

Formulation and Antioxidant Activity of Paper Soap Containing Arabian Bidara Leaf (*Ziziphus spina-christi* (L.)) Extract

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Abstract

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Following the COVID-19 pandemic, public awareness regarding hygiene and the use of natural ingredients in personal care products has increased substantially. One innovation arising from this trend is paper soap, a practical antiseptic soap that can be enriched with natural materials such as Arabian bidara leaf extract (*Ziziphus spina-christi* (L.)). These leaves contain bioactive compounds including flavonoids, alkaloids, terpenoids, saponins, and tannins, which possess potential benefits for skin care applications. This study aimed to determine the formulation, physical and chemical quality, and antioxidant activity of paper soap containing Arabian bidara leaf extract. The research procedures included plant determination, preparation of simplicia powder, extraction of the leaves, phytochemical screening, and formulation of paper soap with the addition of extract at concentrations of F1 (5%), F2 (7.5%), and F3 (10%). Physical and chemical quality evaluations were conducted, followed by antioxidant activity testing using the DPPH method via spectrophotometry. The results showed that all three formulations were homogeneous, with F3 exhibiting a darker color due to its higher extract concentration. The weight uniformity values of F1, F2, and F3 were 0.40 g, 0.42 g, and 0.40 g, respectively. The pH values of the formulations were 9.40, 9.52, and 9.79. Foam height tests indicated high foaming ability, and the moisture content of F1 was below 15%. The antioxidant activity values obtained were 27.18 ppm, 29.01 ppm, and 34.26 ppm for F1, F2, and F3, respectively. In conclusion, all three formulations met the physical quality requirements based on SNI 06-3532-1994, and their antioxidant activity fell within the strong category.

[**Keywords:** antioxidant, *Ziziphus spina-christi*, paper soap]

I. Introduction

Indonesia is recognized as one of the richest countries in the world in terms of herbal plant biodiversity, possessing numerous species that are not found elsewhere. Botanical studies indicate that many Indonesian herbal plants remain unexplored and underutilized (Purwanto, 2022). Indonesia's natural wealth would be further enhanced if the utilization of herbal plants were more extensively actualized. Such efforts can begin with commonly encountered herbal plants which, despite their availability, remain poorly managed and insufficiently developed due to limited public knowledge. One such plant with promising potential is the Arabian bidara leaf (Mauludiyah et al., 2020).

Arabian bidara (*Ziziphus spina-christi* (L.)) is a tropical plant widely found in Indonesia. Traditionally, its leaves are often processed into oil and used by local communities as a remedy for various ailments. Phytochemical studies reveal that Arabian bidara leaves contain flavonoids, alkaloids, triterpenoids, saponins, tannins, and proteins (Lestari et al., 2020). Although the leaves possess notable therapeutic properties, public awareness of their benefits remains limited, leading to minimal cultivation and utilization. If properly processed and innovatively developed, Arabian bidara leaves hold the potential to acquire significant economic value. Due to their high saponin content, these leaves are particularly suitable for formulation into soap-based products, including innovative preparations such as paper soap (Agustina et al., 2021).

Paper soap is defined as a thin sheet of soap that dissolves upon contact with water to produce foam. It is primarily used for handwashing and is designed for single-use application, making it especially suitable as an antiseptic soap (Junita et al., 2024). Therefore, this study formulated a paper soap preparation enriched with Arabian bidara leaf extract at concentrations of 5%, 7.5%, and 10%, and evaluated its antioxidant activity. The addition of Arabian bidara leaf extract is expected to enhance the functional effectiveness of the paper soap. This research aims to determine the formulation, physical and chemical quality, and antioxidant activity of paper soap containing Arabian bidara leaf extract.

II. Methods

This study employed a descriptive research design. The research procedures consisted of several stages: preparation of simplicia powder, extraction, phytochemical screening, paper soap formulation, evaluation of physical and chemical properties, and antioxidant activity testing. The study was conducted in the laboratories of the Politeknik Kesehatan Putra Indonesia Malang.

Instruments and Materials

The instruments used in this study included a maceration extractor, rotary evaporator, water bath, hot plate, beakers (100 mL and 400 mL), analytical balance, oven, desiccator, Erlenmeyer flasks, test tubes, mortar and pestle, measuring cylinders (10 mL and 100 mL), weighing bottles, and a UV-Vis spectrophotometer (Thermo Scientific Genesys 20).

The materials used in this research were 70% ethanol, 96% ethanol (Merck), Arabian bidara leaf extract, virgin coconut oil (VCO), sodium hydroxide (NaOH), stearic acid, sodium lauryl sulfate (SLS), glycerin, glucose, butylated hydroxytoluene (BHT), disodium EDTA, filter paper, Dragendorff reagent, Mayer reagent, acetic anhydride reagent, ferric chloride (FeCl₃), ammonia, magnesium powder, and distilled water.

Research Procedures

Plant Determination

Plant determination was conducted independently by referring to a standard flora identification guide. The morphological characteristics of the collected specimen were compared with the descriptions in the guide to obtain a dichotomous key result (Van, 2008).

Preparation of Simplicia

A total of 500 g of fine powder of Arabian bidara leaves was prepared as simplicia. Mature leaves, harvested in the morning, were selected because they contain optimal chemical constituents. The harvested leaves were carefully sorted to remove damaged or contaminated parts (wet sorting). The initial fresh weight was recorded at this stage.

The leaves were then washed under running water, drained, and dried at room temperature using an air-drying method, ensuring that the leaves were spread thinly to prevent microbial decay. Once completely dry, the leaves were weighed to confirm dryness, then ground into a fine powder and sieved through an 80-mesh sieve. The resulting simplicia powder was stored in an airtight container (Nurazizah et al., 2020).

Preparation of Extract

Extraction was performed using the maceration method to obtain a liquid extract with relatively low viscosity. A total of 500 g of simplicia powder was extracted using 70% ethanol, with a solvent-to-sample ratio of 1:7.5 (Handayani & Sriherfyna, 2016).

The simplicia was placed in a maceration extractor and submerged in 1800 mL of ethanol, approximately 1 cm above the powder surface. The container was sealed tightly and kept away from direct sunlight. Maceration was carried out for 3 days with stirring three times every 24 hours.

After 72 hours, the extract was filtered to separate the filtrate from the residue. The residue underwent two additional remaceration steps, each using 1000 mL of 70% ethanol, and left to

stand for 3 days. All filtrates were combined and concentrated using a rotary vacuum evaporator at 70°C. The remaining solvent was evaporated using a water bath to obtain a liquid extract. Standard: minimum acceptable extract yield $\geq 10\%$ (Indonesia, 2017).

Phytochemical Screening (Mauludiyah et al., 2020)

Flavonoid Identification

One milligram of extract was placed in a test tube, followed by the addition of magnesium powder and 10 drops of 37% HCl. The formation of an orange coloration indicated the presence of flavonoids.

Alkaloid Identification

One milligram of extract was mixed with 2 mL chloroform and 2.5 mL of 10% ammonia. Then, 2 M sulfuric acid was added to facilitate layer separation. The upper layer was transferred to another tube and treated with Mayer and Dragendorff reagents. White precipitate (Mayer) and orange precipitate (Dragendorff) indicated the presence of alkaloids.

Tannin Identification

One milligram of extract was mixed with hot water and 1% FeCl₃. A dark green coloration indicated tannins.

Saponin Identification

One milligram of extract was mixed with 1 mL distilled water, shaken for 1 minute, and left for 10 minutes. Persistent foam (1–3 cm) after addition of 1 N HCl indicated the presence of saponins.

Phenolic Identification

One milligram of extract was treated with 3 drops of 1% FeCl₃. A dark green coloration indicated phenolic compounds.

Formulation of Paper Soap

Paper soap was prepared using the hot-melt method. All ingredients listed in Table 1 were prepared and mixed in a beaker placed in a water bath until homogeneous. While still warm, the mixture was poured into calibrated silicone molds. After solidification, the sheets were removed and subjected to physical and chemical quality evaluation, including organoleptic properties, homogeneity, size uniformity, weight uniformity, foam height, washing time, pH, moisture content, and antioxidant activity (Putri et al., 2023).

Physical and Chemical Evaluation

Organoleptic Test

One sheet from each replicate was visually inspected for shape, color, and odor.

Homogeneity Test

A sheet of paper soap was observed against a white background under light. Uniform color and texture indicated homogeneity.

Size Uniformity

Thickness and diameter were measured using a vernier caliper in 20 samples. Deviation should not exceed 10%.

Weight Uniformity

Twenty samples were individually weighed. No more than two samples may deviate from the mean weight by more than 10%.

Foam Height Test

0.5 g sample was dissolved in 25 mL distilled water, transferred to a 100 mL measuring cylinder, and diluted to 50 mL. The solution was shaken 25 times, allowed to settle, and the foam height was measured. The acceptable foam height according to SNI is 13–220 mm.

Washing Time Test

Twenty samples were tested under running water. The time required for complete dissolution during handwashing was recorded.

pH Measurement

Ten grams of sample were diluted in 100 mL distilled water and left for 2 hours. The pH was measured using a digital pH meter. The acceptable pH for bathing soap is 9–11 (Indonesia, 1994).

Moisture Content

One gram of sample was dried in an oven at 105°C for 2 hours to constant weight (gravimetric method). Maximum acceptable moisture content is 15% (SNI 06-3532-1994).

Antioxidant Activity Test

Preparation of DPPH Solution

Twenty milligrams of DPPH powder was dissolved in a 100 mL volumetric flask using 96% ethanol.

Determination of Maximum Wavelength

DPPH (0.5 mM) was mixed with 4 mL of 96% ethanol and scanned at 510–520 nm using ethanol as blank.

Preparation of Sample Solutions

A stock solution (500 ppm) of paper soap extract was prepared and diluted to obtain concentrations of 20, 40, 60, 80, and 100 ppm.

Preparation of Ascorbic Acid Standard

1000 ppm stock solution of vitamin C was prepared and diluted to obtain working solutions of 4, 6, 8, 10, and 12 ppm.

Calculation of Antioxidant Activity

Antioxidant activity was expressed as percent inhibition using the formula:

$$\% \text{Inhibition} = \frac{A_0 - A_s}{A_0} \times 100\%$$

where

A_0 = absorbance of DPPH control,

A_s = absorbance of sample.

The concentrations of the samples and their corresponding percent inhibition values were plotted on the x- and y-axes, respectively, to generate a linear regression equation. This equation was subsequently used to determine the IC_{50} (inhibitory concentration 50%) of each sample, where the IC_{50} value was obtained by substituting $y = 50$ and solving for x . The IC_{50} represents the concentration of the sample solution required to reduce 50% of DPPH free radicals.

III. RESULT AND DISCUSSION

Plant determination is a process of comparing an unidentified plant specimen with previously identified and documented plant species to avoid errors during sample collection. The Arabian bidara leaves (*Ziziphus spina-christi* (L.) Desf.) used in this study were taxonomically identified at the Pharmacognosy Laboratory, Department of Pharmacy, Politeknik Kesehatan Putra Indonesia Malang. Identification was carried out using the Flora of Java as the primary reference. The dichotomous key results confirmed the taxonomic classification as follows:

Kingdom	: Plantae
Division	: Magnoliophyta (Angiosperms)
Class	: Magnoliopsida (Dicotyledons)
Family	: Rhamnaceae
Genus	: <i>Ziziphus</i>
Species	: <i>Ziziphus spina-christi</i> (L.) Desf.

Dichotomous key:

1b-2b-3b-4b-6b-7b-9b-10b-11b-12b-13b-14a-15a-109b-119b-120b-128b-129b-135b-136b-139b-140b-142b-143b-146a-147b-150b-151a : Rhamnaceae – 1 : *Ziziphus*.

Morphological Description

Habit: A tree with a height ranging from 5 to 15 m.

Stem: Twisted trunk with protrusions; branches often drooping.

Leaves: Petioled; ovate to broadly ovate (4–8 × 2–7 cm); three prominent veins; margins slightly serrated; underside whitish to rust-brown; stipules modified into spines.

Flowers: Inflorescences arranged in auxiliary cymes; short-pedicelled or sessile; pubescent; protective bracts ovate; calyx yellow-green with triangular lobes; corolla with five inverted-ovate petals shaped like a hood, white in color.

Fruits: A fleshy drupe, oval to globose, 1.5–2 cm long; mesocarp white and watery.



Figure 1. Determination Process

The dichotomous identification key indicates the following morphological characteristics of the plant: flowering plants with at least stamens and pistils present (1b); absence of tendrils, although the plant may climb or twine (2b); leaves not needle-shaped and not arranged in fascicles (3b); the plant does not resemble grasses, with distinct leaves and/or flowers (4b); leaves clearly visible (6b); not belonging to or resembling the palm family (7b); the plant does not climb or twine (9b); leaves not arranged densely (10b); a midrib clearly distinguishable from the venation network, with lateral veins extending sideways and upward (11b); not all leaves arranged in whorls, and some leaves may be absent (12b); plant with a shrub-like form (13b); leaves arranged alternately, occasionally opposite (14a); simple leaves, not pinnately compound or bipinnate (15a); terrestrial plant among mangrove species (109b); classified as other terrestrial plants (119b); latex-free plant (120b); leaves not belonging to volatile, easily flammable grass-like species (128b); absence of a prominent leaf sheath, with only partial or minimal encircling of the stem (129b); leaves not bilobed like butterfly-shaped leaves (135b); venation pattern palmate or pinnate (136b); no circular vascular bundles on the

branches (139b); calyx without distinctive glands (140b); branching pattern not as described in the key (142b); absence of scales (143b); plant not characterized by blunt spines or spines ignored (146a); woody plant (147b); petioles unsegmented and broad, with lamina containing oil glands or lacking them (150b). The largest lateral leaf veins curve upward toward the apex, with smaller curved veins emerging near the leaf base, arranged alternately (Van, 2008).

Based on this determination process, it can be concluded that the plant material selected for processing and analysis is correctly identified as *Ziziphus spina-christi* (Arabian bidara).

1. . Preparation of Simplicia

Simplicia preparation was carried out to obtain at least 500 g of fine powder of Arabian bidara (*Ziziphus spina-christi*) leaves. Mature leaves were harvested in the morning, followed by careful wet sorting to remove unwanted materials. The freshly sorted leaves were weighed and then washed thoroughly under running water. Drying was performed at room temperature with adequate aeration, ensuring that the leaves were not stacked on top of one another to prevent microbial spoilage. Once completely dried, the leaves were weighed, pulverized using a blender, and sieved through an 80-mesh sieve. The resulting powder was stored in an airtight container.

2. Extraction of Arabian Bidara Leaves

Extraction was performed using the cold maceration method. Maceration was chosen due to its simplicity, low operational cost, and prolonged contact between the solvent and the plant matrix, facilitating efficient extraction of phytochemicals while preventing thermal degradation of heat-labile compounds. However, maceration also has drawbacks, including long extraction durations and the requirement for relatively large volumes of solvent (Thomas et al., 2024). A polar solvent was utilized because the major bioactive constituents of bidara leaves are polar in nature, thus requiring a polar extraction medium (Samudra et al., 2022).

The obtained extract was further concentrated to collect the semi-solid extract by evaporating the solvent using a rotary evaporator. The mechanism of the rotary evaporator involves heating the sample in an evaporation flask placed in a water bath. Due to differences in boiling points, the component with the lower boiling point evaporates first. The vapor is then condensed by the cooling system under reduced pressure and collected in the receiving flask. The concentrated extract obtained was the semi-solid extract, selected due to its homogeneous consistency suitable for subsequent formulation or mixing processes. The extraction yield met the standard requirement of 16%, confirming that the extract was suitable for further formulation.

3. Phytochemical Screening

Phytochemical screening of the Arabian bidara leaf extract was conducted to identify the major classes of secondary metabolites present. The results of the screening are presented in Table 1. Based on the findings, the extract contains alkaloids, flavonoids, tannins, saponins, and phenolic compounds. Gambar 1. Proses Determinasi

Table 1. Phytochemical Screening Results of Arabian Bidara Leaf Extract

Secondary Metabolites	Observed Result	Conclusion
Alkaloids	Brown precipitate	(+) alkaloids
Flavonoids	Yellow precipitate	(+) flavonoids
Tannins	Dark bluish	(+) tannins
Saponins	Stable foam	(+) saponins
Phenols	Dark greenish	(+) phenols

Preparation of Paper Soap

The formulation of the paper soap is presented in Table 2. The preparation process was carried out using the hot method. Initially, all equipment and materials were prepared. Virgin coconut oil (VCO, 5 g) was heated in a water bath, followed by the addition of stearic acid and continuous mixing until homogeneous. In a separate beaker, 9 g of 30% NaOH solution was prepared. The Arabian bidara extract was then added to the mixture, followed by glycerin (6.5 g), SLS (1 g), BHT (0.1 g), glucose (3 g), and ethanol (7.5 g). The mixture was heated and mixed over the water bath until a uniform consistency was achieved. The hot mixture was then poured into calibrated silicone molds. Once solidified, the paper soap was removed from the mold and subsequently subjected to physical, chemical, and antioxidant evaluation.

Table 2. Paper Soap Formulation

Ingredients	Function	F1	F2	F3
Bidara Leaf Extract	Active compound	5%	7.5%	10%
VCO	Humectant	8%	8%	8%
NaOH 30%	Alkalizing agent	12%	12%	12%
Stearic acid	Solubilizing agent	3.5%	3.5%	3.5%
SLS	Surfactant	1%	1%	1%
Glycerin	Plasticizer	6.5%	6.5%	6.5%
Glucose	Transparency agent	3%	3%	3%

Ingredients	Function	F1	F2	F3
Ethanol 96%	Base	7.5%	7.5%	7.5%
BHT	Antioxidant	0.1%	0.1%	0.1%
Disodium EDTA	Chelating agent & preservative	1%	1%	1%
Fragrance	Aromatic	q.s	q.s	q.s
Distilled water	Solvent	ad 100%	ad 100%	ad 100%

1. Physical, Chemical, and Antioxidant Evaluation of Bidara Leaf Paper Soap

The physical and chemical quality evaluation was conducted to ensure the suitability of the product based on SNI 06-3532-1994 for solid bath soap. The complete formulation is shown in Table 2.

Organoleptic Properties

Organoleptic evaluation included color, odor, texture, and form. A red cosmetic-grade colorant was added with the aim of mimicking the natural appearance of bidara arab leaves. However, the intense dark brown color of the extract reduced the effectiveness of the red colorant.

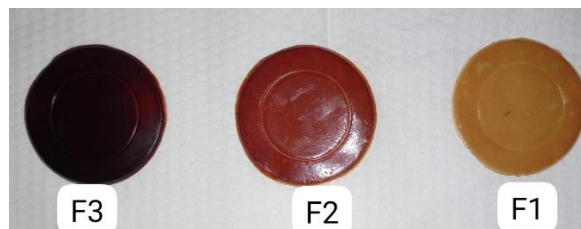


Figure 2. Organoleptic appearance of paper soap

During mixing, the red hue appeared initially, but the heating process caused the extract color to dominate. Formula 1 (F1) showed a yellowish tone due to the lower extract concentration, Formula 2 (F2) appeared brown, and Formula 3 (F3) exhibited a darker, almost black hue. This indicates that increasing extract concentration intensifies the product's natural coloration.

Homogeneity

All formulations (F1–F3) were homogeneous. Homogeneity was mainly influenced by proper mixing and heating techniques.

Size Uniformity

The paper soaps showed uniform diameter (3.6 cm) and thickness (0.11 cm).

Weight Uniformity

The average weights of F1, F2, and F3 were 0.40 g, 0.43 g, and 0.40 g, respectively, meeting the USP requirements. Minor variation was attributed to slight differences during manual pouring into molds.

Foam Height

The saponin content naturally present in bidara extract contributes to foam formation. F1 produced the lowest foam height (10 mm), while F3—containing the highest extract concentration—produced the highest foam height (13 mm). This supports the relationship between extract concentration and foam stability.

Wash-Off Time

The wash-off time was tested directly on the hands to determine dissolution efficiency. Good handwashing practices require at least 60 seconds (Wiritanaya et al., 2024). The paper soap dissolved effectively, with wash-off times of 50–54 seconds, indicating satisfactory performance.

pH Measurement

The pH measurements were conducted in triplicate, with acceptable variations within 0.50. Increasing extract concentration resulted in higher pH values (9.40–9.79). These values align with the acceptable skin pH range for soap products (pH 9–11) according to SNI (Indonesia, 1994; Verawaty et al., 2020).

Moisture Content

The addition of bidara ethanolic extract increased the moisture content of the soap. Similar findings were reported by Sukmawati & Laeha (2017), highlighting that humectants such as glycerin, glucose, and ethanol contribute to higher moisture content due to their hygroscopic properties (Muis, 2015). Moisture content remained within SNI limits (<15%).

Table 3. Physical Characteristics of Bidara Leaf Paper Soap

Parameters	F1	F2	F3
Organoleptic	Flat-round, yellow, coconut aroma	Flat-round, brown, coconut aroma	Flat-round, black, odorless
Homogeneity	Homogeneous	Homogeneous	Homogeneous
Size uniformity (cm)	0.11 × 3.64	0.11 × 3.64	0.11 × 3.64
Weight uniformity (g)	0.40	0.43	0.40
Foam height (mm)	10	12	13
Wash-off time (s)	50	52	54

Parameters	F1	F2	F3
pH	9.40	9.52	9.79
Moisture content (%)	8.35	7.42	6.28

2. Antioxidant Activity of Bidara Leaf Paper Soap

Antioxidant activity was evaluated to determine the presence and effectiveness of antioxidant compounds within the formulated paper soap. Vitamin C served as the positive control.

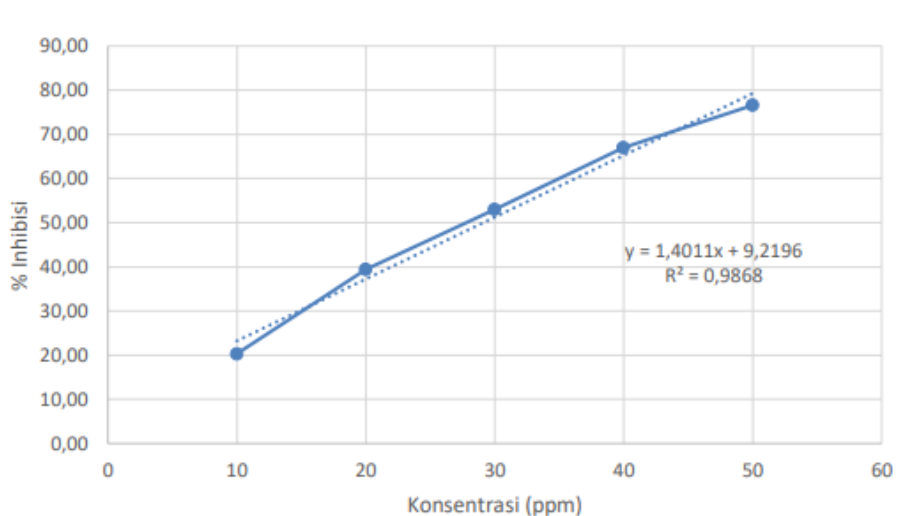


Figure 3. % Inhibition Curve

Higher sample concentrations produced lower absorbance values, resulting in higher % inhibition. The IC_{50} values of the bidara paper soap formulations were 27.18 ppm (F1), 29.01 ppm (F2), and 34.26 ppm (F3).

According to classification standards (Handayani & Sriherfyna, 2016; Mardhiyani & Rehulina, 2023):

- $IC_{50} < 50$ ppm → very strong antioxidant
- 50–100 ppm → strong
- 101–150 ppm → moderate
- 151–200 ppm → weak

Thus, all formulations demonstrate very strong antioxidant activity, and increasing extract concentration enhances antioxidant potency.

3. Conclusion

The physical quality evaluation of all three formulations met the SNI 06-3532-1994 standards for solid soap. The antioxidant activity results (IC_{50} values of 27.18 ppm, 29.01 ppm,

and 34.26 ppm for F1, F2, and F3, respectively) classify the product as having very strong antioxidant activity.

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