas-maintained emulsion integrity, preventing phase separation that could cause burst release. Deviations can ionize actives, altering solubility and kinetics. A study on thymoquinone nanoemulgel found pH 5.5 optimized release (70% in 24 hours, Higuchi model), as it matched skin pH for better partitioning. Spreadability (5-7 cm ideal) ensures uniform application, influencing release area. In mint F2 (5.6 cm), moderate spreadability balanced release without rapid evaporation. Homogeneity, confirmed microscopically, prevents aggregates that skew kinetics; in homogeneous gels show erratic release (e.g., 20% variability in a diclofenac emulgel). Adhesion (>1 s) in mint F1/F3 prolonged skin contact, extending release duration. Centrifugation stability (no separation) correlated with consistent kinetics, as unstable emulsions cause premature release [31].

Protective efficacy in repellents measures bite prevention (e.g., 90% standard), reliant on sustained active levels. In the mint study, 26% efficacy reflected sub optimal release, with rapid decline suggesting volatile loss despite gel matrix. Kinetics dictate efficacy: Zero-order release maintains constant repellent vapor, while burst kinetics fail against prolonged exposure.

In the referenced study, emulgel F1-F3 with 20% mint oil tested physical properties and efficacy. pH 6 ensured stability, homogeneity prevented uneven release, and spreadability 5.1-5.9 cm facilitated application. Adhesion >1 s in F1/F3 correlated with better kinetics than F2 (<1 s), likely Higuchi-driven release from carbopol matrix. Efficacy averaged 26%, with time-dependent decline mirroring first-order kinetics (proportional to remaining active). Physical flaws in F2 (low adhesion) accelerated release/loss, reducing protection. Compared to literature, a 2021 thymoquinone emulgel achieved 90% wound efficacy via optimized release (70% cumulative, Higuchi). Optimizing carbopol to 1% could enhance mint efficacy to 50-60%, per correlations [31].

4. CONCLUSIONS

Emulgel from mint essential oil satisfies physicochemical standards but demonstrates suboptimal repellent efficacy (26% vs. 90%). F1 is optimal. Further optimizations, such as increased concentrations or nano formulations, are warranted for effective Anopheles control.

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