Development Antibacterial Transparent solid and liquid Soap from Agarwood Leaf Ethanol Extract (*Aquilaria malaccensis Lam*.) Formulations

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ABSTRACT

Agarwood is one of Indonesia's mainstay commodities in local and international markets. The use of agarwood leaves in various fields is increasing, such as in the cosmetics sector, which is processed into soap, perfume, aromatherapy, and lotion. The content of Agarwood Leaf Extract (ALE) is in the form of alkaloids, flavonoids, triterpenoids, steroids, and saponins, which have antibacterial properties. This study aims to make transparent and liquid antiseptic soap. Three ALE antiseptic soaps were made in clear solids with ALE levels of 0.2%, 0.5%, and 1% and liquid soaps of 1%, 2%, and 3%. Additional ingredients for making solid soap are stearic acid, pure coconut oil, olive oil, and NaOH. The ingredients used to make clear soap are glycerin, 96% ethanol, and 50% sucrose. The resulting soap was evaluated for its characteristics and antibacterial activity. ALE 0.2%-1% can be made into a good transparent solid liquid antiseptic soap with moderate antibacterial power, and 1%-3% can be made into a good antiseptic liquid soap with strong antibacterial power. ok

Keywood: Agarwood, antibacterial, soap, transparent, liquid,

1. Introduction

Agarwood (Aquilaria malaccensis Lam) or gaharu is a non-timber forest plant known in Indonesia as mengkaras, calabac, karas, kekaras (Dayak), halim (Lampung), alim (Batak), kareh (Minang), galoop (Malay), and seringak (Za'amah Ulfah, 2021). Domestic and international consumer demand, such as Taiwan, China, and Arabia, is increasing (Herman Hidayat, 2020). Currently, the use of agarwood has changed from traditional use to industrial products such as medicines, cosmetics, incense, tea, and accessory preservatives. The use of agarwood leaves in cosmetics includes soap, perfume, aromatherapy, lotion, and others. Various previous research results show that agarwood leaves contain compounds of the alkaloid, phenol, flavonoid, glycoside, steroid/triterpenoid, saponin, and tannin groups (Za'amah Ulfah, 2021).

Polyphenol compounds significantly have antimicrobial activity (Xuening Chen, 2024). Some plant extracts are food preservatives because they have antimicrobial, anti-enterotoxin, anti-quorum sensing, and anti-biofilm activities (Miklós Takó, 2020). Secondary metabolic compounds in the form of phenolics and their derivatives provide antibacterial effects (Danica 20219). Flavonoid secondary metabolites have antibacterial activity (Nur Farisya Shamsudin, 2022; Tati Herlina, 2025), while strong antibacterial activity compounds are owned by oxygenated Terpene compounds showing strong antibacterial activity (Aline Cristina Guimarães, 2019). Saponin and tannin compounds also have antimicrobial effects (Pikhtirova Alina, 2023), (Jinhui Li, 2023), (Arakkaveettil Kabeer Farha, 2020).

The study showed that agarwood leaves have antibacterial, antidiabetic, anti-inflammatory, antioxidant, and sedative effects (Herman, 2020; Agustina et al., 2015; Septiani, 2018). and (Aritonang, 2019). Several studies have shown that agarwood leaf extract can inhibit the growth of Pseudomonas aeruginosa, Escherichia coli, Staphylococcus aureus, and Propionibacterium acnes bacteria (Andhika Ulil Amri, 2024), (Teti Indrawati, 2022), (Misrahanum Misrahanum, 2022). Ethanol extract of agarwood leaves also has anti-inflammatory and anti-acne effects (Delladari Mayefis, 2025; Nur Hidayah, 2023; Aris Suhardiman, 2020**.** Antiseptics are chemical compounds used to kill or inhibit the growth of microorganisms on living tissues such as the skin surface mucosa (Chen et al.,2024). Agarwood is one of Indonesia's mainstay commodities in local and international markets (Lai et al., 2025). The use of agarwood leaves in various fields is increasing, such as in the cosmetics sector, processed into soap, perfume, aromatherapy, and lotion.

Antiseptic soap can clean, protect, and prevent infections from bacteria and germs. There are various types of soap, one of which is liquid soap. Liquid soap form is a type of soap with a base of animal fat and oil derived from plants, sucrose, Na CMC, and stearic acid. The basic ingredients that can be used are animal fat and oil derived from plants; transparent materials such as ethanol, glycerin, and sugar are also used. Both solid soap and clear soap are equally able to clean dirt, smooth, soften, and moisturize the skin, and provide a smooth and soft foam effect, because they use glycerin and sucrose as moisturizers ((Nova et al., 2025),(EAC, 2022),(Nova et al., 2025),(Indrawati et al., 2022), (Eka Margareth et al., 2021)5,6,7 OK

Based on the background above, a study has been conducted on transparent solid antiseptic and liquid soap using thick Gaharu extract. The study began with making transparent solid soap utilizing a thick extract according to the minimum inhibitory level developed by making liquid soap with a higher concentration. **OK**

2. Materials and methods

2.1. Materials:

Agarwood leaves were obtained from an agarwood plantation in Lubuk Village, Central Bangka Regency, Bangka Belitung Islands Province. Virgin coconut oil, Stearic acid, olive oil, NaOH, glycerin, ethanol, sucrose, Butyl Hydroxy Toluene, tetrasodium edetate, citric acid, Sodium Lauryl Sulfate, and Triethanolamine, coconut oil, KOH, Butyl Hydroxy Toluene (BHT), Stearic acid, Glycerin, Hydroxy Propyl Methyl Cellulose (HPMC), Benzyl alcohol.

2.2. Preparation of Agarwood leaf extract (ALE)

Agarwood leaf powder was macerated using 96% ethanol solvent and thickened. The resulting extract was tested for ethanol-free, phytochemical screening was carried out on the powder and ethanol extract of agarwood leaves, which included tests for flavonoids, alkaloids, saponins, tannins, steroids, and antibacterial activity (Hidayah et al., 2023).

2.3. Preparation and evaluation of ALE transparent solid

The ALE was made into four transparent solid soap preparations with 0%, 0.2%, 0.5%, and 1% extract. The amount of materials used is as shown in Table 1. The transparent solid soap preparation was done by mixing the water phase into the oil phase at 60°C, and other additional ingredients with a half-cooked method. Transparent solid soap from ALE was evaluated, including organoleptic, pH, hardness, water content, and diffusion method tests(Hou et al., 2022)(Nova et al., 2025), (Moaddel & Hill, 2016a).(Moaddel & Hill, 2016b)(Andri Prasetiyo, Lungguk Hutagaol, 2020)(Andri Prasetiyo, Lungguk Hutagaol, 2020)

2.4. Preparation and evaluation of ALE liquid soap

The amount of materials used is as shown in Table 1. First, make a base soap by mixing coconut oil and BHT that have been stirred homogeneously, then add KOH that has been dissolved in distilled water, stir until a base soap is formed, after a slightly thickened base soap is formed, add stearic acid that has been melted on a water bath, stir homogeneously until mixed homogeneously, add HPMC that has been previously cultured with hot distilled water, stir until homogeneous. Add benzyl alcohol that has been dissolved in glycerin, stir homogeneously, wait until the temperature is cold, add agarwood leaf extract, stir homogeneously, then add enough fragrance and 100 ml of distilled water, put it in a container. The amount of materials used is as shown in Table 1. Evaluation is carried out on the resulting soap, including organoleptic tests, pH tests, viscosity tests, flow properties tests, foam height and stability tests, and antibacterial tests against Staphylococcus aureus bacteria with concentrations of 1%, 2%, and 3%. (Nova et al., 2025), (Indrawati et al., 2022)Ok

Table 1. The ALE Transparent Solid and Liquid Soap Formula

Material	Weight (%)							
	F-SO	FS-I	FS-II	FS-III	FL-O	FI-I	FL-II	FL-III
ALE	-	0,2	0,5	1	-	1	2	3
Stearic acid	8,00	8,00	8,00	8,00	2,00	2,00	2,00	2,00
Virgin coconut oil	19,40	19,40	19,40	19,40	30,00	30,00	30,00	30,00
olive oil	6,00	6,00	6,00	6,00				
NaOH	10,00	10,00	10,00	10,00				
KOH					8,44	8,44	8,44	8,44

glycerin	9,40	9,40	9,40	9,40	5,00	5,00	5,00	5,00
Ethanol	15,00	15,00	15,00	15,00				
Sucrose	13,40	13,40	13,40	13,40				
Triethanolamine	6,00	6,00	6,00	6,00				
Sodium Lauryl Sulfate	6,00	6,00	6,00	6,00				
Tetrasodium edetate	0,10	0,10	0,10	0,10				
BHT	0,02	0,02	0,02	0,02	0,02	0,02	0,02	0,02
Citric acid	2,00	2,00	2,00	2,00				
HPMC					3,50	3,50	3,50	3,50
Benzyl alcohol					1,00	1,00	1,00	1,00
Water	4,68	4,68	4,68	4,68	50,04	49,04	48,04	47,04

Notes: FS-O, FS-I, FS-II, and FS-III are the blank, I, II, and III formulas of a solid transparent. FL-0, FL-I, FL-II, and FL-III are blank, I, II, and III formulas of liquid soap.

3. Results and discussion OK

A thick extract weighing 162.2 g with a yield of 32.4% was obtained from the maceration process of 1000 g of dried Gaharu leaf powder. Gaharu leaf extract (EDG) is a thick liquid form, dark green to blackish, has a distinctive aromatic odor, bitter astringent taste, and has a pH of 4.61. Both dry powdered Gaharu leaves and their thick extracts contain alkaloids, steroids, saponins, flavonoids, and tannins. Alkaloid compounds are reported to have antibacterial activity, namely damage to bacterial walls due to the bacterial cell wall assembly process, which begins with peptide chains that will form peptide cross bridges that cause the cell walls to bind perfectly (Hou et al., 2022),(Hashim et al., 2016). This condition causes bacterial cells to experience lysis easily, both physically and cosmetically, and causes membrane permeability(Chen et al., 2024),(Li et al., 2021)(Li et al., 2021). Flavonoids are reported to work as antibacterials by forming complex compounds against extracellular proteins that can disrupt the integrity of bacterial cell membranes (Takó et al., 2020), (Herlina et al., 2025), (Chen et al., 2024), (Wei Li,2020),(Li et al., 2021)(**Nur Farisya Shamsudin,2021)**. Tannins are thought to have an antibacterial mechanism using tannin toxicity, which can damage bacterial cell membranes. Astringent tannin compounds can induce the formation of complex compounds that bind enzymes or microbial substrates (Farha et al., 2020). Saponins can hemolyze cells by increasing membrane permeability (Alina et al., 2023)OK

Table 2. The Bacterial Growth Result Tests Of Agarwood Leaf Extract

Table 2. The Bacterial Growth Result Tests Of Agarwood Leaf Extract

Agarwood lLeaves Extract(%)	Bacterial Growth
0,1	+
0,2	-

0,5	-
1	-
2	-
4	-
6	-

The results of the minimum inhibitory concentration MIC test of ethanol extract of agarwood leaves (Aquilaria malaccensis Lam.) against Staphylococcus aureus can be seen in Table 2. The MIC test of ethanol extract of agarwood leaves (Aquilaria malaccensis Lam.) against Staphylococcus aureus was 0.2%. The antibacterial activity of the ethanol extract of Agarwood leaves can be caused by chemical compounds, namely alkaloids, steroids, saponins, flavonoids, and tannins(Chen et al., 2024), (Herlina et al., 2025) , **Nur Farisya Shamsudin,2021),** (Alina et al., 2023)) Based on the Minimum Inhibitory Concentration obtained, the concentration of ethanol extract of agarwood leaves (Aquilaria malaccensis Lam.) to be used in the formulation of antiseptic clear solid soap is 0.2%, 0.5%, and 1%. OK

The saponification process between lauric acid and oleic acid will produce sodium oleate, sodium laurate, and glycerol(Félix et al., 2017), (Andri Prasetiyo, Lungguk Hutagaol, 2020),)((Félix et al., 2017),(Moaddel & Hill, 2016b), (Flick, 1992). This occurs when making Agarwood leaves (Aquilaria malaccensis Lam.). Sodium laurate and sodium oleate act as surfactants to bind dirt. Surfactants have two parts with different polarities, namely the polar part (hydrophilic) in the form of COONa molecules that will bind water, and the non-polar part (hydrophobic) in the form of $C_{11}H_{23}$ and $C_{17}H_{32}$ molecules that will bind oil. Glycerol formed in the saponification reaction will bind to the triglyceride fat (Félix et al., 2017).

Table 3. The Organoleptic Test Results

	Form	Odor	Color
FS-O	Solid Transparent	Odorless	Yellow
FS-I	Solid Transparent	Agarwood leaves	Lingt brown
FS-II	Solid Transparent	Agarwood leaves	Brown
FS-III	Solid Transparent	Agarwood leaves	Dark brown
FL-O	quite thick	Odorless	White
FL-I	quite thick	Agarwood leaves	brownish white
FL-II	quite thick	Agarwood leaves	light brown

FL-III	quite thick	Agarwood leaves	dark brown

Notes: FS-O, FS-I, FS-II, and FS-III are the blank, I, II, and III formulas of a solid transparent.
FL-0, FL-I, FL-II, and FL-III are blank, I, II, and III formulas of liquid soap.

The results of the antiseptic liquid Soap and transparent solid soap of ethanol ALE organoleptic can be seen in Table 3. All formula liquid and solids have an odor like Agarwood leaves. All soaps have a solid and transparent form. The soap color gets darker with increasing amount of extract, which causes the soap to appear opaque. All formula liquid soaps are slightly thick and have a distinctive odor of gaharu leaves, white on the blank, brownish white in FL-I, light brown in FL-II, and dark brown in FL-III. The color of transparent soap is yellow for FS-0, light brown for FS-I, brown for FS-II, and dark brown for FS-III. This is because the color of the ethanol extract of agarwood leaves (Aquilaria malaccensis Lam.) contains phenolic and flavonoid compounds (Herlina et al., 2025),(Miklós Takó, 2020). Cosmetic coloring can be added to the formula to make transparent soap more attractive.
OK

Table 4. The PH, Height, and Stability Foam Result Test

Formula	Foam height (cm)		PH
	0 (min)	5 (min)	
FS-O	7,300 ±0,577	6,67 ±0,289	9,81 ± 0,17
FS-I	7,00 ± 0,500	6,17v±0,89	9,72 ± 0,16
FS-II	7,33 ±0,764	6,33 ±0,577	9,61 ±0,110
FS-III	6,33 ±0,289	5,17 ±0,289	8,84 ± 0,092
FL-O	11,16 ± 0,29	9,83 ±0,76	8,58 ± 0,020
FL-I	10,00 ± 1,32	7,16 ±1,04	9,67 ± 0,015
FL-II	9,33 ± 1,15	8,5 ± 0,87	9,54 ± 0,045
FL-III	8,83 ±1,26	8,16 ± 1,26	9,69 ± 0,051

Table 4 shows the results of the foam tests for transparent solid and liquid soap. The four solid soap formulas show a foam height of 5.17 cm - 7.33 cm in distilled water. Soap that produces more foam has faster cleaning power. The foam produced by the soap will bind dirt that has been emulsified, suspended, and dissolved, so easy to clean with water. Therefore, it is necessary to measure the foam height to determine the cleaning power of the soap. All liquid soap formulas show a foam height of 7.16 cm - 11.16 cm. The public assumes soap with a lot of foam has faster cleaning power(Moaddel & Hill, 2016a),(Nova et al., 2025). Therefore, it is necessary to measure the foam height because it can affect the level of consumer acceptance of the soap made.

The transparent solid and liquid soap pH test results can be seen in Table 4, with an average of 8.84-9.81 and 9,54 -9,69. According to the Indonesian National Standard SNI 2588:2017, the pH for antiseptic liquid soap is 4-10. This shows that the FS-O, FS-I, FS-II, and FS-III preparations meet the requirements, with the FS-II preparation being the closest to the optimal pH of commercial transparent soap(Nova et al., 2025). So all the formulas in this study are expected to provide optimal cleansing and antiseptic benefits without causing adverse side effects. OK

Table 5. The Transparent Soap Result Test of Hardness and Water Content

Formula	Hardness (mm/sec)	Water content (%)
FS-O	2,10 ± 0,200	14,19 ±0,165
FS-I	2,49 ± 0,522	14,30 ±0,259
FS-II	2,21 ± 0,459	13,93 ±0,160
FS-III	3,13 ± 0,404	14,47 ± 0,299

The evaluation results of the hardness of transparent solid soap can be seen in Table 5. The hardness values for FS-I, FS-II, and FL-III are 2.10-3.13 mm/second. The FS III formula soap hardness is lower than FS-I, FS-II, and FS-O. The hardness of commercial transparent soap is between 0.967 and 6.867. So, the antiseptic transparent solid soap with ethanol ALE meets the criteria for commercial transparent solid soap (Nova et al., 2025). So, all of the transparent solid soap formulas in this study are expected to provide optimal cleansing and antiseptic benefits without causing adverse side effects. OK

The water content of transparent solid soap is 13.93-14.47% as can be seen in Table 5, According to INS, the water content is not more than 15%, so all transparent solid soap formulas have met SNI standards(Nova et al., 2025). The water content in soap should not be high because the more water contained in the soap, the more easily it will shrink when used OK

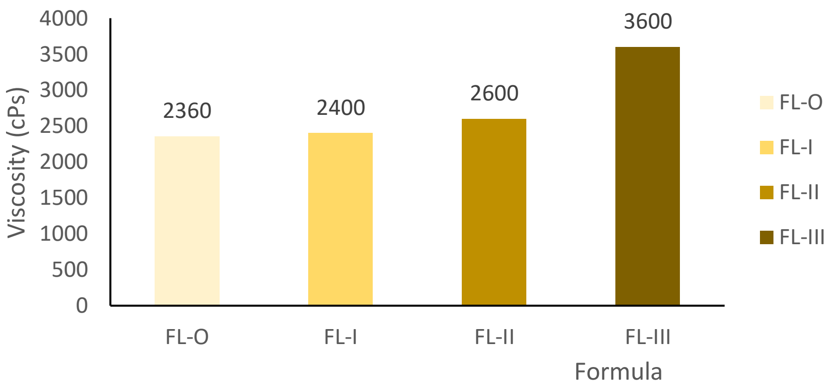

Figure 1. Liquid soap Viscosity

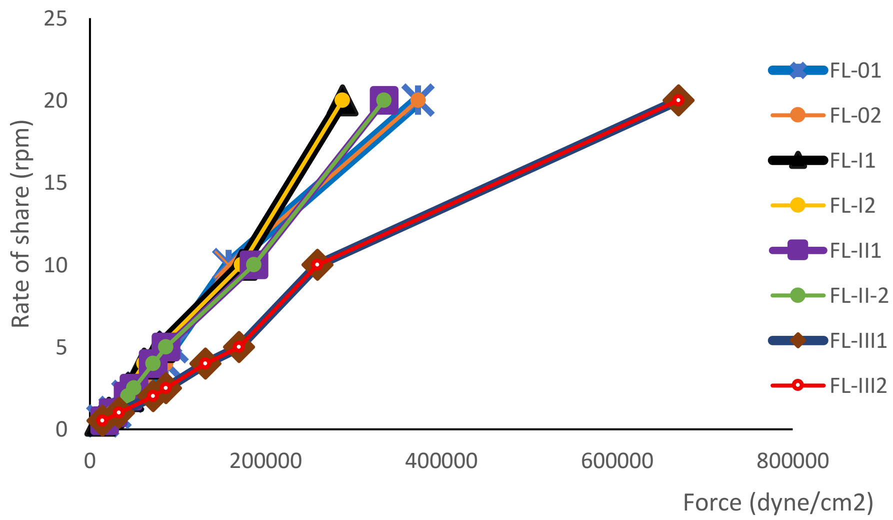

Figure 2. Flow Propertes of ALE Liquid Transparent Soaps

The results of viscosity and flow properties measurements are shown in Figures 1 and 2. The increase in viscosity from FL-0 to FL-III (2200-3600) cPs is caused by the ALE increase and meets the requirements of SNI 2588:2017. All formulas have Newtonian flow properties. This can be seen in the graph, which shows that if drawn straight, the linear line passes through the zero point. Table 6 shows the results of the antibacterial activity test of solid and liquid soap. The inhibition diameter of solid soap increases from FS-0 to FS-II, while FS-II is below the inhibition diameter of FS-I. According to Zakiyah 2019, antibacterial power can be divided into three categories based on the value of the inhibition zone diameter: more than 20 mm is considered strong, 10-20 mm is considered moderate, and less than 10 mm is considered weak (Nova et al., 2025), (Ulpiyah et al., 2019). So, all clear solid soaps are included in the category of solid soaps with moderate antibacterial power, and FS-II has an optimum inhibition diameter (18.78 ± 1.018) mm. All antibacterial liquid soap formulas are included in the category of strong antibacterial soap, and FL-II has an optimum inhibition diameter (26.00 ± 1.016) mm. The decrease in the diameter of the inhibition power in FS-III and FL-III compared to FS-II and FL-II is likely due to an increase in the amount of ALE, so that the pH decreases to 8.84 ± 0.092 (pH FS-III) and 9.54 ± 0.051 (pH FL-III). OK

Conclusion

1. ALE (Ethanol extract of agarwood leaves (Aquilaria malaccensis Lam.) 0.2%-1% can be made into a transparent solid liquid antiseptic soap with moderate antibacterial power.
2. Transparent solid antiseptic soap ALE is light brown to dark brown, transparent, has a distinctive ALE odor, pH 8.84-9.81, soap hardness (2.10-3.13) mm/second, water content (13.93-14.47) %, foam height (6.33-7.33) cm, and has a diameter of inhibition power (14.11 - 18.78) mm
3. ALE 1%-3% can be made into an antiseptic liquid soap with strong antibacterial power.
4. ALE liquid soap is a thick liquid that is brownish white to dark brown, has a distinctive ALE odor, pH (9.54-9.69), foam height (8.83-10.00) cm, viacosity (2400-3600) cPs, with Newton water properties and a diameter of inhibition (24.33-26.00 (mm).

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