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Formulation and Antibacterial Activity of Bidara (*Ziziphus mauritiana* Lamk.) Leaf Toothpaste Against *Streptococcus mutans*

Hurria[1,*], Arifuddin Yunus[2]

[1]Department of Pharmacy, Faculty of Health, Universitas Muhammadiyah Palopo, Kota Palopo
[2]Department of Pharmacy, STIKES Salewangang, Maros

*Corresponding author e-mail: hurria@umpalopo.ac.id

ABSTRACT

Bidara (Ziziphus mauritiana Lamk.) is a native plant of Central Asia that has been widely cultivated in Indonesia. Bidara leaves contain many flavonoids, polyphenolic hydrolysable tannins, triterpenoids, sterols, and alkaloids. Bidara has potential as an antibacterial and has been widely used. The antibacterial activities of Bidara are used to formulate toothpaste against bacteria in the mouth. The study aimed to formulate a toothpaste from bidara leaves that have good physical stability and can be against Streptococcus mutans which causes dental plaque. This type of research is an experimental laboratory using the maceration method and formulated into toothpaste. After that, the physical stability of the toothpaste was tested, and antibacterial activity against S. mutans using the agar diffusion method. Bidara leaves can be used to formulate toothpaste against S. mutans bacteria. The research produced a toothpaste formula from Bidara leaf extract. Formula III is the best formula based on physical stability tests and Streptococcus mutans anti-bacterial tests.

***KEYWORDS**: Antibacterial, formulation, bidara, toothpaste*

INTRODUCTION

Bidara or Jujube (*Zizyphus mauritiana* Lamk.) belongs to the Rhamnaceae family and is native to Central Asia (Rout & Singh, 2021). Bidara has been cultivated and spread in various parts of the world, including Indonesia. Bidara is a small, thorny, fruit-producing tree that grows in dry areas. This plant grows upright or spreads with dangling branches, and the supporting leaves are thorns (Goyal et al., 2012). Bidara leaves contain many flavonoids, polyphenolic hydrolyzable tannins, triterpenoids, sterols, and alkaloids (Prakash et al., 2021). The highest flavonoid content was found in the leaves (0.66%). It contains quercetin 3-O-rhamnoglucoside 7-O-rhamnoside, the main flavonoid compound in all parts of the plant. It also contains alkaloids like zizyphine-F, jubanine-A, and amphibine-H, a new peptide of spinanine-A alkaloids isolated from the bidara tree's bark. Spinanine-A is one of 14 types of amphibine-B cyclopeptide alkaloids (Mojtaba et al., 2016).

Extracts of *Z. mauritiana* were investigated for their antibacterial activities

against *Staphylococcus aureus*, *Escherichia coli*, *Klebsiella pneumoniae*, *Proteus vulgaris*, *Citrobacter freundii*, *Pseudomonas aeruginosa*, *Streptococcus pyogenes*, *Listeria monocytogenes*, and *Bacillus subtilis* (Goyal et al., 2012). The extracts were shown to be effective as antibacterial both on gram-positive and gram-negative bacteria.

The antibacterial ability of bidara leaves can be used to treat dental health problems caused by bacteria. Now, dental health should receive more attention because if one's teeth are not healthy, it will interfere with the digestive process. Teeth are hard body tissues, but damage can occur, one of which is caused by bacteria in the oral cavity. One of the bacteria found in the oral cavity is *Streptococcus mutans*. This bacterium is a normal flora of the oral cavity, but if there is an increase in population, it will cause the formation of dental plaque (Harmely et al., 2011). Dental plaque forms a mixture of food debris and bacteria mediated by saliva attached to the tooth surface. If not cleaned, this plaque accumulation will form dental caries (Harmely et al., 2011).

Bidara, which is proven to have chemical content as an antibacterial, can be used to make toothpaste made from nature. The study aimed to formulate toothpaste from bidara leaves that have good physical stability and can be against *Streptococcus mutans* which causes dental plaque. The novelty of this research is the formulation of toothpaste from Bidara leaf extract and testing with antibacterial agents, which cause dental caries.

MATERIAL AND METHODS

Materials

The materials used in this study were bidara leaves, *Streptococcus mutans* bacteria, calcium carbonate, Glycerin (One Med), sodium cyclamate, sodium lauryl sulfate, Na CMC (Aloin), methyl paraben, aquades and natrium agarose (Merck).

Methods

Extraction

As much as 1 kg of bidara leaves are taken and then sorted wet or washed. The bidara leaves are then chopped and dried and then sorted dry. The leaves were then macerated using 96% ethanol (1x24 hours), and the filtrate was taken 2 times. This filtrate was concentrated using a rotary evaporator to obtain a thick extract of bidara leaves. The extract was then evaporated using a water bath to obtain a dry extract of bidara leaves. Experiments using three formulations of toothpaste (Table 1).

Evaluation of toothpaste

The physical stability test was carried out by organoleptic, pH, and viscosity measurements using a viscometer and dispersion test. An organoleptic test was conducted by observing the smell, color, and taste. A homogeneity test is carried out by applying the substance on a piece of glass or other suitable material, which must show a

homogeneous arrangement and not show coarse grains. The spread ability test was carried out by placing a sample weighing 0.5 g on glass and waiting for 1 minute. The diameter of the sample spread was measured. Then 150 g of the load was added and allowed to stand for 1 minute, and then a constant diameter was measured. A total of 100 ml of gel was put into a 250 ml beaker then its viscosity was measured with a viscometer using a spindle and the appropriate speed. The pH measurement was carried out by measuring the pH of the gel using a pH meter that had been calibrated at pH 4.00 and pH 6.86 (Sayuti 2015).

Antibacterial activity of toothpaste

Test the activity of bidara leaf toothpaste against *S. mutans* using the agar diffusion method (disc diffusion) or the so-called Kirby & Bauer test. The plate containing the bidara leaf toothpaste is placed on the agar medium that has been planted with *S. mutans* which will diffuse into the agar medium. The clear area indicates the inhibition of the growth of *S. mutans* by bidara leaf toothpaste that appears on the surface of the agar medium. The clear zone will be calculated and the concentration of toothpaste with the largest clear zone is the one with the greatest inhibition of *S. mutans* (Trisia et al., 2018).

Data Analysis

The data obtained were analyzed using variance (F test) at 5%. If the treatment has a significant effect on the observed response, data analysis is continued with the smallest significant difference test (Mattjik and Sumertajaya, 2013). The analysis was carried out using STAR 2.0.1 software.

RESULTS AND DISCUSSION

The results of the organoleptic test showed that all formulas were in a good category. However, formula 3 is the best because it has a refreshing smell, is green in color, and tastes sweet and refreshing. This taste will certainly be preferred compared to formulas I and II which have an astringent taste (Table 2). This sweet and refreshing taste is also the same as toothpaste control in children and will also be preferred in the community.

Bidara leaf toothpaste shows homogeneous properties because the active ingredients and color are evenly distributed. Gel preparations are homogeneous if there is an even color match and the absence of palpable particles or coarse materials (Septianingrum., 2013). The spread ability test showed the ability to spread bidara leaf toothpaste on the prepared glass. Formula III has the highest dispersion of 15 cm (Table 3). Spread ability is very important because it relates to the transfer of the active ingredient to the target area in the right dose, ease of use, the pressure required to get out of the package, and acceptance by the consumer. The higher number of bidara leaf in formula III produces a fresher taste.

Formula 3 also has a higher viscosity value than other formulas. The amount of

bidara leaf extract can cause this to be used more than the other formulas. The pH value obtained followed gel toothpaste's standards and quality requirements in SNI 12-3524-1995, namely 4.5 - 10.5. The pH obtained is 7-8 and has entered the SNI standard. Measurement of pH is an important physicochemical parameter in topical preparations because pH is related to the effectiveness of the active substance, the stability of the active substance and preparation, and comfort on the skin when used (Warnida et al., 2016).

The antibacterial test results showed that all formulas had the ability against *S. mutans* (Table 4). Formula 3 has a more effective inhibition zone diameter than the other formulas. It is because the quantity of bidara leaf extract in Formula III is more than the others. All formulas differed significantly based on the LSD test and are very important to consider in developing the results of this study at a later date. The chemical content found in bidara leaves, such as flavonoids and alkaloids, causes this bidara leaf toothpaste to act as an antibacterial that causes dental plaque.

The inhibition zone of bidara leaves in toothpaste against *S. mutans* is more significant than against *Staphylococcus aureus*, *Bacillus cereus*, *Proteus vulgaris*, *Pseudomonas aeruginosa*, and *Klebsiella pneumoniae* (Abdallah et al., 2016; Jain et al., 2019). The antibacterial ability is very appropriate for the development of natural toothpaste and reducing the use of fluoride.

CONCLUSION

The research produced a toothpaste formula from Bidara leaf extract. Formula III is the best formula based on physical stability tests and *Streptococcus mutans* anti-bacterial tests.

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Table 1. Toothpaste formulation from Bidara leaves

No	Materials	Formula		
		F1	F2	F3
1.	Bidara leaf extract	1%	2%	3%
2.	CaCO3	20%	20%	20%
3.	Gliserin	15%	15%	15%
4.	Natrium Siklamat	0,3%	0,3%	0,3%
5.	Natrium Lauril Sulfat	1%	1%	1%
6.	Na CMC	5%	5%	5%
7.	Metil Paraben	0,3%	0,3%	0,3%
8.	Aquades	ad 100%	ad 100%	ad 100%
9.	**Total**	10 ml	10 ml	10 ml

Table 2. Organoleptic test of toothpaste made from bidara leaves

Organoleptic test	Formula I	Formula II	Formula III	Control (Children's toothpaste)
Smell	The distinctive smell of the leaves is quite sharp	Slightly distinctive smell of leaf extract and mint	Dominated by the smell of mint (fresh) and cover the distinctive smell of leaf extract	Orange smell
Color	Dark green	Green	Light green	White
Taste	Bitter and sour	Sour but slightly sweet	Sweet and fresh	Sweet and fresh

Table 3. Physical Stability Test

Physical stability test	Formula I	Formula II	Formula III
Organoleptic	Good	Good	Good
Homogeneity	Homogeny	Homogeny	Homogeny
Spread ability	14.11±0.03 cm	14.13±0.04 cm	15±0.10 cm
Viscosities	27.92±0.26 cp	29.96±0.22 cp	32.97±0.199 cp
pH	7.03±0.097	7.99±0.071	8.03±0.093

Table 4. Antibacterial activity of *Bidara* leaf toothpaste against *Streptococcus mutans*

Formula	Average inhibition zone diameter (mm)
Formula I	16.67 ± 0.58^{c}
Formula II	22.38 ± 1.22^{b}
Formula III	25.51 ± 1.12^{a}

Note: Numbers followed by the same letter show that they are not significantly different using the LSD 5% test.