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Optimization of Carbopol 940 Concentration in *Bidara Laut* Leaf Extract Anti-Acne Gel Preparations: Physical Stability and Inhibitory Effectiveness Study

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Abstract

Acne vulgaris is a widespread skin condition associated with *Propionibacterium acnes*, and conventional antibiotics often lead to resistance and irritation, underscoring the need for safer, natural therapies. This research explored the antibacterial potential of *Strychnos ligustrina* (*Bidara Laut*) leaf extract and its formulation into a topical gel. Leaves collected from Bima, West Nusa Tenggara, were processed into ethanol extracts, which were then screened for phytochemicals, confirming the presence of tannins and phenolics. Antibacterial activity was evaluated using disc diffusion at concentrations of 15%, 20%, and 25%, with clindamycin as the positive control and DMSO as the negative control. Gel formulations containing Carbopol 940 at concentrations of 0.5%, 1%, and 1.5% were prepared and evaluated for their physical properties, including organoleptic characteristics, homogeneity, pH, viscosity, spreadability, adhesion, and stability under accelerated storage conditions. The extract exhibited moderate inhibition of *P. acnes*, with the most substantial effect observed at a concentration of 25% (7.73 mm). Among the gel formulas, the 1.5% Carbopol gel (Formula 3) was the most stable and produced the largest inhibition zone (12.89 mm), although it was still lower than that of clindamycin (33.87 mm). Overall, the findings suggest that *Bidara Laut* extract can be formulated into a stable gel with measurable antibacterial activity, indicating its potential as a natural topical option for acne management. However, further refinement is needed to enhance its efficacy.

Keywords: Antibacterial; Carbopol 940; Gel; P. Acnes; *Bidara Laut* Leaf.

INTRODUCTION

The skin protects the body from both physical and chemical impacts. It also enhances a person's attractiveness. Tactile sensations, pain, or negative external influences are common causes of disturbances in skin appearance. These abnormalities can lead to skin disorders. Acne is a common skin condition affecting the general population (Ibrahim et al. 2023) (Żmuda et al. 2024) (*Advancing Acne Care*, 2025).

Acne vulgaris is an obstructive and inflammatory skin disease that affects the sebaceous glands (oil glands) (Xu et al. Acne is frequently caused by an excess of sebum produced by the sebaceous glands, which clogs skin pores (Salman & Alkhuzaie, 2024). P. acnes is the bacterium that most commonly causes acne. Acne is frequently treated with antibiotics such as clindamycin, tetracycline, and erythromycin (Legiawati et al. 2023) (Zhou et al. 2023). However, these medications might cause side effects such as resistance and skin irritation. As a result, it is vital to seek antibacterials derived from natural substances that are recognized as safer than chemical-based medications (*Evaluation of Nutmeg Extract as a Natural Anti-Acne Agent Against P. acnest | Journal of Biobased Chemicals*, t.t.) (Dewi et al. 2020a).

Bidara laut (*Strychnos ligustrina* Blume) is an antimicrobial herb. *Bidara laut* is a plant that is widely distributed in West Nusa Tenggara. People frequently use *bidara laut* plants for antimalarial, acne, diarrhoea, anthelmintic, antioxidant, and cosmetic purposes (Misgiati, 2022b). *Bidara laut* contains a variety of phytochemical substances, including alkaloids, flavonoids, tannins, phenolics, and saponins. Meanwhile, *bidara laut* leaves contain active components, such as flavonoids, alkaloids, tannins, and phenolics, with antibacterial activity. (Misgiati, 2022a).

Flavonoids suppress bacterial growth by damaging the permeability of the bacterial cell wall. Alkaloids can interfere with the constituent components of peptidoglycan in bacterial cells, preventing the cell wall layer from forming properly and leading to cell death (Uzma et al. 2018) Tannin contains a mechanism that inhibits bacterial protein synthesis, inactivating bacterial enzymes and blocking bacterial cell wall transport proteins, thereby damaging the bacterial cell wall. Phenol

chemicals destroy bacteria by denaturing cell proteins (Farha et al. 2020) (Farizha et al. 2021).

Gel preparations are suitable topical dosage forms for treating acne. Gel treatments have several advantages over other topical therapies. When applied to the skin, the gel feels light, making it more comfortable to use. Gels are soft, delicate, and easy to apply. They do not leave a greasy film on the skin surface (Almoshari, 2022) (Cui et al. 2025) (Cahyaningsih, t.t.).

The gel was chosen because it does not contain oil, so it will not irritate acne. It is clear, dries easily to form a film that rinses off easily, and the gel dosage form is also suitable for topical therapy of acne, especially in patients with oily skin. (L dkk., 2019). Gel formulations offer several advantages, including even skin distribution, ease of washing, non-stickiness, and effective medication release. (Dewi dkk., 2020b) (Barnes et al. 2021) (Khafi et al. 2025).

Based on the background above, the researchers conducted a study titled 'Formulation and Effectiveness Test of *bidara laut* Leaf Extract Gel (*Strychnos ligustrina* Blume) Against *P. Acne* Bacteria'.

The study aimed to assess the activity of *bidara laut* leaf extract against P. acnes, to create a physically stable gel formulation from *Bidara laut* leaf extract, and to evaluate if the gel preparation of *bidara laut* leaf extract inhibits the growth of *P. acnes* bacteria.

MATERIALS AND METHODS

Study area

Samples of *bidara laut* leaves were collected from Roi Village, Palibelo Subdistrict, Bima Regency, West Nusa Tenggara Province (Figure 1).

Figure 1. *Strychnos ligustrina Blume.*

Procedures

Collection and Processing of Research Materials

Samples of *bidara laut* leaves were collected at Roi Village in Palibelo District, Bima Regency, West Nusa Tenggara. *bidara laut* leaves were selected, wet sorted, and then rinsed under running water to eliminate any contaminants that remained attached to the simplisia after wet sorting. The simplisia is then cut to minimize its size and increase its surface area, making the extraction process easier. It is then dried by aerating without direct sunlight, followed by dry sorting until simplisia is achieved.

Preparation of Bidara Laut Leaf Extract

The dry simplisia of *bidara laut* leaf was weighed at 520 g and placed in a maceration container with 96% ethanol until completely submerged. The maceration container was maintained closed for 3 × 24 hours, protected from direct sunlight, and was shaken occasionally. The residue and sample filtrate were then filtered separately. The residue was re-macerated with the same volume of new 96% ethanol. The ethanol extract was then evaporated using a rotary evaporator to produce a thick extract.

Tool Sterilisation

The tools were cleansed with soap and rinsed with distilled water. The instruments were dried upside down and then covered in parchment paper. Test tubes and Erlenmeyer flasks were initially corked with clean cotton. Glass tools were sterilized in an oven at 180 ºC for 2 hours, while plastic tools were sterilized in an autoclave at 121 ºC for 15 minutes. The ose needle was directly heated until incandescent.

Preparation of Mueller Hinton Agar (MHA) Medium

A total of 9.5 grams of MHA were suspended in 250 milliliters of sterile distilled water and microwaved until boiling. To ensure that the media was correctly suspended, it was stirred using a magnetic stirrer. Perfectly suspended media is autoclaved at 121 ºC for 15 minutes.

Rejuvenation of Test Bacteria

The test bacteria were cultured on MHA medium by scratching bacteria from pure culture with an ose needle on an angled agar surface. Bacteria scratched on the press are cultured at 37°C for 24 hours.

Preparation of Test Bacteria Suspension

Test bacteria that have been rejuvenated for 24 hours are collected with a sterile ose needle, inoculated into a test tube containing 5 mL of 0.9% NaCl solution, and homogenized until the turbidity of the bacterial suspension matches that of the 0.5 McFarland standard (equivalent to 3x10-8 CFU/mL).

Antibacterial Activity Testing of Bidara laut Leaf Extract
Antibacterial activity was tested using the disc diffusion method. Test bacterial suspensions were distributed onto solidified MHA medium in a Petri dish. Paper discs with a diameter of 6 mm were soaked in a test solution of marine Bidara leaf extract at various concentrations (15%, 20%, and 25%). In a Petri plate, 10% DMSO was used as a negative control, and clindamycin was used as the positive control. Incubated at 37°C for 24 hours, then the inhibitory zone was measured with a caliper.

Preparation
The Carbopol gel base was dispersed in 70°C distilled water, stirred until dissolved, and then stored for 24 hours. The TEA was then gradually blended into the base and homogenized. Dissolve the *Bidara laut* leaf extract in propylene glycol, then add it to the gel base gradually while stirring with a homogenizer until a homogeneous gel composition is formed. The remaining aquadest was then combined and homogenized. The completed gel preparation was placed in a container. (**Table 1**).

Data analysis
Evaluation of the preparation
- Organoleptic Testing
  Organoleptical testing on gel preparations involves observing changes in the gel's color, odor, texture, and consistency. This test was performed both before and after storage under accelerated conditions.
- Homogeneity Testing
  Homogeneity testing is performed by placing the gel on a piece of glass or other suitable transparent medium; the preparation must have a homogeneous composition with no visible coarse grains.
- pH testing
  This examination is performed to determine the pH of the preparation, ensuring that the pH of the gel corresponds to the pH of the skin and does not cause irritation upon application. The pH value is determined using a pH stick from a pH meter that has been dipped in the preparation. The preparation that fits the skin parameters has a pH of 4.5 to 6.5.
- Viscosity Testing
  The viscosity was tested with a Brookfield viscometer. The gel was evaluated on the first day of manufacture, followed by an accelerated storage test in a climatic chamber at five°C and 35°C for ten cycles. The viscosity was then examined again. Good gel viscosity ranges from 50 to 1000 dPa s, with an ideal viscosity of approximately 200 dPa s.
- Spreadability Testing
  Spreadability testing determines how well the gel spreads on the skin. The gel was weighed to 0.5 grams and placed in a spherical glass lined with graph paper before being placed on top of another glass and left for one minute. In addition, the increased load (50, 10, 150, 200, and 250 grams) was allowed to stand for 1 minute before measuring the constant diameter. Tests were performed before and after accelerated storage. An excellent gel has a spreadability of 5–7 cm.
- Adhesion Testing
  A 0.25-gram sample was placed in an object glass and covered with another object glass on the adhesion test equipment. After this, a 250-gram load was applied for 5 minutes; the pressure was then lifted, and a 50-gram load was applied to the device. The time until the two object glasses were released was then recorded. The adhesion test determines the time it takes for the preparation to attach to the skin. Tests were conducted before and after accelerated storage.
- Accelerated Storage Testing
  Accelerated storage at a higher temperature than usual is one method for accelerating stability evaluation. The accelerated storage test was conducted in a climatic chamber at 40 ºC with a relative humidity of 75% for 14 days.

Effectiveness Test of Bidara laut Leaf Extract Gel
The pitting method was used to test the gel's efficacy. The injected p. Acnes bacterium suspension was placed into a solidified mha medium. The mha medium was then pitted with iron plugs. The test was performed by putting a stable formula, formula three, a negative control in the form of a gel base without extracts, and a positive control, x brand gel products, into the wells. Petri dishes were incubated at 37°c for 1 x 24 hours. Measurements were taken on the clear zone generated around the wells, indicating the area of bacterial growth inhibition.

RESULTS AND DISCUSSION

Table 1. *Bidara laut* Leaf Extract Anti-acne Gel Formula.

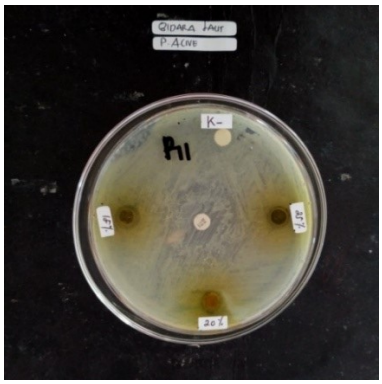
Material	Consentration (%b/v)				
	Range	F1	F2	F3	Usage
Bidara Laut Leaf Extract	-	15	15	15	Active substance
Carbopol	0,5 – 2,0	0,5	1	1,5	Gel Basis
Propylene glycol	~15	5	5	5	Humektan
DMDM Hydantoin	≤ 0,6	0,1	0,1	0,1	Preservative
Triethanolamine (TEA)	2 - 4	qs	qs	qs	Multiplier

Figure 1. Gel preparations with Carbopol 940 variations

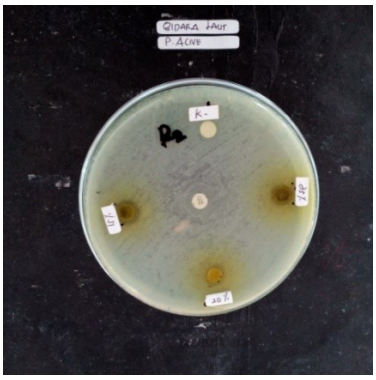
The extract was then subjected to phytochemical screening to determine the class of chemical components present in *bidara laut* leaves. The findings of phytochemical screening are shown in Table 2.

Table 2. Phytochemical Screening Results of *Bidara Laut* Leaf Extracts.

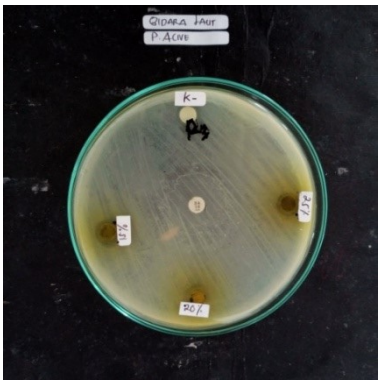
Secondary Metabolites	Test Method	Research Results	Description
Tannin	$FeCl_3$ 5%	Blackish green	(+)
Phenolic	$FeCl_3$ 1%	Blackish green	(+)



Replication extract activity test 1



Replication extract activity test 2



Replication extract activity test 3

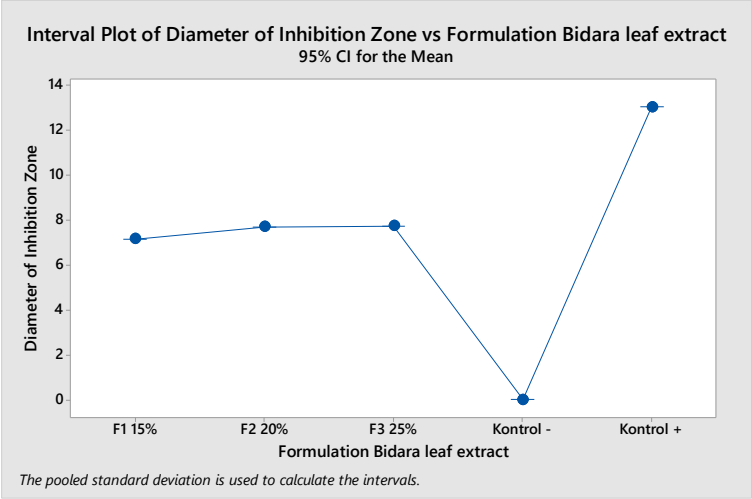


Figure 3. Graph Of Mean Antibacterial Activity Test Of Sea Thistle Leaf Extract.

One-way ANOVA: Diameter of Inhibition Zone versus Formultion Bidara Leaf Extract

Method

Null hypothesis	All means are equal
Alternative hypothesis	Not all means are equal
Significance level	$\alpha = 0,05$

Equal variances were assumed for the analysis.

Factor Information

Factor	Levels	Values
Formula *Bidara Laut*	5	F1 15%; F2 20%; F3 25%; Control -; Control +

Analysis of Variance

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Formula *bidara laut*	4	86,44	21,61	*	*
Error	0	*	*		
Total	4	86,44			

Model Summary

S	R-sq	R-sq(adj)	R-sq(pred)
*	100,00%	*	*

Means

Formula *Bidara Laut*	N	Mean	StDev	95% CI
F1 15%	1	7,160	*	(*; *)
F2 20%	1	7,690	*	(*; *)
F3 25%	1	7,730	*	(*; *)
Kontrol -	1	0,000000	*	(*; *)
Kontrol +	1	13,04	*	(*; *)

Pooled StDev = *

Table 3. Organoleptic test results.

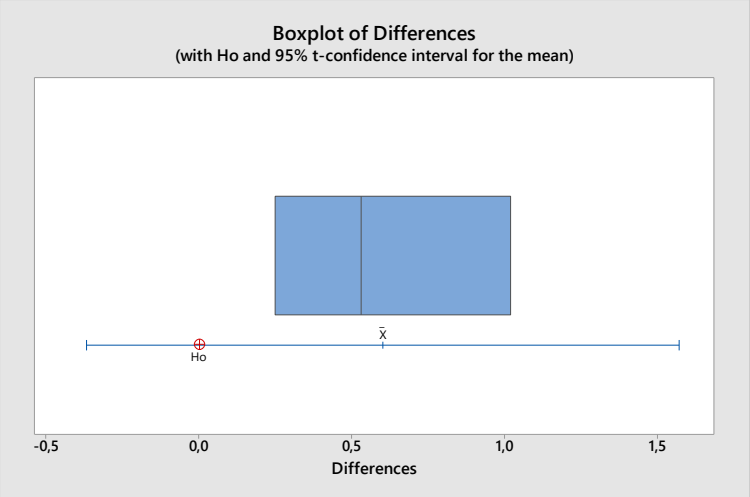
Formula	Organoleptic	Before accelerated storage	After accelerated storage
F1	Odour	Typical	Typical
	Shape	Liquid	Liquid
	Colour	Light green	Light green
F2	Odour	Typical	Typical
	Shape	Semi-solid	Semi-solid
	Colour	Intense green	Intense green
F3	Odour	Typical	Typical
	Shape	Semi-solid	Semi-solid
	Colour	Intense green	Intense green

Table 4. Homogeneity Test Results.

Formula	Before accelerated storage	After accelerated storage
F1	Not Homogeneous	Not Homogeneous
F2	Homogeneous	Homogeneous
F3	Homogeneous	Homogeneous

Table 5. pH Test Results.

Formula	Before accelerated storage	After accelerated storage
F1	4,92	4,67
F2	5,24	4,71
F3	7,16	6,14



Paired T-Test and CI: Before accelerated storage; After ...rated storage

Descriptive Statistics

Sample	Mean	StDev	SE Mean
Before accelerated storage	5,773	1,212	0,699
After accelerated storage	5,173	0,837	0,483

Estimation for Paired Difference

Mean	StDev	SE Mean	95% CI for μ_difference
0,600	0,390	0,225	(-0,368; 1,568)

μ_difference: mean of (Before accelerated storage - After accelerated storage)

Test

Null hypothesis	H_0: μ_difference = 0
Alternative hypothesis	H_1: μ_difference ≠ 0

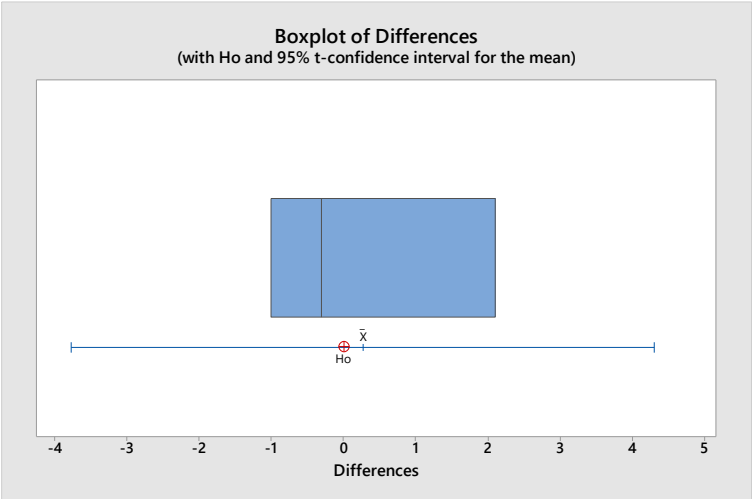
T-Value	P-Value
2,67	0,117

Table 6. Viscosity Test Results.

Formula	Before accelerated storage	After accelerated storage
F1	20.000 cPs	14.000 cPs
F2	31.500 cPs	25.500 cPs
F3	Unreadable	Unreadable

Table 7. Results Of the Dispersion Test.

Formula	Before accelerated storage	After accelerated storage
F1	7,6 cm	7,9 cm
F2	5,2 cm	6,2 cm
F3	6,8 cm	4,7 cm



Paired T-Test and CI: Before Accelerated Storage; After ...ated Storage

Descriptive Statistics

Sample	Mean	StDev	SE Mean
Before Accelerated Storage	6,533	1,222	0,706
After Accelerated Storage	6,267	1,601	0,924

Estimation for Paired Difference

Mean	StDev	SE Mean	95% CI for μ_difference
0,267	1,626	0,939	(-3,772; 4,305)

μ_difference: mean of (Before Accelerated Storage - After Accelerated Storage)

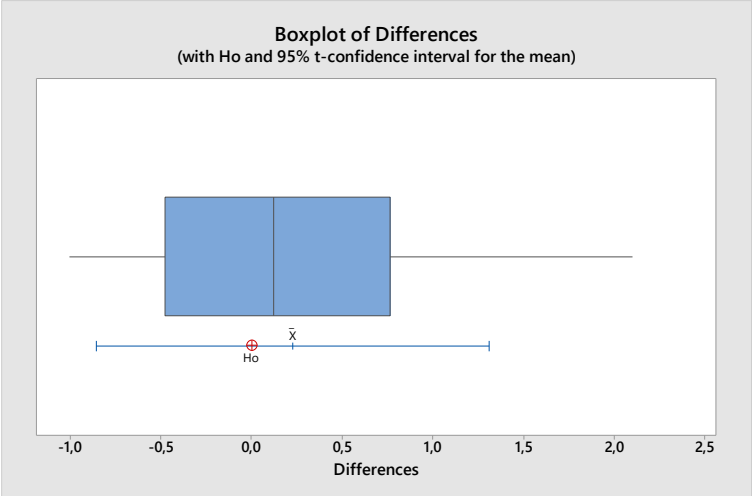
Test

Null hypothesis	H_0: μ_difference = 0
Alternative hypothesis	H_1: μ_difference ≠ 0

T-Value	P-Value
0,28	0,803

Table 8. Adhesion Test Results.

Formula	Before accelerated storage	After accelerated storage
F1	1,72 s	1,52 s
F2	1,55 s	1,50 s
F3	1,62 s	1,30 s



Paired T-Test and CI: Before Accelerated Storage; After ...ated Storage

Descriptive Statistics

Sample	N	Mean	StDev	SE Mean
Before Accelerated Storage	6	4,08	2,80	1,14
After Accelerated Storage	6	3,85	2,83	1,16

Estimation for Paired Difference

Mean	StDev	SE Mean	95% CI for μ_difference
0,228	1,033	0,422	(-0,855; 1,312)

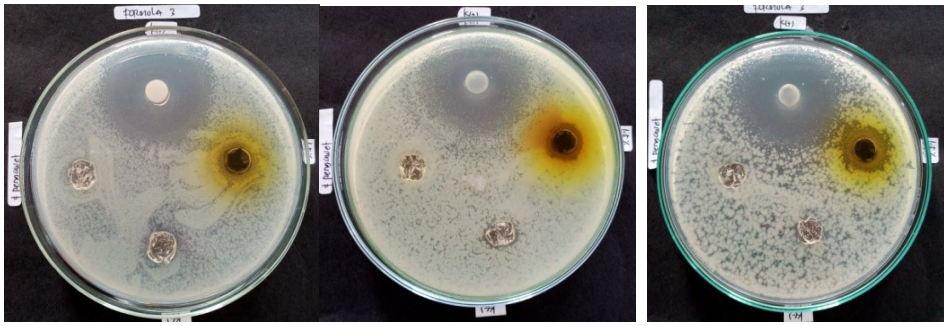
μ_difference: mean of (Before Accelerated Storage - After Accelerated Storage)

Test

Null hypothesis H_0: μ_difference = 0
Alternative hypothesis H_1: μ_difference ≠ 0

T-Value	P-Value
0,54	0,611

Description:
F1: Carbopol 940® concentration of 0.5%
F2: Carbopol 940® concentration of 1%
F3: Carbopol 940® concentration of 1.5%



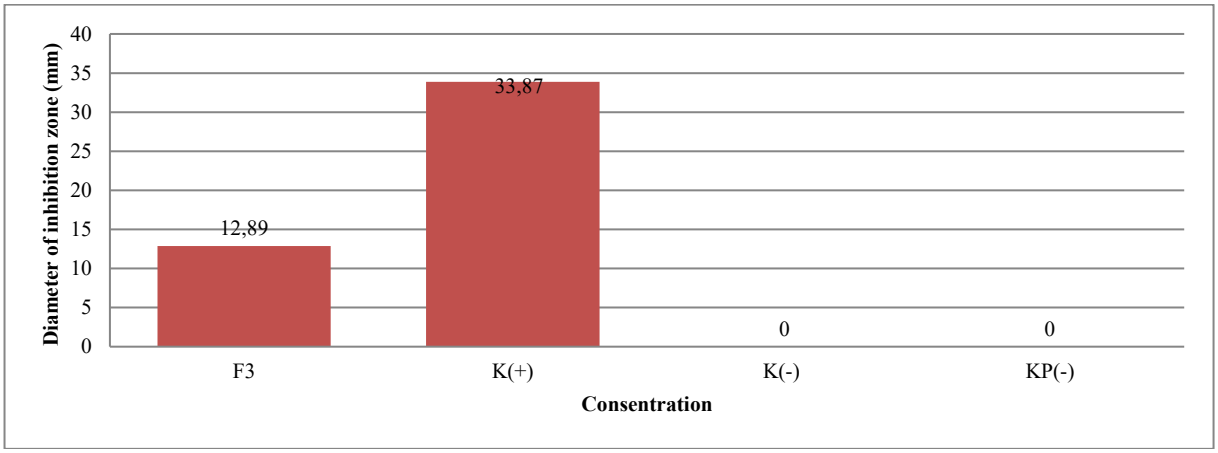
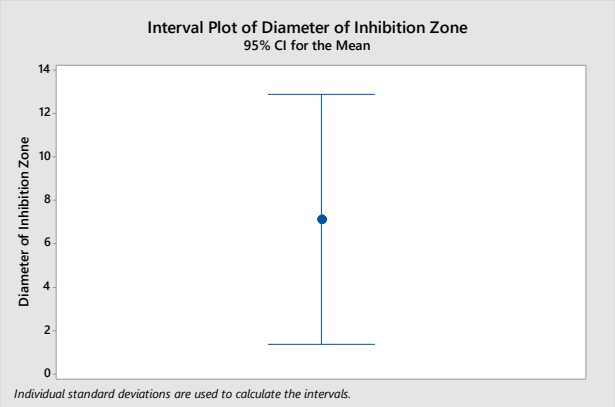
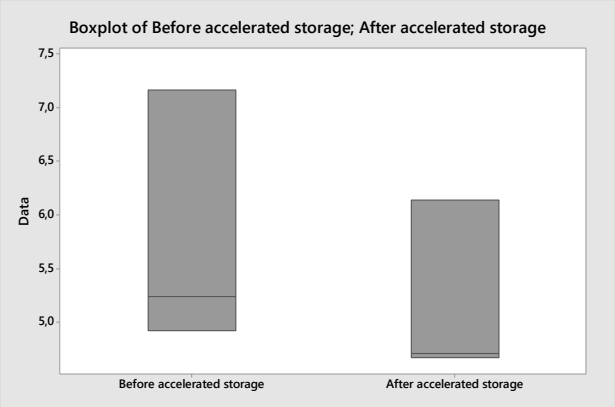


Figure 3. Graph Of the Average Effectiveness Test of Bidara laut Leaf Extract Gel.



The antibacterial activity against P. acnes varied significantly among formulations ($p < 0.05$). As shown in Figure 1, Formula 3 (1.5% Carbopol) exhibited the highest inhibition zone (12.89 mm) among the extract-based gels, suggesting that higher polymer concentration may optimize the release or retention of bioactive compounds on the agar surface.



Physical stability evaluation showed a slight decrease in pH values after the 14-day accelerated storage period (Figure 2). However, statistical analysis (Paired T-test) confirmed that this reduction was not significant ($p > 0.05$), and the values remained within the physiologically acceptable range for topical applications (pH 4.5 – 6.5).

Discussion

Bidara laut leaves, dried and macerated in 96% ethanol, yielded a 6,000 g dry extract with an 8.6% yield. *Bidara laut* leaf extract contains tannins and phenolic substances. The antibacterial activity of the marine Bidara leaf extract was next tested at 15%, 20%, and 25% using 10% DMSO as a negative control and Clindamycin paper disc as a positive control.

This study employed samples of *bidara laut* leaves collected in Bima, West Nusa Tenggara. According to the processing results, simplisia can weigh up to 6000 grams. The simplisia was removed using the maceration process. According to Prasetyorini's (2011) research, a 96% ethanol solvent can extract molecules with a wide range of polarities, from nonpolar to polar. In this work, a thick extract weighing 520 grams was obtained with an 8.6% yield.

According to the phytochemical screening results in Table 2, the *bidara laut* leaf extract contains tannins and phenolic compounds that are believed to possess antibacterial properties. This finding is consistent with Ashri's (2016) research, which reported positive results containing tannin and phenol components with a blackish-green color in the phytochemical screening test of *bidara laut* leaf extract. (Ashri, 2016). Tannin chemicals work by disrupting the permeability of the cell wall or cell membrane, causing it to become wrinkled and lose its integrity. Due to permeability breakdown, cells are unable to perform essential life functions, leading to growth inhibition or cell death (Putri & Anindhita, 2022). Phenol acts by denaturing proteins, thereby inhibiting metabolic activity and ultimately leading to bacterial cell death (Miranti & Suwary, 2013).

Furthermore, extracts containing recognized chemical components are evaluated for antibacterial activity against *Propionibacterium acnes*. The activity test was conducted using the diffusion method, specifically the paper disc method. In this test, extracts at 15%, 20%, and 25% were used. Clindamycin was used as a positive control, with 10% DMSO serving as a negative control. The figure below shows the results of the inhibition test.

According to the plot in (Figure 1), marine Bidara leaf extract at a concentration of 25% has the most significant inhibition, with an inhibition zone diameter of 7.73 mm, compared to doses of 15% or 20%. According to Afifi et al. (2018), the higher the concentration of the extract used, the larger the inhibitory zone against bacterial growth. Based on the findings, it is possible to conclude that a 25% concentration of *Bidara laut* leaf extract (Strychnos ligustrina Blume) exhibits moderate suppression against P. acnes bacterium (Afifi dkk., 2018).

The results of organoleptic observations in Table 3 indicate that formulas 2 and 3 have physically stable gel formulations that remain unchanged in terms of scent, shape, and color before and during accelerated storage. Formula 1's dosage form has been changed to a liquid, which does not meet gel standards because the carbopol content is 0.5%, resulting in a more liquid consistency. The higher the concentration of the gelling agent, the higher the viscosity, and the lower the concentration, the lower the viscosity.

The observation of homogeneity in Table 4, comparing the three formulas before and after accelerated storage, reveals that Formulas 2 and 3 have a homogeneous arrangement. In contrast, formula one does not work due to particles in the gel and an uneven color equation during preparation, both before and after accelerated storage. The gel is deemed homogeneous if it has an even color and no distinct particles are observed (Sayuti, 2015). It can be concluded that of the three formulas above that have stability in terms of

homogeneity, namely F2 and F3, while F1 is not stable in terms of homogeneity.

Based on pH measurements taken with a pH meter, all formulas exhibit lower pH values following accelerated storage (Table 5). This is affected by external conditions, such as acidic gases that enter the gel preparation. (Sayuti, 2015). Additionally, temperature variations occur during storage. However, the change in pH before and after storage is not significant; therefore, the preparation's pH is considered stable and meets standards, as it is consistent with the pH of the skin, which ranges from 4.5 to 6.5. If the gel falls within the acidic pH range, it can irritate the skin; if it has an alkaline pH, the skin will become dry or scaly. (Arikumalasar i, J, Dewantar a, I G.N.A., Wijayanti, 2009). It can be concluded that the three formulas still meet the skin's pH requirements.

According to Table 6, F1 and F2 had a drop in viscosity following accelerated storage. This is because the gel preparation undergoes syneresis, a process that releases the liquid from entanglements within the gel, allowing it to migrate towards the surface. (Astuti dkk., 2018). The reduction in viscosity is attributed to the influence of extract additions, air humidity during storage, and packaging that is less impermeable, which may allow the gel to absorb water from the outside and increase the volume of water in the gel (Panjaitan et al.). Meanwhile, F3 contains a higher concentration of gelling agent, resulting in a higher viscosity than F1 and F2, which prevents the gel preparation from accurately measuring viscosity. Based on the statistics presented above, we can conclude that F1 and F2 meet the viscosity requirements, as the viscosity of a proper gel preparation is typically between 2000 and 50000 (SNI 16-4399-1996).

The spreadability test measures the gel's ability to spread when subjected to a specific level of force, allowing the gel preparation to be recognized for its capacity to spread on the skin or mucosa. This is related to the dispersion of the active ingredient in the mixture. Good spreadability is between 5 and 7 cm. According to Table 7, the three formulations before accelerated storage exhibit good spreadability. Although each formula has a varied spreadability, it still passes the standards. However, after accelerated storage, F3's spreadability deteriorated to the point that it no longer met the spreadability standards, whereas F1 and F2 did. This could be due to the influence of storage temperature.

The adhesion test was performed to measure the gel's ability to attach to the skin surface. The longer the gel remains on the skin, the more active ingredients are absorbed, and the more effective its therapeutic effect (Voigt, 1984). In this test, F1, F2, and F3 showed decreased adhesion following accelerated storage (Table 8). The base and other components can influence this during both preparation and storage at varying temperatures. A reduction in viscosity can lead to decreased adhesion, as adhesion is directly proportional to viscosity (Riski et al.). Good gel adhesion is defined as lasting more than 1 second (Cahyaningsih, 2018).

The pitting method was used to evaluate the efficacy of the *bidara laut* leaf extract gel, as shown in the diagram (Figure 3). The results from the three formulas revealed that F3 had the largest inhibition zone, measuring 12.89 mm, compared to F1 and F2. The positive control exhibited an inhibition zone of 33.87 mm, whereas the negative controls, both with and without preservatives, showed no inhibition zone. However, the inhibitory zone was larger when formulations were used instead of extracts, because the activity and efficacy tests used different methodologies. The presence of gelling agents influences the release of extracts that inhibit microorganisms. The gelling agent concentration is sufficiently high to achieve a higher viscosity. As a result, the higher the viscosity, the greater the resistance, making diffusion of the active material difficult, and vice versa.

CONCLUSIONS

Bidara laut leaf extract demonstrated antibacterial activity against *Propionibacterium acnes* bacteria, with inhibition zones averaging 7.16 mm at a 15% concentration, 7.69 mm at a 20% concentration, and 7.73 mm at a 25% concentration. *Bidara laut* leaf extract can be prepared in a gel dosage form using various gelling agents to create a physically stable gel. Gel preparation of *Bidara laut* leaf extract at a concentration of 1.5% inhibits the growth of Propionibacterium acnes bacteria, with an average diameter of the inhibition zone of 12.89%.

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