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Utilization of Calophyllum inophyllum L. (Nyamplung) from Aceh as an Antioxidant Compound in Transparent Solid Soap

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Abstract: Nyamplung (Calophyllum inophyllum L.) is a plant commonly found in coastal areas and lowlands. In Aceh, it is locally known as boeh beunot, a coastal species that grows easily and has various local names in different regions. This plant belongs to the Clusiaceae Lindl. Family and can be propagated both vegetatively (cuttings) and generatively (seeds). Nyamplung begins to bear fruit at the age of 5–20 years and can produce throughout the year, with peak harvest occurring in May–June. Fruit production can reach up to 20 tons/ha/year or approximately 250 kg/tree/year. In this study, nyamplung seeds originating from Aceh Province were utilized as a source of bioactive compounds for the formulation of transparent solid soap with antioxidant properties. The research stages included sample preparation (drying, peeling, and size reduction into powder), followed by extraction using the maceration method. Extraction optimization was carried out using the Response Surface Methodology (RSM) approach with Box-Behnken Design (BBD), involving three main factors (sample amount, extraction time, and solvent volume) at three levels (low, medium, and high). The obtained nyamplung seed extract was characterized through phytochemical analysis, GC-MS testing, and antioxidant activity assays. Optimization results indicated the best conditions were achieved with 200 g of sample, 1,000 mL of solvent, and 36 hours of extraction, yielding antioxidant activity with an IC_{50} value of 18.5 ppm. Phytochemical tests identified the presence of phenolics, flavonoids, terpenoids, steroids, and saponins. The extract with the highest antioxidant activity was subsequently formulated into antioxidant transparent solid soap. Characterization of the transparent soap formulated with nyamplung seed oil showed a pH of 10.53, which remains within the safe range for alkali-based soaps. The measured moisture content was 15.05%, indicating good physical stability and a low risk of microbial growth. Furthermore, skin irritation tests revealed no signs of redness, itching, or allergic reactions, confirming that the soap is safe for human skin.

Keywords: Antioxidant; Extraction; Nyamplung oil; Nyamplung seeds; Solid soap

Introduction

Nyamplung (*Calophyllum inophyllum L.*) is distributed across various coastal areas and lowland regions adjacent to the shoreline. This tree species began to be cultivated in Indonesia around 1950, primarily as a coastal protector against abrasion, a barrier against sea to land winds, tidal wave protection, riverbank and coastal slope reinforcement, and a safeguard for brackish water quality. Currently, its habitat extends

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from coastal forests, riverbanks, swamps, to mountainous forests. Globally, nyamplung has a wide distribution, including Madagascar, East Africa, South and Southeast Asia, the Pacific Islands, the West Indies, and South America. In Indonesia, it is found across Sumatra, West Java, Central Java, East Java, Bali, Alor, Sulawesi, Kalimantan, Timor, and Ternate. However, it has not yet been extensively cultivated and remains primarily grown as a forest tree under stands and along coastal areas (Handayani et al., 2020; Raharivelomanana et al., 2018).

The vegetable oil derived from nyamplung seeds contains major fatty acids, namely: oleic acid (30–50%), linoleic acid (25–40%), palmitic acid (15–17%), stearic acid (8–16%), palmitoleic acid (0.5–1%), arachidonic acid (0.5–1%), and gadoleic acid (0.5–1%) (Thy et al., 2020). This oil is characterized by its brownish-green color, thick consistency, a strong caramel-like odor, and a very high content of unsaturated fatty acids (Hasibuan & Sahirman, 2013).

Almost all parts of Calophyllum inophyllum L. are widely used in traditional medicine, particularly the oil extracted from its seeds, which has been applied to treat various skin ailments. This is also supported by Saechan et al. (2021), who reported that nyamplung seed oil has strong potential for cosmetic applications due to its excellent characteristics as a promising antioxidant agent for skin health.

Specifically, nyamplung seed oil from the coastal areas of Aceh has been utilized as a base material for polyurethane membrane production. The oil yield from Aceh nyamplung seeds ranges between 55.5%–66.6%, with an iodine value of 83.53 mg I_2/g and a hydroxyl value of 64.29 mg KOH/g. The major fatty acid components of the oil include palmitic acid (17.94%), linoleic acid (23.12%), oleic acid (42.54%), and stearic acid (15.33%) (Marlina et al., 2017). Furthermore, several studies on nyamplung oil have been conducted, such as its formulation in sunscreen gel (Fadhlullah et al., 2015) and its antioxidant role in cosmetic products containing Calophyllum inophyllum oil (Saechan et al., 2021; Itoigawa et al., 2001).

Previous studies have consistently demonstrated that nyamplung seeds possess potential as a natural antioxidant source that can be further developed as raw material for pharmaceuticals and cosmetics (Fitriyana et al., 2023; Brand-Wiliams et al., 1995), including formulations in antioxidant lotion production (Fitriyana & Aisyah, 2024).

Method

Nyamplung seeds (*Calophyllum inophyllum L.*) were collected from Leungah Village, Seulimum Subdistrict, Aceh Besar District. The initial stage involved determination testing of the nyamplung plant from which the fruits were harvested, in order to identify the species along with its complete taxonomic classification before proceeding to further processes. The maceration method was employed to extract the seeds, which were then used as a formulation for antioxidant solid soap production. *n*-Hexane was used as the solvent, with optimization carried out through the Response Surface Methodology (RSM) approach. Flowchart of methodology is presented in figure 1.

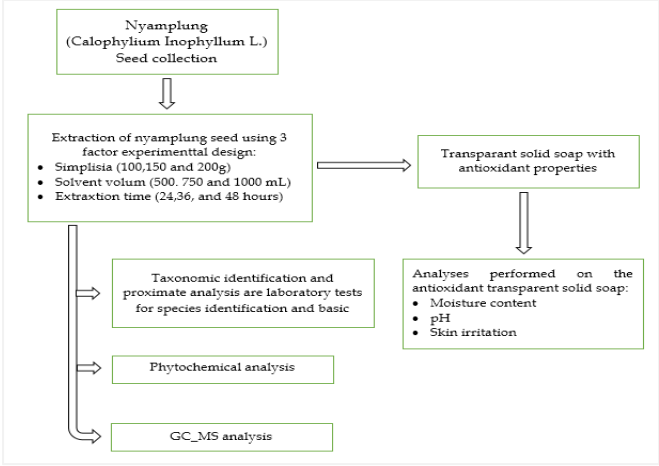


Figure 1. Flowchart of methodology

Three experimental factors were examined: raw material amount (100 g, 150 g, and 200 g), solvent volume (500 mL, 750 mL, and 1,000 mL), and extraction time (24 h, 36 h, and 48 h). The Response Surface Methodology (RSM) design is presented in Table 1.

Table 1. Combination Design and Antioxidant Activity from the Maceration Process Using Response Surface Methodology (RSM) with Box-Behnken Design

Run	Factor 1 A:Simplicia (g)	Factor 2 B:Solvent (mL) n-Heksan	Factor 3 C:Extraction Time
1	100	500	36
2	150	750	36
3	100	1000	36
4	150	750	36
5	100	750	24
6	150	1000	24
7	150	750	36
8	200	1000	36
9	200	750	48
10	150	500	48
11	100	750	48
12	150	750	36
13	150	750	36
14	150	500	24
15	200	500	36
16	150	1000	48
17	200	750	24

Result and Discussion

This study focused on the characterization of nyamplung seeds (Calophyllum inophyllum L.) originating from Leungah Village, Seulimum Subdistrict, Aceh Besar District, Aceh Province, with the objective of exploring their potential as a source of vegetable oil suitable for transparent antioxidant solid soap formulation. The sampling location is shown in Figure 2, which illustrates the geographic conditions of the area. The quality of nyamplung oil is influenced by several factors, including the growth environment (soil type, water availability, and sunlight intensity), fruit maturity at harvest, seed processing methods (drying and storage), as well as the extraction method employed.

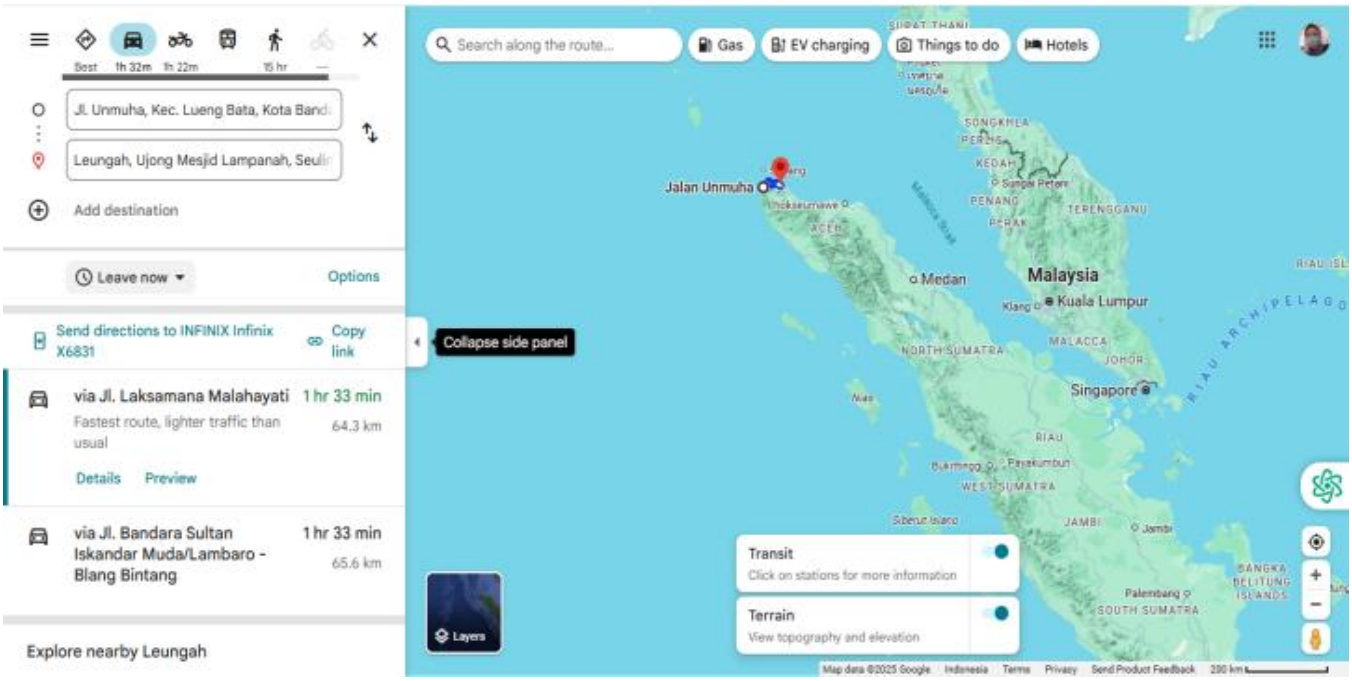


Figure 2. *Nyamplung* seed sampling location. *Nyamplung* seed sampling location in Desa lengah, Seulimum, Aceh Besar

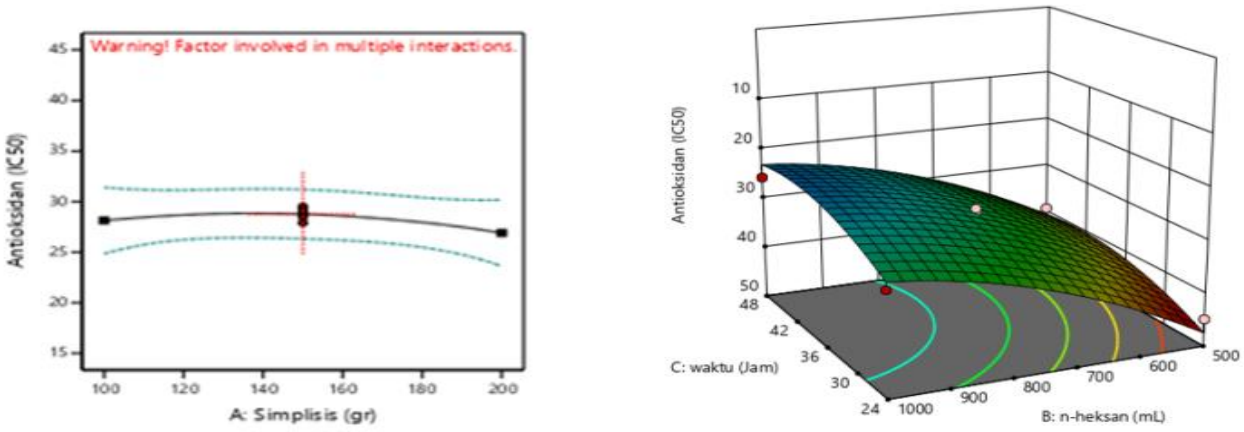
Preliminary Data Analysis

The determination test of the nyamplung plant from Leungah Village, Seulimum Subdistrict, Aceh Besar District, Aceh Province, identified the plant's taxonomy as follows: Kingdom Plantae, Subkingdom Tracheobionta, Superdivision Spermatophyta, Division Magnoliophyta, Subclass Dilleniidae, Order Theales, Family Clusiaceae Lindl., Genus Calophyllum, Species Calophyllum inophyllum L.

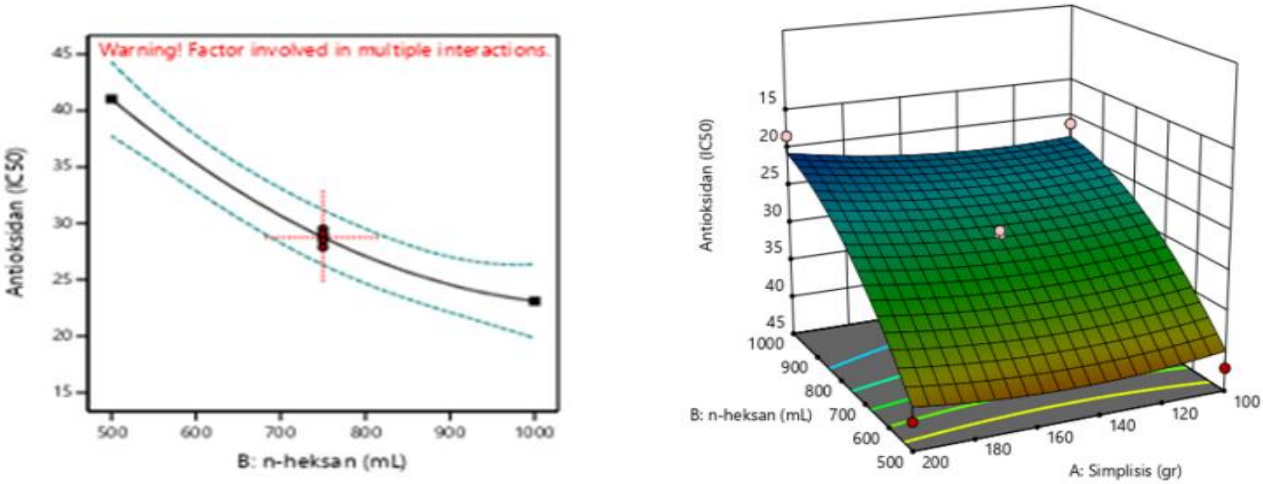
Nyamplung seeds possess various biological activities that support their utilization as raw materials for cosmetics and pharmaceuticals (Pribowo et al., 2021). Seeds growing in coastal areas of Aceh demonstrate excellent characteristics in terms of morphology, oil content, and bioactive composition. Morphologically, nyamplung seeds are round to oval with a diameter of 2–4 cm, a hard dark brown shell when mature, and a kernel with a yellowish-white oily texture (Taebenu et al., 2023; Arlia et al., 2025; Anindya et al., 2023). Oil yield from Aceh nyamplung seeds is relatively high, ranging from 40–74% of kernel dry weight, indicating significant potential as raw material for bioenergy and cosmetics (Fitriyana et al., 2023).

Table 2. Combination Design and Antioxidant Activity from the Maceration Process Using Response Surface Methodology with Box-Behnken Design

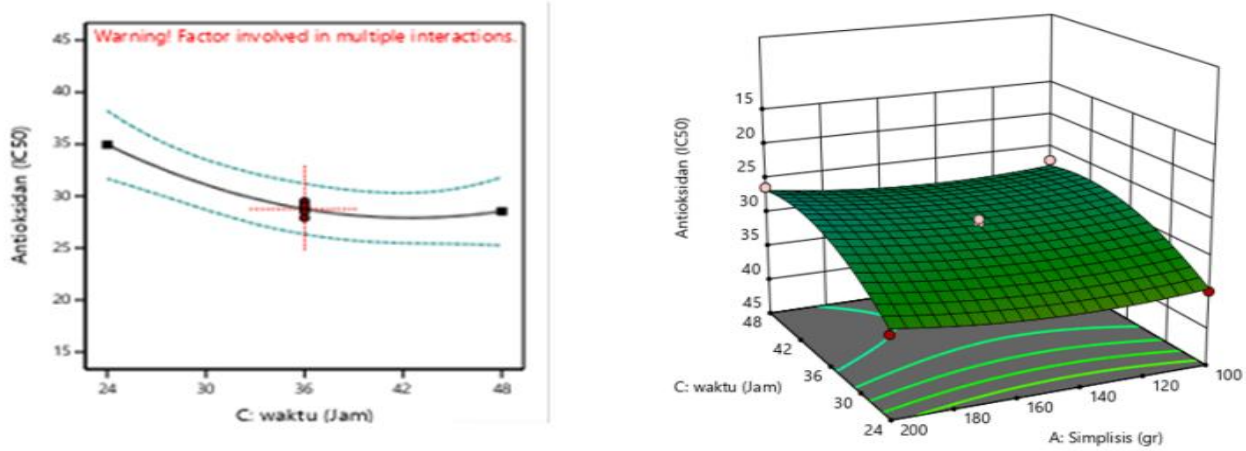
Run	Factor 1 A:Simplicia	Factor 2 B:Solvent n-Heksan	Factor 3 C:Time	Response 1 Antioxidant (IC_{50})
1	100	500	36	42.1
2	150	750	36	29.5
3	100	1000	36	21.2
4	150	750	36	28.8
5	100	750	24	34.7
6	150	1000	24	30.5
7	150	750	36	27.9
8	200	1000	36	18.5
9	200	750	48	26.3
10	150	500	48	39.2
11	100	750	48	27.1
12	150	750	36	29.1
13	150	750	36	28.5
14	150	500	24	44.8
15	200	500	36	41.5
16	150	1000	48	25.7
17	200	750	24	33.9



Interaction between the amount of simplicia (A) and the solvent concentration (B)



Interaction between the amount of simplicia (A) and the extraction time (C)



Interaction between the solvent concentration (B) and the extraction time (C)

Figure 3. (a), (b), (c), 3D response surface plot of solvent concentration and extraction time on antioxidant activity

The chemical composition of Aceh nyamplung oil is dominated by unsaturated fatty acids, namely oleic acid (±30–50%) and linoleic acid (±15–25%), along with saturated fatty acids such as palmitic acid (±10–20%) and stearic acid (±10–15%). Additionally, the oil is rich in bioactive compounds including flavonoids, phenolics, coumarins (notably calophyllolide), vitamin E (tocopherols), and β-carotene, which contribute to antioxidant, antimicrobial, and wound-healing activities (Marlina et al., 2017; Farida et al., 2016). Physically,

nyamplung oil from Aceh appears yellowish-green to brown, with a distinct pungent aroma and a thick viscosity similar to castor oil. Its relatively high acid value requires purification for food applications, though this is not a limitation for cosmetic and pharmaceutical uses (Fitriyana & Aisyah, 2024; Islam et al., 2019; Santi et al., 2024). These characteristics position Aceh nyamplung seeds as a high-value local resource for health, beauty, and renewable energy products.

The analysis results revealed that the primary factors affecting the antioxidant activity of nyamplung seed oil were the type/concentration of n-hexane solvent (B) and extraction time (C). The combination design and antioxidant activity of the maceration process using Response Surface Methodology (RSM) with Box-Behnken Design can be seen in Table 2.

Solvent type and extraction duration significantly influenced the levels of bioactive compounds, especially phenolics and flavonoids, which act as antioxidants (Putri et al., 2024; Siyvaruli et al., 2021). Meanwhile, the amount of simplicia (A) did not directly influence the results, but instead showed a quadratic effect—meaning that too little or excessive material could reduce extraction efficiency (Singam et al., 2022; Fajriansyah & Sartika et al., 2022).

As shown in the 3D response surface plot (Figure 2), the combination of higher n-hexane concentration and longer extraction time yielded optimal antioxidant activity. Interactions between factors (AB, AC, BC) were not significant, indicating that each factor operated mostly independently. This finding is consistent with Fitriyana et al. (2024), who reported that solvent and extraction duration were more dominant than inter-factor interactions.

Phytochemical Content

Characterization of nyamplung seed oil began with phytochemical screening, as presented in Table 3. Phytochemical analysis is essential to detect the active compounds contained in natural materials. Based on the tests conducted using the maceration extraction method with n-hexane solvent, the extract was found to contain secondary metabolite groups such as phenolics, flavonoids, terpenoids, steroids, and saponins. The use of n-hexane as the extraction solvent proved highly effective because of its non-polar nature, which matches the characteristics of major lipid compounds such as triglycerides, tocopherols, sterols, and lipophilic pigments. This polarity compatibility enables n-hexane to selectively dissolve neutral lipid fractions, resulting in a higher oil yield compared to polar solvents (Saini et al., 2021; Raharivelomanana et al., 2018). In addition, n-hexane has low viscosity and a relatively low boiling point (~69 °C), which facilitates penetration into the cell matrix, accelerates diffusion of oil compounds, and simplifies solvent recovery through evaporation (Emilda, 2019). These characteristics make n-hexane the primary solvent in large-scale vegetable oil industries due to its high extraction efficiency and relatively low operational costs (Aparamarta et al., 2022).

Table 3. Phytochemical Screening of Nyamplung Seed Extract

Metabolite compounds	Maceration
Fenolik	+
Tannin	-
Flavonoid	+
Terpenoid	+
Steroid	+
Saponin	+
Alkaloid	
Dragendorff	-
Mayer	-
Wagner	-

Although effective, n-hexane is known to be toxic due to its metabolite 2.5-hexanedione. Therefore, controlling solvent residues through distillation and ensuring product safety verification is necessary, especially when applied in food or cosmetic products (Broto et al., 2021; Ong et al., 2019). Despite this, n-hexane remains considered the standard solvent widely used for oil extraction (Susanty & Bachmid, 2016). The screening also revealed the absence of alkaloids, a result consistent with previous studies that reported similar findings (Fitriyana, Supardan, et al., 2023).

GC-MS (Gas Chromatography–Mass Spectrometry) Analysis

The GC-MS analysis of Calophyllum inophyllum (nyamplung) seed oil revealed the presence of numerous bioactive compounds, with each extract containing approximately 30–40 different compounds (Cassien et al., 2021). The major identified compounds included palmitic acid (hexadecanoic acid, methyl ester), oleic acid (9-octadecenoic acid, methyl ester), stearic acid (octadecanoic acid, methyl ester), arachidonic acid (eicosanoic acid, methyl ester), and hexanoic acid (docosanoic acid, methyl ester). The number and types of compounds obtained strongly depended on the solvent and extraction method used. Generally, solvents with different polarities extract distinct compound groups. Non-polar solvents such as n-hexane are more selective for lipophilic compounds, including fatty acids, tocopherols, triterpenoids, and steroids, which play key roles in antioxidant and antimicrobial activities (Gupta & Gupta, 2020). These compounds are recognized as antioxidants, antimicrobials, and natural emollients, supporting the use of nyamplung oil in cosmetics and pharmaceuticals (Gonfa et al., 2023; Supriadi et al., 2022).

Additionally, nyamplung oil contains polyunsaturated fatty acids (PUFAs) such as

docosapentaenoic acid (DPA) and docosahexaenoic acid (DHA) esters, which enhance antioxidant activity and provide protective effects against cellular damage caused by free radicals (Purwaningsih, 2024; Fatima & Shahid, 2018; Bergonio & Perez, 2016). These PUFAs are also known for their anti-inflammatory and anti-aging properties, making them highly suitable for transparent soap and skincare applications.

The GC-MS analysis further identified phytosterols such as campesterol and sterol/alcohol derivatives such as ethyl iso-allocholate. Phytosterols are known to enhance cell membrane stability, act as antioxidants, and improve the skin barrier function (Saini et al., 2021). This strengthens the added value of nyamplung seed oil as a raw material in personal care products.

Other detected compounds included adlupulone, which exhibits antimicrobial activity, and chalcone-derived flavonoids such as 2′-(trimethylsilyloxy)-3.4′.5-tetramethoxy chalcone, recognized for their high antioxidant activity (Chandimali et al., 2025). The presence of these compounds supports the claim that nyamplung seed oil is not only a source of fatty acids but also a reservoir of bioactive compounds with pharmacological potential.

In conclusion, GC-MS analysis confirmed that Calophyllum inophyllum seed oil contains various active compounds, particularly fatty acid esters, PUFAs, sterols, and chalcone-derived flavonoids, which synergistically contribute to its antioxidant, antimicrobial, moisturizing, and skin-healing properties. Therefore, nyamplung seed oil holds great potential as a base ingredient for transparent solid soap that functions not only as a cleanser but also as a skin health enhancer.

Process of Making Antioxidant Transparent Solid Soap

Raw materials, additives, and equipment were prepared before proceeding with the soap-making process. Nyamplung oil (60 mL) was heated in a water bath placed in a beaker glass. Stearic acid (21 g) was then added and stirred until homogeneous, followed by the addition of 30% NaOH solution (60.9 mL), stirred for 2–4 minutes until soap was formed. Stirring was continued until the mixture was homogeneous. Next, other ingredients were added: ethanol 96% (45 mL), glycerin (3.9 mL), a sucrose + aquadest solution (45 mL), Cocamide DEA (9 g), and NaCl (0.6 g), and stirred until fully mixed. For natural colorant extracts, the soap mixture was cooled to approximately 50 °C before incorporation. The mixture was stirred again until the extract was evenly dispersed, then poured into prepared molds. The soap was left to cure for two weeks to eliminate residual NaOH before being tested for parameters such as moisture content, pH, and antioxidant activity.

Quality of Antioxidant Transparent Solid Soap from Nyamplung Oil

The quality test results of transparent solid soap made from Calophyllum inophyllum seed oil showed a pH of 10.53 and a moisture content of 15.05%. The typical pH of solid soap ranges between 9–11 (Supriadi et al., 2022), thus a pH of 10.53 is still acceptable for solid bathing soap. While such alkalinity is effective for removing dirt and oil from the skin surface, it may cause dryness. However, the presence of bioactive compounds in nyamplung oil—such as oleic acid, palmitic acid, and phytosterols—functions as natural emollients, helping to maintain skin moisture despite the soap's alkaline nature.

The measured moisture content was 15.05%, slightly above the maximum limit of 15% set by the Indonesian National Standard (SNI 06-3532-1994) (BSN, 1994). High moisture content can cause soap to dissolve faster during use and affect shelf life (Cepeda et al., 2019; Dewi et al., 2024). Nevertheless, the value of 15.05% is still very close to the standard threshold, meaning the soap remains compliant and suitable for use. In addition to pH and moisture content analysis, a skin irritation test was conducted to ensure the safety of the antioxidant transparent solid soap made from nyamplung seed oil. The results of the irritation test are presented in Table 4.

Table 4. Skin Irritation Test Results

Subject	Observation Time	Erythema (0–4)	Edema (0–4)	Total score
S1	1 selai	0	0	0
S1	24 selai	0	0	0
S1	48 selai	0	0	0
S2	1 selai	0	0	0
S2	24 selai	1	0	1
S2	48 selai	0	0	0
S3	1 selai	0	0	0
S3	24 selai	0	0	0
S3	48 selai	0	0	0

Based on Table 4, no erythema or edema was observed in all test subjects (score ≤1), indicating that the transparent solid soap is safe and does not cause skin irritation.

Overall, transparent solid soap made with nyamplung oil—pH 10.53 and moisture content 15.05%—meets the quality requirements of SNI solid bathing soap. Its advantages lie in the bioactive compounds of nyamplung oil, which provide antioxidant, antimicrobial, and emollient activities. Observations also revealed that all test subjects scored ≤1 across all observation periods, indicating that the antioxidant transparent solid soap did not cause skin irritation. No redness, swelling, or itching was observed, confirming that the soap functions not only as a cleanser

but also as a skincare product with added health benefits (Chandimali et al., 2025).

Conclusion

Based on the findings, the extraction process of nyamplung seed oil (Calophyllum inophyllum L.) using the Response Surface Methodology (RSM) produced the highest yield under the conditions of 200 g sample weight, 1,000 mL of n-hexane solvent, and 36 hours of extraction. This indicates that extraction duration significantly affects the optimization of bioactive compound dissolution. Phytochemical analysis identified the presence of secondary metabolites, including flavonoids, phenolics, and saponins, which play an important role as natural antioxidants. The formulated transparent solid soap demonstrated physical, chemical, and organoleptic properties that comply with soap quality standards, including transparency, pH, hardness, moisture content, as well as acceptable aroma, color, and texture. The presence of bioactive compounds from nyamplung seed oil was proven to provide significant antioxidant activity, thereby enhancing the functional value of the product. Therefore, nyamplung seed oil holds great potential as a natural antioxidant source in transparent solid soap formulations. Optimization of extraction and formulation processes through RSM creates opportunities to develop soap products that are stable, effective, environmentally friendly, and possess added value in the advancement of natural cosmetics.

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Conceptualization, methodology, formal analysis, investigation, resources, data curation, and original draftwriting: L.F.; validation, review and editing, and visualization: R.S. All authors have read and approved the published version of the manuscript.

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Conflicts of Interest
All author declares that there is no conflict of interest.

References

Aparamarta, H. W., Gunawan, S., Ihsanpuro, S. I., Safawi, I., Bhuana, D. S., Mochtar, A. F., & Yusril Izhar Noer, M. (2022). Optimization and kinetic study of biodiesel production from nyamplung oil with microwave-assisted extraction (MAE) technique. *Heliyon*, *8*(8), e10254. https://doi.org/10.1016/j.heliyon.2022.e10254

Arlia, E., Gunawan, E. R., Murniati, M., Handayani, S. S., & Suhendra, D. (2025). Optimasi Sintesis Biodiesel dari Minyak Biji Nyamplung (Calophyllum inophyllum) Melalui Reaksi Transesterifikasi Menggunakan Katalis TiO2. *Jurnal Sains Teknologi & Lingkungan*, *11*(1), 80–90. https://doi.org/10.29303/jstl.v11i1.759

Anindya, L. F., Fitriyani, N. L., Maulana, J., & Akbar, H. (2023). Efectivenness of Bioinsecticide Spray Against Aegypti Mosquitoes: Literature Review. *Promotif Jurnal Kesehatan Masyarakat, 13*(2), 66-73. https://doi.org/10.56338/promotif.v13i2.4543

Bergonio, K., & Perez, M. A. The Potential of Male Papaya (Carica Papaya L.) Flower as a Functional Ingredient for Herbal Tea Production. *Indian Journal of Traditional* Knowledge, *15*(1), 41-49. Retrieved from https://www.researchgate.net/publication/290201149_The_potential_of_male_papaya_Carica_papaya_L_flower_as_a_functional_ingredient_for_herbal_tea_production

Broto, W., Fatimah, S., Arifan, F., & Kiki Damayanti, E. (2021). Pemanfaatan Ekstrak Batang Serai dan Limbah Kulit Jeruk Sebagai Obat Spray Anti Nyamuk. *Pentana*, *2*(1), 6–11. Retrieved from https://ejournal2.undip.ac.id/index.php/pentana/article/view/15074

Brand-Wiliams, W., Cuvelier, M. E., & Berset, C. L. W. T. (1995). Use of Free Radical Metod to Evaluate Antioxidant Activity. *LWT-Food Science and Technology, 28*(1), 25-30. http://dx.doi.org/10.1016/S0023-6438(95)80008-5

Cassien, M., Mercier, A., Th, S., Culcasi, M., Ricquebourg, E., Asteian, A., Herbette, G., Bianchini, J., Raharivelomanana, P., & Pietri, S. (2021). Improving the Antioxidant Properties of Calophyllum inophyllum Seed Oil from French Polynesia : Development and Biological Applications of Resinous Ethanol-Soluble Extracts. *Antioxidants*, *10*(2), 199. https://doi.org/10.3390/antiox10020199

Cepeda, G. N., Lisangan, M. M., Roreng, M. K., Permatasari, E. I., Manalu, D. C., & Tanlain, W. (2019). Aktivitas Penangkapan Radikal Bebas dan Kemampuan Reduksi Ekstrak Kulit Kayu Akway (Drimys piperita Hook. f.). *Jurnal Aplikasi Teknologi Pangan*, 7(4). https://doi.org/10.17728/jatp.3239

Chandimali, N., Bak, S. G., Park, E. H., Lim, H. J., Won, Y. S., Kim, E. K., Park, S. I., & Lee, S. J. (2025). Free radicals and their impact on health and antioxidant defenses: a review. *Cell Death Discovery*, *11*(1). https://doi.org/10.1038/s41420-024-02278-8

Dewi, A. M. P., Santoso, U., Pranoto, Y., & Marseno, D. W. (2024). Phytochemical and Antioxidant Activity of Akway (Drymis Piperita Hook F.) Stem Bark Ethanol Extract. *Advance Sustainable Science, Enginering and Technology*, *6*(3), https://doi.org/10.26877/asset.v6i3.598

Emilda, E. (2019). Tumbuhan Nyamplung (Calophyllum inophyllum Linn) dan Bioaktivitas Nya. *Simbiosa*, *8*(2), 136. https://doi.org/10.33373/sim-bio.v8i2.2000

Fadhlullah, M., Widiyanto, S. N. B., & Restiawaty, E. (2015). The Potential of Nyamplung (Calophyllum inophyllum L.) Seed Oil as Biodiesel Feedstock: Effect of Seed Moisture Content and Particle Size on Oil Yield. *Energy Procedia*, *68*, 177–185. https://doi.org/10.1016/j.egypro.2015.03.246

Fajriansyah, F., & Sartika, I. (2022). Pengaruh Ekstrak Daun Pepaya (*Carica Papaya Linn*) Terhadap Larvasida Aedes Aegypti. *Jurnal SAGO Gizi dan Kesehatan*, *3*(2), 157. https://doi.org/10.30867/gikes.v3i2.926

Farida, M., Mustanir, M., & Marlina, M. (2016). Preliminary Studies of Systhesis Polyurethane Membrane of Nyamplung Seed Oil (*Calophyllum Inophyllum*) With Hexamethilene-16-Diisocyanate (Hmdi). *Jurnal Natural Unsyiah*, *16*(2), 20-22. https://doi.org/10.24815/jn.v16i2.4920

Fatima, U. & Shahid, S. (2018). Pharmacological Activities of Carica Papaya Linn. *Journal of Basic & Applied Sciences*, *14*(1), 210-216. https://doi.org/10.6000/1927-5129.2018.14.33

Fitriyana, L., & Aisyah, Y. (2024). Global Journal of Environmental Science and Management Optimised extraction of antioxidant components from Calophyllum inophyllum L. seeds using response surface methodology. *Global J. Environ. Sci. Manage*, *10*(3), 39. https://doi.org/10.22035/gjesm.2024.03.

Fitriyana, L., Supardan, M. D., Aisyah, Y., & Irfan. (2023). Analysis of Nyamplung (Callophylum inophyllum) Seed Extract as Antioxidants Through Various Methods. *Rasayan Journal of Chemistry*, *16*(4), 2119–2125. https://doi.org/10.31788/RJC.2023.1648364

Gonfa, Y. H., Tessema, F. B., Bachheti, A., Rai, N., Tadesse, M. G., Nasser Singab, A., Chaubey, K. K., & Bachheti, R. K. (2023). Anti-inflammatory activity of phytochemicals from medicinal plants and their nanoparticles: A review. *Current Research in Biotechnology*, *6*, 100152. https://doi.org/10.1016/j.crbiot.2023.100152

Gupta, S., & Gupta, P. (2020). The Genus Calophyllum: Review of Ethnomedicinal Uses, Phytochemistry and Pharmacology. In *Bioactive Natural products in Drug Discovery* (pp. 215–242). Springer Singapore. https://doi.org/10.1007/978-981-15-1394-7_5

Handayani, S. S., Gunawan, E. R., Suhendra, D., Murniati, M., & Aditha, I. M. (2020). Karakterisasi Sifat Fisiko Kimia Minyak Nyamplung Sebagai Bahan Baku Sabun Padat Transparan. *Jurnal Pijar Mipa*, *15*(4), 411–415. https://doi.org/10.29303/jpm.v15i4.1328

Hapsari, S., Jadid, N., Aparamarta, H. W., & Gunawan, S. (2023). Impact of solvent type, solvent-water concentration, and number of stages on the extraction of coumarin mixture from tamanu (Calophyllum inophyllum) oil and its antioxidant activity. *Arabian Journal of Chemistry*, *16*(2), 104449. https://doi.org/10.1016/j.arabjc.2022.104449

Hasibuan, & sahirman. (2013). Karakteristik Fisikokimia dan Antibakteri Hasil Purifikasi Minyak Biji Nyamplung (*Calophyllum Inphyllum L.*). *Agritech*, *33*(3), 311-319. https://doi.org/10.22146/agritech.9553

Islam, Q. S., Sohrab, M. H., Sharmin, S., & Hasan, C. M. (2019). Phytochemical Investigation of Calophyllum Inophyllum L. *Dhaka University Journal of Pharmaceutical Sciences*, *18*(2), 179-182. https://doi.org/10.3329/dujps.v18i2.43260

Purwaningsih, P., & Indrayudha, P. (2024). A Systematic Review : Ethnomedicinal Uses and Pharmacological Activity of Male Papaya Flower (Carica papaya L.). *Pharmaceutical Journal Indonesia 21*(1), 65–76. Retrieved from https://journals.ums.ac.id/pharmacon/article/view/23474

Itoigawa, M., Ito, C., & Tan, H. T. (2001). Cancer Chemopreventive Agents, 4-Phynlcoumarin From Inophyllum. *Cancer Lertters*, *26*(1), 15-19. https://doi.org/10.1016/s0304-3835(01)00521-3

Marlina, Farida, M., & Mustanir. (2017). Synthesis and characterization of polyurethane membrane from Nyamplung seed oils (Calophyllum inophillum). *Asian Journal of Chemistry*, *29*(9), 1912–1916. https://doi.org/10.14233/ajchem.2017.20568

Ong, H. C., Milano, J., Silitonga, A. S., Hassan, M. H., Shamsuddin, A. H., Wang, C. T., Indra Mahlia, T. M., Siswantoro, J., Kusumo, F., & Sutrisno, J. (2019). Biodiesel production from Calophyllum inophyllum-Ceiba pentandra oil mixture: Optimization and characterization. *Journal of Cleaner Production*, *219*, 183–198. https://doi.org/10.1016/j.jclepro.2019.02.048

Pribowo, A., Girish, J., Gustiananda, M., Nandhira, R. G., & Hartrianti, P. (2021). Potential of Tamanu (Calophyllum inophyllum) Oil for Atopic Dermatitis Treatment. *Evidence-Based Complementary and Alternative Medicine*, *2021*, 1–9. https://doi.org/10.1155/2021/6332867

Putri, F. S., Arief, M. J., & Rusli, R. (2024). Uji aktivitas

antiinflamasi akut ekstrak etanol dan ekstrak air daun telang (Clitoria ternatea L.) dengan induksi karagenan. *Jurnal Mandala Pharmacon indonesia, 10*(1), 151-156. Retrieved from https://jurnal-pharmaconmw.com/jmpi/index.php/jmpi/article/view/467

Raharivelomanana, P., Ansel, J. L., Lupo, E., Mijouin, L., Guillot, S., Butaud, J. F., Ho, R., Lecellier, G., & Pichon, C. (2018a). Tamanu oil and skin active properties: From traditional to modern cosmetic uses. *OCL - Oilseeds and Fats, Crops and Lipids*, *25*(5), 1–6. https://doi.org/10.1051/ocl/2018048

Raharivelomanana, P., Ansel, J. L., Lupo, E., Mijouin, L., Guillot, S., Butaud, J. F., Ho, R., Lecellier, G., & Pichon, C. (2018). Tamanu oil and skin active properties: From traditional to modern cosmetic uses. *OCL - Oilseeds and Fats, Crops and Lipids*, *25*(5). https://doi.org/10.1051/ocl/2018048

Saechan, C., Kaewsrichan, J., Leelakanok, N., & Petchsomrit, A. (2021). Antioxidant in cosmeceutical products containing Calophyllum inophyllum oil. *OCL - Oilseeds and Fats, Crops and Lipids*, *28*, 28. https://doi.org/10.1051/ocl/2021015

Saini, R. K., Prasad, P., Shang, X., Keum, Y.-S., & Parinandi, L. (2021). Molecular Sciences Advances in Lipid Extraction Methods-A Review. *Int. J. Mol. Sci*, *22*, 13643. https://doi.org/10.3390/ijms222413643

Santi, S. R., Sukadana, I. M., Manurung, M., & Bawa, A. (2024). A Studu on Compounds With Spermicidal Potential in Calophullum Inophyllum L. Seed Shell Towards Mus Musculus. *Journal of Applied and Natural Science*, *16*(4), 1702-1708. https://doi.org/10.31018/jans.v16i4.5722

Singam, G. C., Jabal, A. R., & Augustina, I. (2022). literature Review: Perbandingan Efektivitas Ekstrak Pepaya (Carica papaya L.)Sebagai Larvasida Alami Terhadap Larva. *Jurnal Kedokteran Universitas Palangka Raya*, *10*(2), 19–24. https://doi.org/10.37304/jkupr.v10i2.7455

Supriadi, S., Suryani, S., Anggreani, L., Perawati, S., & Yulion, R. (2022). Analisis Penggunaan Obat Tradisional Dan Obat Modern Dalam Penggunaan Sendiri (Swamedikasi) Oleh Masyarakat. Jurnal Kesehatan, *14*(2), 138. https://doi.org/10.24252/kesehatan.v14i2.20347

Susanty, S., & Bachmid, F. (2016). Perbandingan Metode Ekstraksi Maserasi dan Refluks Terhadap Kadar Fenolik dari Ekstrak Tongkol Jagung (Zea mays L.). *Jurnal Konversi*, *5*(2), 87. https://doi.org/10.24853/konversi.5.2.87-92

Syivarulli, R., Pambudi, N. A., Syamsiro, M., & Saw, L. H. (2021). Upgrading the quality of solid fuel made from nyamplung (Calophyllum inophyllum) wastes using hydrothermal carbonization treatment. *Energy Engineering: Journal of the Association of Energy Engineering*, *118*(1), 189–197. https://doi.org/10.32604/EE.2020.010493

Taebenu, D. A. N. T., Arpiwi, N. L., & Sudatri, N. W. (2023). Formulation of Sunscreen Body Lotion From Moringa (Moringa Oleifera L.) Leaf Extract. *Jurnal Biosains Pascasarjana*, *25*(2), 137–145. https://doi.org/10.20473/jbp.v25i2.2023.137-145

Thy, L. T. M., Le Khoi, T., Do Dat, T., Le Thao My, P., Thanh, V. H., Duc Viet, N., Khanh Duy, H., Nam, H. M., Phong, M. T., & Huu Hieu, N. (2020). Extraction Of Tamanu Oil From Calophyllum Inophyllum L. Seeds By Ultrasound-Assisted Method And Testing Wound Care Treatment. *Journal of Science Technology and Food*, *20*(3), 54–66. Retrieved from https://vjol.info.vn/index.php/hufi/article/view/52551

Wirasti, W. (2018). Pembuatan Dan Analisis Sediaan Kosmetika Sabun Transparan Basis Minyak Kelapa Murni. *Jurnal Farmasi Sains Dan Praktis*, *4*(2), 53–56. https://doi.org/10.31603/pharmacy.v4i2.2322