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Development of a Lip Scrub Formulation Based on Sappan Wood Bark Extract (*Caesalpinia sappan* L.) as a Natural Antioxidant Source

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Abstract: Sappan wood (*Caesalpinia sappan* L.) contains high levels of phenolic compounds, particularly brazilin and flavonoids, which offer strong natural antioxidant potential. Evaluating its bioactivity and physicochemical stability after processing is essential for cosmetic applications. This study developed a lip scrub formulation containing sappan wood bark extract as a natural antioxidant source and evaluated its physicochemical properties and antioxidant activity. Botanically authenticated raw material was extracted using a digestion method with water, followed by concentration. The extract was evaluated for organoleptic properties, pH, drying loss, and DPPH radical scavenging activity. Three lip scrub formulations with varying extract concentrations were evaluated for organoleptic properties, homogeneity, spreadability, pH, DPPH antioxidant activity, and total flavonoid content using the aluminum chloride colorimetric method. The extract showed very strong antioxidant activity with an IC50 of 15.25 ± 0.03 µg/mL and a total flavonoid content of 35.2551 mg QE/g. All formulations exhibited acceptable physical characteristics and pH values safe for lip application. The formulations maintained very strong antioxidant activity, with IC50 values of 26.73 ± 0.07 µg/mL, 26.65 ± 0.08 µg/mL, and 26.56 ± 0.01 µg/mL for Formulas I, II, and III, respectively. Formula III demonstrated the lowest IC50 value and the highest flavonoid content. Although processing slightly reduced antioxidant capacity compared to the crude extract, the formulations successfully retained significant antioxidant activity, confirming sappan wood bark extract as a promising natural ingredient for functional lip care products.

Introduction

The skin is the largest organ of the human body and serves as the primary protective barrier against ultraviolet radiation, pollution, microorganisms, and chemical exposure. Such exposures can increase the generation of free radicals. leading to oxidative stress within the skin tissues. Oxidative stress contributes to premature aging, collagen degradation, hyperpigmentation, and other dermatological disorders. Therefore, the incorporation of antioxidant compounds into skincare products represents an important strategy to maintain skin health and preserve its protective function (1).

With the growing trend toward the use of natural ingredients in cosmetics, numerous plants containing secondary metabolites have been explored as potential sources of topical antioxidants. Flavonoids, phenolics, and tannins can scavenge free radicals through electron or hydrogen atom donation mechanisms, thereby inhibiting chain oxidation reactions. In addition to their biological activity, natural ingredients are generally considered safer, associated with lower irritation risk, and aligned with environmentally sustainable cosmetic concepts (1).

Sappan wood bark (*Caesalpinia sappan* L.) is known for its high antioxidant potential. This potential positions sappan wood as a promising natural active. The significant radical-scavenging activity of sappan wood bark extract ingredient for skincare products that not only provide cleansing effects but also offer protection against oxidative damage (2).

A lip scrub was selected as the delivery system because it combines mechanical exfoliation with the application of emollient and functional ingredients in a single lip-specific preparation. The exfoliating agent removes dry and accumulated surface material, whereas

the lipid-based components help maintain lubrication and reduce excessive dryness during application. This combination provides a practical platform for incorporating a natural antioxidant into a product that is applied directly to the lip surface. Unlike conventional facial topical preparations, the formulation is specifically designed for the characteristics and intended use of the lips, with sugar functioning as the exfoliating agent and petroleum jelly, castor oil, and beeswax forming the semi-solid lipid base.

The lips have distinct physiological characteristics and are continuously exposed to environmental factors that may promote oxidative stress. Therefore, incorporation of antioxidant compounds into lip care preparations is functionally relevant because antioxidants may help neutralize reactive species generated by environmental exposure. In the present study, this rationale is evaluated at the formulation level by determining whether the antioxidant activity of sappan wood bark extract remains measurable after incorporation into the lip scrub. However, the present findings should be interpreted as in vitro evidence of antioxidant activity rather than evidence of clinical protection or therapeutic efficacy on the lips (3).

The development of cosmetic products containing natural antioxidants has gained increasing attention due to growing consumer demand for plant-based functional cosmetic ingredients. Antioxidants derived from medicinal plants may neutralize free radicals by donating hydrogen atoms or electrons, thereby preventing oxidative chain reactions and minimizing cellular damage. Combining exfoliating activity with antioxidant protection in lip scrub formulations may improve the functional value of lip care cosmetic products.

Sappan wood bark extract represents a promising candidate for incorporation into lip scrub preparations because of its phenolic and flavonoid content. Brazilin, the major bioactive compound in sappan wood. demonstrates substantial antioxidant activity and contributes to free radical scavenging mechanisms. Previous studies have evaluated sappan wood bark extract in topical cosmetic preparations and antioxidant-related applications. However, investigations concerning incorporation of sappan wood bark extract into lip scrub formulations remain limited. Furthermore, formulation components such as lipid bases, exfoliating agents, and excipients may influence antioxidant stability and physicochemical characteristics, requiring further evaluation to ensure product effectiveness and formulation quality (3).

Based on this background, the present study aimed to develop a lip scrub formulation containing sappan wood bark extract (*C. sappan* L.) as a natural antioxidant source, evaluate its physicochemical characteristics, and determine whether its antioxidant activity was retained after incorporation into the lip scrub matrix (4).

The novelty of this study lies in the development of a lip-specific exfoliating formulation containing sappan wood bark extract and in the evaluation of its antioxidant activity after incorporation into a lipid-based scrub matrix. In contrast to previously reported *C. sappan* cosmetic formulations that have primarily employed tonic or gel-based delivery systems, the present formulation combines mechanical exfoliation with a semi-solid lipid base intended for lip application. The study therefore addresses whether the antioxidant activity of sappan wood bark extract remains measurable after exposure to formulation variables such as heating, lipid-phase incorporation, and interaction with excipients. This approach provides formulation-level evidence for the feasibility of using sappan wood bark extract as a natural antioxidant ingredient in functional lip care products.

Methodology

Materials

The materials used in this study included sappan wood bark extract (*C. sappan* L.) obtained from the Indonesian Medicinal and Aromatic Crops Research Institute (BALITRO), Bogor, Indonesia. The reagents employed consisted of 2.2-diphenyl-1-picrylhydrazyl (DPPH) solution (TCI, Tokyo, Japan), quercetin standard (Sigma-Aldrich, St. Louis, USA), vitamin C (Shinsung Industrial Co., Korea), ethanol pro analysis grade (Merck, Darmstadt, Germany), distilled water, methyl paraben (MedChemExpress, USA), butylated hydroxytoluene (BHT), petroleum jelly (APAR, India), castor oil (PT. Ika Tarmindo Putra Mas, Jakarta, Indonesia), cera alba (Arjun, India), and white sugar (Gulaku, Indonesia). All materials were of analytical or pharmacopeial grade and were considered suitable for laboratory research.

Instruments

The instruments used in this study included a UV–Visible spectrophotometer (Shimadzu UV-1900, Japan), rotary evaporator (IKA RV-10, Germany), microplate reader (Thermo Scientific, USA), hotplate stirrer (Eurostar Power-H IKA-WERKE, Germany), homogenizer (IKA RW-20 Digital, Germany), digital pH meter (Hanna HI-2211, Romania), analytical balance (Dan HM-200, Korea), mesh sieves No. 4 and 18, Whatman No. 1 filter paper, and a complete set of laboratory glassware (Pyrex/Iwaki).

Collection and Botanical Determination

Sappan wood bark (*C. sappan* L.) was obtained from the Indonesian Medicinal and Aromatic Crops Research Institute (BALITRO), Bogor, Indonesia. Botanical authentication was subsequently conducted at the Department of Biology, Faculty of Mathematics and Natural Sciences, Herbarium Depokensis, Universitas Indonesia, Depok, West Java, Indonesia, to confirm the taxonomic identity of the plant species used in this study.

Preparation of Sappan Wood Bark Extract

The sappan wood bark extraction process was performed through several systematic steps to obtain an optimal quality extract. Raw sappan wood bark was washed under running water to remove adhering dirt, dust, and other surface contaminants. After washing, the material was dried (**Figure 1**) until its moisture content was sufficiently reduced to prevent microbial growth and facilitate the grinding process. The dried material was then pulverized using a blender to obtain a smaller particle size. Subsequently, the resulting simplicia powder was sieved through mesh No. 4 and No. 18 to achieve a uniform particle size distribution (4, 5).

Subsequently, the powdered sappan wood bark was extracted using the digestion method with water as the solvent at a material-to-solvent ratio of 1:10 (w/v). Water



Figure 1. Drying process of sappan wood bark (*C. sappan* L.).

was selected because sappan wood contains polar antioxidant compounds. including brazilin and flavonoids, which are effectively extracted using polar solvents. The digestion method combined with mild heating (40 °C) facilitates diffusion of phenolic compounds from plant matrices while minimizing degradation of thermolabile bioactive constituents, thereby preserving antioxidant activity. To facilitate the diffusion of active compounds into the solvent, 100 g of simplicia powder was immersed in the solvent and heated for 2 h at approximately 40 °C for 2 h. After the completion of the first digestion process, a redigestion step was performed for an additional 1 h under the same conditions to maximize the extraction of the remaining bioactive compounds from the plant matrix (6).

The resulting extract was separated from the residue by filtration using Whatman No. 1 filter paper until a clear filtrate free of solid particles was obtained. The filtrate was then concentrated using a rotary evaporator at approximately 80 °C, under a pressure of 200 mmHg and a rotation speed of 50 rpm, to yield a thick extract. This concentration step aimed to remove the solvent and increase the concentration of active constituents in the extract (7).

The thick extract obtained was weighed to determine the Drug Extract Ratio (DER-native) and to calculate the percentage yield. The extraction yield was calculated as the ratio between the weight of the thick extract and the initial weight of the simplicia, expressed as a percentage. This parameter served as an indicator of extraction efficiency and the quality of the raw material used (8).

Evaluation of Sappan Wood Bark Extract

The thick sappan wood bark extract obtained from the extraction process was evaluated to determine its initial physicochemical characteristics and ensure quality before formulation. These evaluations included organoleptic assessment, pH determination, solvent compatibility testing, and loss determination on drying (9).

Organoleptic evaluation was performed through direct observation of the extract's visual and sensory characteristics, including color, form or consistency, and characteristic odor. Observations were conducted under adequate lighting conditions at room temperature to ensure representative characterization. The organoleptic profile served as an initial directly observing the visual and sensory characteristics of the extract (9).

The pH of the extract was determined using a calibrated digital pH meter to ensure measurement accuracy. Calibration was carried out sequentially using standard buffer solutions at pH 4 and pH 7. The electrode was rinsed with distilled water between buffer solutions to prevent cross-contamination. After calibration, the electrode was gently dried with lint-free tissue and immersed into the extract solution until the sensing portion was fully submerged. The pH value was recorded once a stable reading was achieved, typically within a few minutes. The obtained pH value reflects the acidity of the extract and serves as a basis for assessing its compatibility with topical formulation bases (10, 11).

Loss on drying was determined to quantify the content of volatile components remaining in the thick extract. Approximately 1 g of extract was accurately weighed into a previously tared dish. The sample was heated in an oven at 105 °C for 30 min, cooled in a desiccator to room temperature. and weighed again. The heating and weighing process was repeated until a constant weight was obtained. The percentage of loss on drying was calculated based on the difference between the initial and final weight relative to the initial sample weight. This parameter serves as an indicator of residual moisture or solvent content and is an important quality attribute influencing storage stability and biological activity of the extract (12).

Determination of Antioxidant Activity of Sappan Wood Bark Extract

The antioxidant activity of sappan wood bark extract was determined using the 2.2-diphenyl-1-picrylhydrazyl (DPPH) radical scavenging method, a spectrophotometric assay based on the color change of the DPPH solution upon reaction with antioxidant compounds. To prevent degradation of the DPPH solution, all procedures were performed under light-protected conditions (13).

The DPPH solution was prepared by accurately weighing approximately 4 mg of DPPH (molecular weight 394.32) and dissolving it in analytical-grade ethanol to a final volume of 25.0 mL in a volumetric flask. The solution was stored in an amber bottle to maintain radical stability throughout the experiment (14).

Prior to antioxidant measurements. wavelength optimization was experimentally conducted using UV–Visible spectrophotometry to determine the maximum absorbance wavelength (λmax) of DPPH solution. The maximum wavelength was identified at 517 nm and subsequently used throughout antioxidant evaluation. Analytical linearity was confirmed using regression analysis of concentration versus percentage inhibition. demonstrating acceptable linearity ($R^2 > 0.99$).

The blank solution was prepared by pipetting 1 mL of DPPH solution into a 5 mL volumetric flask. followed by the addition of analytical-grade ethanol to the mark and homogenization. The flask was tightly capped and wrapped with aluminum foil to protect it from light exposure. This blank solution was used as the reference for

Table 1. Formulation of lip scrub containing sappan wood bark extract.

Ingredient	Blank	I	II	III
Sappan Wood Bark Extract (%)	–	0.2079	0.4158	0.6237
Petroleum Jelly (%)	30	30	30	30
Castor Oil (%)	12	12	12	12
Cera Alba (Beeswax) (%)	5	5	5	5
Methyl Paraben (%)	0.18	0.18	0.18	0.18
Butylated Hydroxytoluene (BHT) (%)	0.1	0.1	0.1	0.1
White sugar ad	10 g	10 g	10 g	10 g

absorbance measurements (14).

The extract test solution was prepared by accurately weighing 10.0 mg of sappan wood bark extract and dissolving it in analytical-grade ethanol to a final volume of 10.0 mL. yielding a stock solution with a concentration of 1000 ppm. Serial dilutions were subsequently prepared from the stock solution to obtain concentrations of 5, 10, 15, 20, and 25 µg/mL. Each concentration was prepared in triplicate before antioxidant activity measurement. A specific volume of the stock solution was pipetted into a 5.0 mL volumetric flask, followed by the addition of 1.0 mL DPPH solution and ethanol to the final volume (15).

Vitamin C was used as a positive control. A stock solution was prepared by dissolving 10 mg of vitamin C in analytical-grade ethanol to a final volume of 100 mL. Serial dilutions were prepared in 5.0 mL volumetric flasks to obtain various comparison concentrations. Each solution was mixed with 1.0 mL of DPPH solution, diluted to volume with ethanol, homogenized, and protected from light with aluminum foil (16).

All test solutions, blank, and positive control were incubated for 30 min at room temperature in the dark to allow optimal radical scavenging reactions. After incubation, the absorbance of each solution was measured using a UV–Visible spectrophotometer at the maximum wavelength of 517 nm against the blank solution.

Antioxidant activity was expressed as the percentage inhibition of DPPH radicals, calculated based on the difference between the absorbance of the control and the sample relative to the control absorbance. The percentage inhibition values at each concentration were used to determine the half maximal inhibitory concentration (IC_{50}) through linear regression analysis between sample concentration and percentage inhibition. The IC_{50} value represents the concentration of extract required to inhibit 50% of DPPH radicals, where a lower IC_{50} value indicates stronger antioxidant activity (17).

Determination of Total Flavonoid Content of Sappan Wood Bark Extract by Colorimetric Method

The total flavonoid content of sappan wood bark extract (*C. sappan* L.) was determined using the AlCl3 colorimetric method, with quercetin as the reference standard. This method is based on the spectrophotometric ability of flavonoid hydroxyl groups to form a colored complex with aluminum ions, which can be measured spectrophotometrically. The resulting color intensity is proportional to the flavonoid concentration in the sample.

A quercetin stock solution was prepared by accurately weighing 5 mg of quercetin and dissolving it in analytical-grade ethanol to a final volume of 10 mL, yielding a concentration of 500 ppm. This stock solution was subsequently used to prepare a series of standard solutions through serial dilution to obtain several working concentrations. Each standard solution was placed in sealed vials wrapped with aluminum foil to prevent light-induced degradation (18).

The extract test solution was prepared by accurately weighing 10 mg of sappan wood bark extract and dissolving it in analytical-grade ethanol to a final volume of 10 mL, resulting in a concentration of 1000 ppm. The solution was stored in a tightly closed vial and used as the stock solution for total flavonoid analysis

For measurement, 50.0 µL of each quercetin standard solution and extract solution was pipetted into individual wells of a 96-well microplate using a micropipette. Subsequently, 50.0 µL of 2% $AlCl_3$ solution was added to each well, gently homogenized, and incubated for 40 minutes in the dark at room temperature to allow optimal complex formation. After incubation, the absorbance of each well was measured using a microplate reader at a wavelength of 430 nm against the appropriate blank (19).

A calibration curve was constructed by plotting quercetin concentration against absorbance values, and this curve was used to calculate the total flavonoid content of the extract. The results were expressed as milligrams of quercetin equivalents per gram of extract (mg QE/g extract). The calculation considered the standard concentration, initial solution volume, and dilution factors applied during sample preparation.

The obtained total flavonoid content served as a quantitative parameter representing the flavonoid-derived phenolic compounds present in the sappan wood bark extract and provided a basis for interpreting its antioxidant activity.

The preparation of the lip scrub formulation began with the preparation of all required instruments and materials according to the predetermined formula composition in **Table 1**. Each ingredient was accurately weighed using an analytical balance to ensure precise formulation. The next step involved melting the base components: Cera alba was melted at approximately 80 °C, while petroleum jelly was melted at approximately 60 °C until completely liquefied. Subsequently, the two lipid phases were combined in a beaker and homogenized using a homogenizer until a uniform base mixture was obtained (20).

Methyl paraben and butylated hydroxytoluene (BHT) were first dissolved in a portion of castor oil to enhance their solubility and ensure uniform distribution of the preservative and antioxidant within the formulation

system. The resulting solution was gradually incorporated into the melted base mixture under continuous homogenization until a homogeneous blend was achieved. Subsequently, sappan wood bark extract (*C. sappan* L.), previously dissolved in a small amount of castor oil, was added gradually into the base while stirring continuously to ensure even dispersion (20).

Once the base and extract were uniformly mixed, white sugar was incorporated as the primary abrasive agent in the lip scrub formulation. The addition was performed gradually with continuous stirring until all components were thoroughly blended, resulting in a uniform semi-solid mass. The final lip scrub formulation was then transferred into clean and dry containers, tightly sealed, labeled according to the respective formula, and stored under appropriate conditions until further evaluation was conducted (20).

Evaluation of Lip Scrub Preparation Containing Sappan Wood Bark Extract

Lip scrub formulations containing sappan wood bark extract were assessed for their physical and chemical quality and suitability as topical lip care products. The tests included physical evaluations, such as organoleptic properties, homogeneity, and spreadability, as well as chemical evaluations, including pH measurement, determination of antioxidant activity using the DPPH method, and total flavonoid content analysis using the aluminum chloride colorimetric method (21).

Organoleptic evaluation was performed using visual, olfactory, and tactile senses to assess the color, odor, taste, and physical form of the lip scrub formulations. Observations were carried out at room temperature under adequate lighting conditions to obtain a representative description of product quality. These parameters served as initial indicators of consumer acceptability and formulation stability during storage (22).

Homogeneity testing was conducted by spreading a small amount of the formulation evenly onto a glass slide and visually observing for the presence of coarse particles, agglomeration, or phase separation. The formulation was considered homogeneous if no visible clumps were detected and the distribution of components appeared uniform across the observation surface.

Spreadability evaluation was conducted by placing approximately 1 g of lip scrub preparation between two glass plates. Sequential loads of 50 g, 100 g, and 200 g were applied, and the diameter of spread was measured after each load application. Measurements were performed in triplicate, and the mean spreadability value was subsequently calculated (21).

Chemical evaluation began with pH measurement. Approximately 1 gram of lip scrub was dispersed in 100 mL of distilled water and measured using a previously calibrated pH meter with standard buffer solutions. The electrode was immersed in the sample solution until a stable reading was obtained, and the pH value was recorded. The pH parameter is essential to ensure product safety for lip tissue and to minimize the risk of irritation (22).

The antioxidant activity of the lip scrub formulations was determined using the DPPH method, following a procedure comparable to that used for the extract. The DPPH solution was prepared beforehand, followed by the preparation of control and test solutions. Approximately 0.5 g of lip scrub sample was dissolved in 20 mL of analytical-grade ethanol, homogenized, and centrifuged at 1000 rpm for 10 min to obtain a clear supernatant. Serial concentrations were prepared from this solution and mixed with DPPH solution, then incubated under dark conditions. After incubation, absorbance was measured using a UV–Visible spectrophotometer, and the percentage inhibition and IC_{50} values were calculated to determine the antioxidant strength of the formulations (22).

The total flavonoid content of the lip scrub formulations was determined using the aluminum chloride colorimetric method with quercetin as the reference standard. Preparation of standard solutions and calibration curves followed the same procedure as for the extract analysis. Approximately 10 mg of each formulation sample was weighed and dissolved in analytical-grade ethanol to obtain the required concentration. The solution was reacted with $AlCl_3$ reagent, incubated in the dark, and its absorbance measured using a microplate reader. Total flavonoid content was calculated based on the quercetin calibration curve and expressed as quercetin equivalents relative to the formulation weight (22).

Data Analysis

The IC_{50} values of antioxidant activity and total flavonoid content of each formulation were statistically analyzed using one-way analysis of variance (ANOVA) at a 95% confidence level ($\alpha = 0.05$). Prior to ANOVA analysis. data normality was assessed using the Shapiro–Wilk test and homogeneity of variance was evaluated using Levene's test. When statistically significant differences were observed. Tukey's post-hoc test was subsequently performed to identify pairwise differences among formulations. Statistical significance was established at $p < 0.05$.

Results

Collection and Preparation of Raw Material

The primary raw material used in this study was sappan wood bark (*C. sappan* L.), obtained from the Indonesian Medicinal and Aromatic Crops Research Institute (BALITRO), Bogor, Indonesia. The simplicia used consisted of dried sappan wood bark that had undergone a drying process until completely dehydrated and exhibited a characteristic bright orange color. This physical condition indicated that the material met the initial quality requirements as a suitable simplicia for subsequent extraction and further analytical testing.

Botanical Determination

Botanical authentication was conducted at Herbarium Depokensis (UIDEP), Biodiversity Collection Room, Universitas Indonesia. The results confirmed that the sample was identified as *C. sappan* L., belonging to the family Fabaceae, with specimen code JI24-P-131. This verification ensured the authenticity of the botanical identity of the research material, thereby supporting the scientific validity of using the plant as a source of bioactive compounds in this study.

Table 2. Results of simplicia preparation and extraction of sappan wood bark.

Parameter	Results	Description
Weight of simplicia powder	1566.8 g	–
Weight passing sieve No. 4	1566.8 g	Meets specification
Percentage passing sieve No. 4	100%	Meets specification
Weight passing sieve No. 18	606.1 g	Meets specification
Percentage passing sieve No. 18	38.68%	Meets specification

Table 3. Yield and DER-native of thick sappan wood bark extract.

Extraction	Parameter	Result	Description
1	Weight of simplicia	100 g	–
	Weight of extract	26.67 g	Meets specification
	DER-native	3.75	–
	Yield	26.67%	–
2	Weight of simplicia	100 g	–
	Weight of extract	25.35 g	Meets specification
	DER-native	4.00	–
	Yield	25.35%	–

Determination of Foreign Organic Matter

The determination of foreign organic matter in the sappan wood bark simplicia yielded a value of 1.66%, based on an initial simplicia weight of 2007.3 g and a foreign organic matter weight of 33.32 g. This value was below the maximum limit specified in the simplicia monograph according to Materia Medika Indonesia, which stipulates a limit of not more than 2%.

These findings indicate that the simplicia used possessed good purity and was relatively free from contamination by other plant parts such as petioles or stems, considering that the plant part used in this study was the bark. Therefore, the sappan wood bark simplicia met the quality standards required for herbal raw materials and was suitable for use in the extraction process and subsequent biological activity evaluation.

Simplicia Size

Based on the determination of particle size using sieves No. 4 and No. 18 in **Table 2**, the results met the required specifications. The percentage passing sieve No. 4 was 100%, whereas the percentage passing sieve No. 18 was 38.68% (22, 23).

Thick Extract Yield

The extraction of sappan wood bark was carried out using water as the solvent through the digestion method, assisted by a hotplate stirrer at 40 °C for 2 h with a material-to-solvent ratio of 1:10 (w/v), as summarized in **Table 3**. A re-digestion step was subsequently performed for an additional 1 h under the same conditions to maximize extraction of the remaining bioactive compounds. The extraction was performed in 100 g batches of simplicia.

The extraction yield obtained from the thick sappan wood bark extract met the required standard, as the minimum acceptable yield according to the Indonesian Herbal Pharmacopoeia (FHI) is not less than 8.1%. The yields obtained in this study were substantially higher than this threshold, indicating good extraction efficiency.

The extraction yield obtained from thick sappan wood bark extract ranged from 25.35–26.67%, exceeding the minimum requirement according to the Indonesian Herbal Pharmacopoeia (23).

Evaluation of Thick Sappan Wood Bark Extract

Organoleptic Evaluation

Organoleptic evaluation was conducted using sensory observation to determine the physical characteristics of the obtained thick sappan wood bark extract. The observed parameters included color, odor, and physical form. The sappan wood bark extract exhibited a reddish-brown color, a characteristic sappan wood odor, and a thick, viscous consistency that resembled honey. These characteristics suggest that the extraction and concentration processes were conducted effectively, enabling the successful recovery of secondary metabolites, particularly phenolic pigments characteristic of sappan wood (22).

pH Determination

The pH measurement was performed to determine the acidity level of the extract (5.65 ± 0.02), which may influence both color stability and chemical stability of active compounds. Sappan wood is known to contain brazilin, a pigment that imparts a bright red color under near-neutral pH conditions. However, brazilin undergoes color changes depending on environmental pH. Under acidic conditions (pH 2–5), brazilin tends to appear yellow, whereas under near-neutral to slightly alkaline conditions it shifts toward a purplish-red hue. Furthermore, oxidation of brazilin can result in the formation of brazilein, which exhibits a reddish-brown color.

The pH measurement results showed that the extract exhibited values ranging from 5.63 to 5.66, with a mean value of 5.65 ± 0.02. This indicates that the extract is slightly acidic, a condition that still allows the formation of a reddish-brown color due to the presence of brazilein formed from the partial oxidation of brazilin during the extraction and concentration processes. This pH range also suggests that the extract is relatively stable and remains within an appropriate range for further development into topical formulations, including lip scrub preparations.

Table 4. Determination of maximum wavelength and operating time.

Parameter	Result
Maximum wavelength	517 nm
Operating time	30 minutes

Table 5. IC_{50} of sappan wood bark extract.

Sample	Concentration (µg/mL)	Inhibition (%)	IC_{50} (µg/mL)
I	5	14.30	15.28
	10	31.63	
	15	52.23	
	20	63.39	
	25	83.73	
II	5	14.29	15.26
	10	31.85	
	15	52.03	
	20	63.56	
	25	83.88	
III	5	14.42	15.22
	10	31.72	
	15	52.16	
	20	63.70	
	25	84.27	
Mean ± SD IC_{50}			**15.25 ± 0.03**

Table 6. Quercetin absorbance data.

Concentration (µg/mL)	Absorbance Measurement				
	1	2	3	Mean	Quercetin
10	0.2289	0.2155	0.2237	0.2227	0.1091
20	0.2368	0.3251	0.3205	0.2941	0.1805
30	0.3158	0.3837	0.4294	0.3763	0.2627
40	0.3943	0.5632	0.4908	0.4828	0.3691
50	0.5098	0.6182	0.6009	0.5763	0.4627
Blank	0.1145	0.1125	0.1139	0.1136	–

Solvent Compatibility

The solvent compatibility test was conducted using castor oil (Oleum ricini) as the solvent. Approximately 50 mg of sappan wood bark extract was completely dissolved in 50 mL of castor oil after stirring, indicating good compatibility with the oil phase. These findings demonstrate that the extract has the potential to be homogeneously dispersed in oil-based topical systems, thereby supporting its incorporation into lip scrub formulations (23).

Loss on Drying

The loss on drying value of the sappan wood bark extract was determined to be 9.89%, which meets the specified requirement as it is below the maximum limit of 10%. This result indicates a relatively low moisture content in the extract, thereby reducing the risk of microbial growth, enzymatic reactions, and degradation of active compounds. Therefore, the extract demonstrates adequate stability for use as a raw material in formulation development (23).

Antioxidant Activity and IC_{50} Determination of Sappan Wood Bark Extract

The antioxidant activity of the sappan wood bark extract was evaluated using UV–Visible spectrophotometry at the maximum wavelength and optimal incubation time. The determination of the maximum wavelength aimed to obtain the highest and most stable absorbance, while the operating time was established to ensure that the reaction between the DPPH solution and the sample had reached equilibrium, thereby minimizing measurement error. The results showed that the maximum wavelength was 517 nm with an operating time of 30 min. These conditions were used as the basis for measuring the antioxidant activity of the sappan wood bark extract at various concentrations in **Table 4**.

The percentage inhibition increased with increasing extract concentration across all test samples. indicating a dose–response relationship and confirming the extract's ability to scavenge DPPH free radicals. The calculated IC_{50} value demonstrated that the sappan wood bark extract exhibited strong antioxidant activity in **Table 5**, with a mean IC_{50} value of 15.25 ± 0.03 µg/mL (24).

Total Flavonoid Content (TFC) of Sappan Wood Bark Extract

The determination of total flavonoid content in sappan wood bark extract was carried out using a color TFC visible region. which can be measured spectrophotometrically.

The calibration curve constructed using quercetin as the reference standard demonstrated a linear relationship between concentration and absorbance. with the

regression equation Y = 0.009X + 0.0081. This equation was used to calculate the total flavonoid content of the sappan wood bark extract. where Y represents the absorbance value and X represents the flavonoid concentration in the sample (25). These results indicate that the analytical method exhibited good linearity and is suitable for the quantitative determination of total flavonoid content in the extract.

Based on **Table 6**, total flavonoid content was determined by measuring absorbance at 430 nm after incubation for 40 minutes in the dark. Following incubation, the absorbance was recorded and total flavonoid content was calculated using the quercetin calibration curve. The mean total flavonoid content of sappan wood bark extract was 35.2551 mg QE/g extract. This value represents 35.2551 mg quercetin equivalents per gram of extract.

Evaluation of Lip Scrub Containing Sappan Wood Bark Extract

Organoleptic Test

Organoleptic evaluation was conducted to assess the physical characteristics of the lip scrub preparations. including color. odor. and form. The blank preparation was white and nearly odorless. whereas the formulations containing secang extract (F1, F2, and F3) exhibited color variations ranging from orange to brown as the extract concentration increased in **Table 7**. The color differences are associated with the presence of brazilin pigment in secant. which produces a reddish hue under near-neutral pH conditions. All formulations presented a semi-solid consistency with sugar granules functioning as the scrubbing agent (25).

Homogeneity Test

The homogeneity test demonstrated that all preparations, including the blank, F1, F2, and F3, exhibited uniform mixing without phase separation in **Table 8**. No coarse particles resulting from component incompatibility were observed, indicating that all formulations met the homogeneity requirements. The visible sugar granules were not considered defects because they serve as the intended abrasive agent in the lip scrub formulation.

Overall, the results of organoleptic and homogeneity evaluations indicate that the lip scrub formulations containing sappan wood bark extract meet the fundamental physical quality requirements and are suitable for further chemical and biological activity assessments (26).

Spreadability

The spreadability test was conducted to evaluate the lip

Table 7. Organoleptic evaluation results of lip scrub containing sappan wood bark extract.

Lip Scrub Preparation	Color	Odor	Form
Blank	White	Nearly odorless	Semi-solid with sugar granules
F1	Orange	Nearly odorless	Semi-solid with sugar granules
F2	Brownish orange	Slight characteristic odor of castor oil	Semi-solid with sugar granules
F3	Brown	Slight characteristic odor of castor oil	Semi-solid with sugar granules

Table 8. Homogeneity test results of lip scrub containing sappan wood bark extract.

Lip Scrub Preparation	Result	Requirement	Remark
Blank	All components well mixed/homogeneous	Meets requirement	Meets requirement
F1	All components well mixed/homogeneous	All components homogeneous and no coarse particles observed	Meets requirement
F2	All components well mixed/homogeneous	All components homogeneous and no coarse particles observed	Meets requirement
F3	All components well mixed/homogeneous	All components homogeneous and no coarse particles observed	Meets requirement

Table 9. Spreadability test results of lip scrub containing sappan wood bark extract.

Lip Scrub Preparation	Applied Load (g)	Spread Diameter (cm)
Blank	50	1.30
Blank	100	1.40
Blank	200	1.40
F1	50	1.30
F1	100	1.35
F1	200	1.40
F2	50	1.25
F2	100	1.30
F2	200	1.30
F3	50	1.20
F3	100	1.30
F3	200	1.30

scrub preparation's ability to spread on the surface of the lips during application. All formulations, including the blank and those containing sappan wood bark extract, exhibited relatively similar spreadability values across different loading weights. The spread diameter ranged from 1.20 to 1.40 cm, indicating that the preparation possessed a semi-solid consistency that allowed adequate spreading (26).

In general. increasing the applied load from 50 to 200 g did not significantly change the spread diameter. This finding suggests that the formulation's structural matrix was sufficiently stable in maintaining its viscosity. As the main components of the base in **Table 9**. Cera alba and vaseline contributed to the semi-solid texture and stability of the preparation. The observed spreadability values are still within the acceptable range for semi-solid topical preparations, indicating that the product can provide user comfort and uniform distribution of active ingredients on the lip surface (27).

pH

Based on the pH measurement results. the blank formulation (without extract) exhibited a near-neutral pH, whereas the sappan wood bark extract-containing formulations exhibited slightly acidic pH values. This is attributed to the intrinsic acidity of the sappan wood bark extract. Nevertheless, the pH values of the blank, F1, F2, and F3 remained within the acceptable pH range of 4.5–6.5 for lip preparations in **Table 10**, which is 4.5–6.5. If the pH is too acidic, it may cause dryness and cracking of the lips, whereas excessively alkaline conditions may induce irritation, such as itching and burning sensations (27).

Antioxidant Activity of Lip Scrub Containing Sappan Wood Bark Extract

The antioxidant activity test of the lip scrub preparation was conducted to evaluate whether the sappan wood bark extract retained its antioxidant capacity after the incorporation of excipients and to determine whether the IC_{50} values differed among formulations containing varying extract concentrations (28).

The antioxidant activity of the lip scrub preparations was assessed to determine whether the sappan wood bark extract maintained its radical scavenging ability after being formulated with various excipients, as well as to evaluate differences in IC_{50} values among formulations with different extract concentrations. Antioxidant activity was determined using the DPPH method, in which absorbance was measured using a UV–Vis spectrophotometer and IC_{50} values were subsequently calculated as a parameter of antioxidant strength (28).

All lip scrub formulations exhibited IC_{50} values within the range of approximately 26 µg/mL, which falls into the category of strong antioxidant activity in **Table 11**. The relatively similar IC_{50} values among the formulations indicate that the incorporation of various excipients during the formulation process did not significantly reduce the antioxidant activity of sappan wood bark extract.

Formula III demonstrated the lowest IC_{50} value and therefore exhibited the highest antioxidant activity compared with the other formulations. This finding suggests that increasing the extract concentration in the formulation contributes to enhanced free radical scavenging activity. The antioxidant activity of secang wood is associated with the presence of phenolic and flavonoid compounds, particularly brazilin and brazilein, which are known to donate hydrogen atoms to stabilize free radicals (23).

Overall, these results indicate that sappan wood bark extract retained measurable antioxidant activity after incorporation into the lip scrub formulation. supporting its potential use as a natural antioxidant ingredient in lip care cosmetic products (29).

It can be concluded that F1 < F2 < F3 in terms of antioxidant activity, as a lower IC_{50} value corresponds to stronger antioxidant capacity. All formulations were categorized as possessing very strong antioxidant activity (29).

This difference is influenced by the extract concentration in F3, which was higher than that in F1 and F2. One-way ANOVA demonstrated no statistically significant difference among F1, F2, and F3 ($p > 0.05$). The amount of sappan wood bark extract increased by 0.2079 g between successive formulations (0.2079 g in F1, 0.4158 g in F2, and 0.6237 g in F3). This may be attributed to the relatively small variation in extract concentration during weighing. The lip scrub preparations'antioxidant performance was influenced by the intrinsic antioxidant activity of sappan wood bark extract, which exhibited an IC_{50} value of 15.25 ± 0.03 µg/mL and is classified as solid. However, a slight reduction in antioxidant activity was observed when the extract was compared with the developed lip scrub. This decrease may be attributed to differences in extract concentration within the formulation, the presence of additional excipients that could potentially interfere with antioxidant performance. and possible

Table 10. pH test results of lip scrub containing sappan wood bark extract.

Lip Scrub Preparation	pH
Blank	6.02 ± 0.02
F1	5.98 ± 0.01
F^2	5.83 ± 0.01
F^3	5.78 ± 0.01

Table 11. IC_{50} of lip scrub containing sappan wood bark extract.

Sample	IC_{50} (µg/mL)
FI	26.73 ± 0.07
F^2	26.65 ± 0.08
F^3	26.56 ± 0.01

Table 12. Total flavonoid content (mg QE/g preparation).

Sample	Total Flavonoid Content (mg QE/g extract)
FI	8.0593 ± 1.20
F^2	9.5667 ± 1.23
F^3	13.7556 ± 0.82

degradation due to inadequate storage conditions. such as exposure to light (30).

Total Flavonoid Content of Lip Scrub Containing Sappan Wood Bark Extract

The total flavonoid content in the lip scrub preparation was determined using the $AlCl_3$ colorimetric method, with absorbance measured using a microplate reader, based on **Table 7** after incubation for 40 min under dark conditions. The total flavonoid content was calculated based on the quercetin standard calibration curve using the regression equation y = 0.009x + 0.0081, where y represents the absorbance value and x represents the flavonoid concentration (30).

F3 exhibited the highest total flavonoid content, with a mean value of 13.7556 mg QE/g preparation in **Table 12**. This finding is consistent with the higher extract concentration used in F3 than in F1 and F2. One-way ANOVA demonstrated significant differences in total flavonoid content among formulations ($p < 0.05$), followed by Tukey post-hoc analysis.

These findings differ from the IC_{50} results, where no significant differences were observed among the formulations. The discrepancy may be attributed to the presence of various flavonoid-containing compounds in sappan wood bark extract, including other phenolic compounds such as anthocyanins, which collectively contribute to the total flavonoid content.

Discussion

Raw material quality is a fundamental factor determining the success of the extraction process and the consistency of the resulting biological activity. In this study, the primary material, secang wood (*C. sappan* L.), was obtained from the Indonesian Spice and Medicinal Crops Research Institute (BALITRO), Bogor, Indonesia. A clearly documented source from a reputable institution provides initial assurance of the quality of the crude drug material used. Physically, the secang wood crude drug had undergone proper drying and exhibited a characteristic bright orange color. This coloration indicates the presence of the primary phenolic pigment, brazilin, which is the dominant active compound in *C. sappan*. The bright orange appearance suggests that the drying process was conducted optimally without causing excessive thermal degradation. Proper drying is crucial to reduce moisture content, inhibit microbial growth, prevent enzymatic reactions, and maintain the stability of secondary metabolites (30).

The dry and homogeneous physical condition of the crude drug suggests good raw material quality suitable for extraction and further biological evaluation. The bright orange color observed may indicate preservation of major bioactive compounds during post-harvest handling and storage, thereby supporting extract quality for subsequent formulation development (31).

Botanical identification was performed at Herbarium Depokensis (UIDEP), Universitas Indonesia, and the sample was confirmed as *C. sappan* L. (family Fabaceae) with specimen code JI24-P-131. Botanical authentication plays a crucial role in natural product research, as misidentification of plant species can lead to significant variations in phytochemical composition and directly affect biological outcomes. Accurate species identification ensures that the expected secondary metabolites—such as brazilin, brazilein, flavonoids, tannins, and other phenolic compounds—originate from the correct plant source. *C. sappan* is widely recognized as a natural antioxidant source due to its high phenolic content. Brazilin, as the major component, exerts antioxidant activity through electron donation and free radical stabilization mechanisms (2).

Beyond ensuring scientific accuracy, documented botanical authentication enhances research reproducibility. Other researchers can replicate the study using the same species and obtain comparable phytochemical profiles. In the context of scientific publication, herbarium documentation serves as formal authentication, strengthening the credibility of the research. The confirmed quality of the raw material and its validated botanical identity provide a strong foundation for subsequent research stages, including extraction, antioxidant activity evaluation, and formulation development. High-quality raw material ensures that the resulting extract contains optimal levels of secondary metabolites, so the measured biological activity truly reflects the plant's natural potential. Furthermore, consistent crude drug quality minimizes experimental variability. Variations in the initial material may lead to fluctuations in extraction yield, flavonoid content, and IC_{50} values in antioxidant assays. Therefore, this initial phase of the study fulfills the principle of raw material quality control, which is essential in the development of herbal-based cosmetic products. Overall, the results of collection, preparation, and botanical authentication demonstrate that the sappan wood used in this study met the criteria for good-quality crude drug material, both physically and taxonomically. Botanical authentication confirmed the taxonomic identity of *C. sappan* L., thereby supporting the validity and reproducibility of the subsequent extraction, antioxidant evaluation, and lip scrub formulation development (1, 23). Botanical authentication confirmed the taxonomic identity of *C. sappan* L. used in this study, thereby supporting the validity and reproducibility of subsequent extraction, antioxidant evaluation, and lip scrub formulation development (3).

Sieving analysis using mesh numbers 4 and 18 demonstrated that 100% of the powder passed through mesh no. 4 and 38.68% passed through mesh no. 18.

These results comply with pharmacopeial requirements, which state that all powder must pass through mesh no. 4 and not more than 40% may pass through mesh no. 18. Particle size directly influences extraction efficiency. An appropriate particle size increases the surface area of contact between the crude drug and the solvent, thereby accelerating the diffusion of active compounds from the plant matrix. If the powder is too coarse, the limited surface area reduces extraction efficiency. Conversely, excessively fine powder may clog filter pores during filtration, leading to technical difficulties in separating the filtrate from the residue. Thus, the degree of fineness obtained in this study can be considered optimal, enabling efficient extraction without technical obstacles during filtration (3).

The extraction process yielded 26.67% in the first extraction and 25.35% in the second extraction, with corresponding DER-native values of 3.75 and 4. These values comply with the Indonesian Herbal Pharmacopeia standard for thick extracts, indicating that the extraction process was quantitatively effective. The extraction yield obtained indicates that the extraction conditions applied in this study adequately recovered bioactive compounds contributing to antioxidant activity. The strong antioxidant activity observed suggests that the extraction procedure successfully preserved antioxidant constituents present in sappan wood bark extract. Minor differences between the first and second extraction yields may result from variations in particle distribution, mixture homogeneity, or diffusion dynamics, yet these differences were not significant and indicate good process consistency. The DER-native value (3.75-4) indicates that approximately 3.75-4 parts of crude drug produce 1 part of thick extract. Lower DER values indicate higher extract concentration. In this study, the values reflect a well-concentrated extract suitable for cosmetic formulation. Extraction time and temperature are critical parameters affecting efficiency. Excessively short extraction may lead to incomplete diffusion, whereas prolonged extraction risks degradation of heat-sensitive compounds (3, 5).

The digestion method applied mild heating (plus minus 40 °C) for 2 h followed by 1 h of re-digestion. This moderate temperature enhances diffusion without causing significant degradation of phenolic compounds. Excessive heat could accelerate oxidation of brazilin into brazilein, potentially affecting color stability. Moderate heating also aids in reducing residual moisture in the thick extract, facilitating concentration and improving storage stability (6).

Water was selected due to its polarity and ability to dissolve polar bioactive compounds such as flavonoids, tannins, and phenolics. Although extraction yield reflects total dissolved components (including inactive compounds), in the case of secang wood, the high yield likely corresponds largely to water-soluble phenolic constituents. Efficient extraction of phenolics forms the foundation for subsequent antioxidant testing, as higher phenolic content generally correlates with stronger radical scavenging activity (7). The thick extract exhibited a reddish-brown color, characteristic odor, and viscous honey-like consistency. The color indicates partial oxidation of brazilin into brazilein, which contributes to the reddish-brown hue. This oxidation does not necessarily indicate degradation but rather reflects the presence of active phenolic compounds. The characteristic odor suggests that volatile components remained intact, indicating that moderate heating did not cause excessive degradation. The viscous consistency confirms effective concentration and reduced moisture content, which is advantageous for semi-solid formulation (7).

The extract pH (5.65 ± 0.02) indicates slightly acidic conditions, favorable for phenolic stability. Phenolic compounds are generally more stable under mildly acidic conditions than alkaline environments. This pH range also supports antioxidant activity, as phenolic hydroxyl groups function optimally in non-excessively ionized states. Moreover, the pH falls within the physiological range of lips (4.5–6.5), reducing the need for extreme adjustment during formulation and minimizing irritation risk (23).

Spreadability values ranged from 1.20–1.40 cm under increasing loads. The preparation exhibited plastic behavior, spreading proportionally under pressure while maintaining structural integrity. Higher extract concentrations slightly reduced initial spreadability due to increased viscosity. Cera alba provided structural rigidity, while vaseline and castor oil contributed emollient properties and aided spreading. Overall, the spreadability values indicate acceptable performance for semi-solid lip cosmetic applications. Blank formulation showed pH 6.02 ± 0.02, while F1, F2, and F3 showed 5.98 ± 0.01, 5.83 ± 0.01, and 5.78 ± 0.01, respectively. The gradual decrease reflects the acidic nature of phenolic compounds in the extract. All values remained within the physiological lip pH range, ensuring safety and compatibility. Slight acidity may further enhance phenolic stability during storage (8, 23).

The increase in IC_{50} from 15.25 ± 0.03 µg/mL for the sappan wood bark extract to approximately 26.56–26.73 µg/mL after incorporation into the lip scrub indicates a reduction in apparent radical-scavenging potency after formulation. However, this difference should not be interpreted solely as chemical degradation of the active compounds. The IC_{50} of the crude extract represents the activity of the concentrated botanical material, whereas the IC_{50} of the lip scrub represents the activity of a complete formulation in which the extract constitutes only a fraction of the sample mass. Thus, dilution of the extract by the formulation base may partly account for the higher IC_{50} values observed in the formulated preparations. Thermal exposure during formulation may also have contributed to the observed decrease in antioxidant activity. The lipid base was prepared using elevated temperatures to melt beeswax and petroleum jelly, and phenolic pigments of *C. sappan*, particularly brazilin/brazilein-related compounds, may undergo structural alteration or oxidation under certain heating and pH conditions. Previous studies have demonstrated that brazilein degradation increases with heating temperature and is strongly influenced by pH, with greater thermal degradation occurring under neutral-to-alkaline conditions than under acidic conditions. Therefore, thermal oxidation represents a plausible contributor to the reduced antioxidant activity observed after formulation; however, this mechanism cannot be confirmed in the present study because individual phenolic compounds were not quantified before and after the formulation process (7).

Total flavonoid content increased with increasing sappan wood bark extract concentration, with Formula III showing the highest value. Although Formula III also exhibited the numerically lowest IC_{50} value, antioxidant activity did not differ significantly among F1, F2, and F3 ($p > 0.05$). Therefore, the present data do not establish a statistically significant correlation between total flavonoid content and IC_{50}. The findings instead suggest that increasing the amount of extract increased the measurable flavonoid content, whereas the radical-scavenging response was less sensitive to these relatively small compositional differences. This may reflect the combined effects of formulation dilution, antioxidant partitioning within the lipid matrix, extraction efficiency during sample preparation, and contributions from non-flavonoid antioxidant constituents. A notable finding was that incorporation into the lip scrub formulation did not markedly reduce the measured antioxidant activity. The extract exhibited an IC_{50} value of 15.25 ± 0.03 µg/mL, whereas the formulated preparations showed IC_{50} values of 26.73 ± 0.07, 26.65 ± 0.08, and 26.56 ± 0.01 µg/mL for F1, F2, and F3, respectively. These results indicate retention of antioxidant activity after formulation; however, they should not be interpreted as evidence of chemical or physicochemical stability because formal stability testing was not performed. Many natural extracts suffer activity loss after formulation; however, secang extract demonstrated notable stability within the lip scrub system (10, 23). The present study has several limitations, including evaluation restricted to physicochemical properties and antioxidant activity without long-term stability studies or biological efficacy assessment. Future studies are recommended to investigate stability profiles and biological performance to further support cosmetic application of sappan wood bark extract formulations.

Conclusion

This study demonstrated that sappan wood bark extract (*C. sappan* L.) fulfilled quality parameters for crude drug material and thick extract evaluation and exhibited antioxidant activity together with measurable flavonoid content. After incorporation into lip scrub formulations. antioxidant activity was maintained alongside acceptable physicochemical characteristics. including homogeneity. spreadability. and pH suitable for lip application. Formula III demonstrated the lowest IC_{50} value and the highest flavonoid content among tested formulations. These findings support the potential application of sappan wood bark extract as a natural antioxidant ingredient in lip care cosmetic products. Further studies involving biological evaluation are recommended to further support cosmetic application.

Declaration

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During the preparation of this manuscript, the authors used ChatGPT (OpenAI) to assist with English language editing, improving readability, and formatting of the manuscript and references. No AI tool was used to generate, analyze, or interpret the research data. The authors reviewed and edited all AI-assisted content and take full responsibility for the content of this publication.

Conflict of Interest

The authors declare no conflicting interest.

Data Availability

The datasets generated and/or analyzed during the current study are available from the corresponding author on reasonable request.

Ethics Statement

Ethical approval was not required for this study.

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References

1. Park JI, Kim SJ, Kim YJ, Lee SJ. Protective role of *Caesalpinia sappan* extract and its main component brazilin against blue light–induced damage in human fibroblasts. J Cosmet Dermatol. 2022;21(12):7025–34. doi: 10.1111/jocd.15354

2. Maharani ZF, Akbar ND, Priamsari MR. Optimasi formulasi nanopartikel gel ekstrak etanol kayu secang (*Caesalpinia sappan* L.) sebagai antibakteri terhadap *Propionibacterium acnes*. Pharmademica. 2025;5(1):16–25. doi: 10.54445/pharmademica.v5i1.80

3. Maharani ZF, Akbar ND, Priamsari MR. Optimasi formulasi nanopartikel gel ekstrak etanol kayu secang (*Caesalpinia sappan* L.) sebagai antibakteri terhadap *P. acnes*. Pharmademica. 2025;5(1):16–25. doi:

10.54445/pharmademica.v5i1.80

4. Frontiers Editorial Office. Expression of Concern: Brazilin from *Caesalpinia sappan* L. induced apoptosis via mTOR and HO-1 pathway in SW480 human colon cancer cells. Front Energy Res. 2025;13:1701198. doi: 10.3389/fenrg.2025.1701198

5. Salsabilla SFN, Safitri CINH. Combination of Secang (*Caesalpinia sappan* L.) and Glibenclamide in Mice (*Mus musculus*) Hyperglycemia. medfarm. 2025;14(1):58–64. doi: 10.48191/medfarm.v14i1.562

6. Fitriani DS, Soimah S, Kurniasari L. Pembuatan pengawet alami ikan baronang (*Siganus vermiculatus*) dari kayu secang (*Caesalpinia sappan* L.) menggunakan ekstraksi berbantu gelombang ultrasonik. J Tek Kim. 2025;14(1):44–52. doi: 10.32734/jtk.v14i1.15229

7. Christian YE, Rachmawati P, Susanto S, Setiawansyah A. The potential of cantigi leaves extract (*Vaccinium varingiaefolium* Miq.) as a skin-lightening agent through tyrosinase enzyme inhibition. Ad-Dawaa J Pharm Sci. 2025;8(2):271–82. doi: 10.24252/djps.v8i2.61520

8. Christian YE, Hermawati E, Qodriah R, Efrilia M, Falestin SLK, Chandra PPB, et al. Quality evaluation and phytochemical screening of *Kaempferia galanga* and *Zingiber zerumbet* rhizome extracts. medfarm. 2025;14(2):306–24. doi: 10.48191/medfarm.v14i2.651

9. Hananta L, Christian YE, Gokok S. Antibacterial potential of *Avicennia marina* leaf extracts: recent evidence and research gaps. J Trop Pharm Chem. 2025;9(3):294–8. doi: 10.30872/jtpc.v9i3.319

10. Ngamwonglumlert L, Devahastin S, Chiewchan N, Raghavan GSV. Color and molecular structure alterations of brazilein extracted from *Caesalpinia sappan* L. under different pH and heating conditions. Sci Rep. 2020;10:12386. doi: 10.1038/s41598-020-69189-3

11. Chandra PPB, Hermawati E, Christian YE. Standarisasi simplisia dan penetapan kadar flavonoid pada ekstrak etanol 96% buah okra hijau dan merah (*Abelmoschus esculentus* (L.) Moench). J Ilm As-Syifaa. 2023;8(2):138–46. doi: 10.47219/ath.v8i2.265

12. Yuslianti ER, Susanto A, Sutjiatmo AB, Widowati W, Ayuni V, Hadiprasetyo DS, et al. Antimicrobial and antioxidant activities of *Caesalpinia sappan* L. (Sappan Wood) extract: a preliminary study toward toothpaste application. Hacettepe Univ J Fac Pharm. 2025;45(4):316–28. doi: 10.52794/hujpharm.1639004

13. Jeong M, Chun J, Park SM, Yeo H, Na SW, Ha UJ, et al. An investigation of the anticancer mechanism of *Caesalpinia sappan* L. extract against colorectal cancer by integrating a network pharmacological analysis and experimental validation. Plants. 2025;14(2):263. doi: 10.3390/plants14020263

14. He Y, Huang C, Chen J, Shen W. *Caesalpinia sappan* L. ethyl acetate extract regulated angiogenesis in atherosclerosis by modulating the miR-126/VEGF signalling pathway. Heliyon. 2025;11(3):e42159. doi: 10.1016/j.heliyon.2025.e42159

15. Kurniasari L, Kumoro AC, Lee MH, Djaeni M. Microencapsulation of Sappan Wood (*Caesalpinia sappan* L.) extract using spray drying and different wall materials. J Korean Wood Sci Technol. 2025;53(1):49–65. doi: 10.5658/wood.2025.53.1.49

16. Artati A, Pratama R, Nurisyah N, Asyikin A, Abdullah T, Daswi DR, et al. Phytochemical testing, antioxidant activity and determination of specific and non-specific parameters of secang wood extract (*Caesalpinia sappan* L.). JPPIPA. 2025;11(2):918–29. doi: 10.29303/jppipa.v11i2.10563

17. Djaeni M, Budi Sasongko S, Yuni Susanti D, Mahatmanti FW, Cahyo Kumoro A, Kurniasari L. Optimization of ultrasound assisted extraction of sappan (*Caesalpinia sappan* L.) wood for preparation of high quality extract. Case Stud Therm Eng. 2025;10(1):226–33. doi: 10.21924/cst.10.1.2025.1710

18. Amin M, Sedyohutomo A, Amin N, Ibrahim AR, Mauraji I. Ion chromatographic analysis of major electrolyte cations in sappan wood extract (*Caesalpinia sappan* L.). Sci Technol Indones. 2025;10(1):212–20. doi: 10.26554/sti.2025.10.1.212-220

19. Hariyanto G, Aminah N, Kristanti A, Abdjan M, Takaya Y. New potential for colorimetric/visual detection of Pb, Fe, and Cu metals using *Caesalpinia sappan* L. extract and stability analysis using DFT calculations. Russ J Chem. 2025;18(4):2556–63. doi: 10.31788/rjc.2025.1849398

20. Rosniawaty S, Ariyanti M, Mubarok S, Sudirja R, Rachman AL, Septiani D, et al. Impact of elicitor applications and planting distances on growth and phytochemical properties of sappanwood (*Caesalpinia sappan* L.). Res Crops. 2025;26(1):132–7. doi: 10.31830/2348-7542.2025.roc-1152

21. Pengsawang M, Toviwek B, Sangthong W, Boonmee A, Chairatana P, Pongprayoon P. The binding modes of brazilin and hematein from *Caesalpinia sappan* L. to *Cutibacterium acnes* lipase: simulation studies. PLoS ONE. 2025;20(3):e0318706. doi: 10.1371/journal.pone.0318706

22. Safitri R, Krisnamurti ZM, Kuntana YP, Syamsunarno MRAA, Kusmiati R. Chronic toxicity test of secang wood (*Caesalpinia sappan* L.) extract on heart structure and lipid profile of male and female rats (*Rattus norvegicus*). Adv Anim Vet Sci. 2025;13(11):2365–76. doi: 10.17582/journal.aavs/2025/13.11.2365.2376

23. Hayon KE, Akhmad, Serena NA, Turista DDR. In silico analysis of secang wood compounds (*Caesalpinia sappan* L.) as antibacterial candidates against *Salmonella typhi* causing typhoid fever. Alkimia. 2025;9(2):53–62. doi: 10.19109/5yhdeq91

24. Prasdiantika R, Saraswati N, Tolkhah R. Quality test of sappan wood (*Caesalpinia sappan* L.) extract toner. Jurnal Farmasi Sains dan Praktis. 2025;11(2):137–46. doi: 10.31603/pharmacy.v11i2.11813

25. Sazali A, Yusuf AI, Maritsa HU, Nazila, Sormin VG, Pazira RP. Aktivitas antihiperglikemia kombucang (kombucha kayu secang (*Caesalpinia sappan* L.)) terhadap mencit (*Mus musculus* L.) yang diinduksi aloksan. Berita Biologi. 2025;24(1):85–94. doi: 10.55981/berita_biologi.2025.8963

26. Prasetya AANPR, Ratnasari PMD, Ardianti NPL. Aktivitas analgesik ekstrak etanol 70% kayu secang (*Caesalpinia sappan* L.) pada mencit secara in vivo. Jurnal Medika Udayana. 2025;11(1):66–76. doi: 10.35311/jmpi.v11i1.737

27. Widodo TS, Hk LA. Analisis hubungan konsentrasi dan aktivitas antimikroba ekstrak kayu secang (*Caesalpinia sappan* L.) cair serta serbuk. Agritekh. 2025;6(1):13–19. doi: 10.32627/agritekh.v6i1.1471

28. Siskawardani DD. Karakteristik kimia serta organoleptik es krim dengan penambahan puree semangka (*Citrullus lanatus* Schard) dan ekstrak kayu secang (*Caesalpinia sappan* Linn). Foodtech. 2023;14(1):2804. doi: 10.35891/tp.v14i1.2804

29. Hendrawati, Aidina S, Maulidia, Nurhasni, Azizah YN. Formulation and antioxidant activity of lip balm preparate enriched by bidara leaf extract (*Ziziphus spina-christi* L.). EnvironmentAsia. 2022;15(3):95–105. doi: 10.14456/ea.2022.51

30. Maharani ZF, Akbar ND, Priamsari MR. Optimasi formulasi nanopartikel gel ekstrak etanol kayu secang (*Caesalpinia sappan* L.) sebagai antibakteri terhadap *P. acnes*. Pharmademica. 2025;5(1):16–25. doi: 10.54445/pharmademica.v5i1.80

31. Septiyani R, Wikandari R, Santoso U, Raharjo S. Brazilin content, color stability, and antioxidant activity of sappan wood (*Caesalpinia sappan* L.) traditional drink by different blanching and drying methods. Trends Sci. 2024;21(12):8535. doi: 10.48048/tis.2024.8535

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