ISSN 0974-3618 (Print)
0974-360X (Online)
www.rjptonline.org

RESEARCH ARTICLE

Development of Antibacterial Transparent Solid and Liquid Soaps Formulations Utilizing *Aquilaria malaccensis* Lam. (Agarwood) Leaf Ethanol Extract

Teti Indrawati[1], Desy Muliana Wenas*[1], Sherli Septiani[1], Putri Harum Setia Ningrum[1], Andriani[2]
[1]Faculty of Pharmacy, National Institute of Science and Technology (ISTN), Jl. Muh. Kahfi II, South Jakarta, Indonesia.
[2]Bacterial Laboratory, Research Institute for Veterinary Science, Bogor, Indonesia, Jl. RE Martadinata No.30, Bogor.
*Corresponding Author E-mail: **desywenas@istn.ac.id**

ABSTRACT:
Agarwood (*Aquilaria malaccensis* Lam.), one of the Indonesia key commodity, is increasingly valued for its leaves in cosmetics. These leaves has been incorporated into a variety of products, including soaps, perfumes, aromatherapy items, and lotions. The leaf extract of *A. malaccensis* is known for its richness in secondary metabolites such as alkaloids, flavonoids, triterpenoids, steroids, and saponins, which exhibit antibacterial properties. This study begin with extraction of *A. malaccensis* leaf with maceration in 96% ethanolic solvent. This research investigated the antibacterial activity of *A. malaccensis* leaf ethanolic extract with disc diffusion assay method to get the optimum minimum inhibition concentrations. Transparent solid soaps were formulated with leaf extract concentrations of 0.2%, 0.5%, and 1%, while liquid soap formulations utilized 1%, 2%, and 3% extract concentrations. Solid soap formulations included stearic acid, pure coconut oil, olive oil, and NaOH, while liquid soap formulations incorporated glycerin, 96% ethanol, and 50% sucrose. The resulting soaps were evaluated for their organoleptic characteristics, stability test, physical evaluation and antibacterial efficacy. Findings indicate that the transparent solid soap formulations with 0.5% *A. malaccensis* leaf extract showed moderate antibacterial power, while 2 % extract yields an antiseptic liquid soap with strong antibacterial power. The research result about antibacterial soap formulations could be used for the development of antiseptic soap in the future.

KEYWORDS: Agarwood, antibacterial, transparent liquid soap, solid soap.

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[1].

Received on 18.07.2025 Revised on 29.12.2025
Accepted on 26.03.2026 Published on 01.07.2026
Available online from July 04, 2026
Research J. Pharmacy and Technology. 2026;19(7):3309-3316.
DOI: 10.52711/0974-360X.2026.00471

Agarwood, a valuable product from a plant in the Thymelaeaceae family[2], is experiencing strong international consumer demand and strong in markets such as Taiwan, China, and the Arabian Peninsula[3]. 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, and lotion. Agarwood as medicinal plant is generally regarded as safe and effective, with minimal undesirable side effects[4]. Their complex actions often involve multiple complementary or synergistic effects on the body's physiological systems simultaneously. This makes them highly promising for the development of new antibacterial

agents, as they naturally contain a wide array of pharmacologically active compounds[5]. Various previous research results show that agarwood leaves contain compounds of the alkaloid, phenol, flavonoid, glycoside, steroid/triterpenoid, saponin, and tannin groups[1]. Polyphenol compounds significantly have antimicrobial activity[6]. Some plant extracts are food preservatives because they have antimicrobial[7], anti-enterotoxin, anti-quorum sensing, and anti-biofilm activities[8]. Secondary metabolic compounds in the form of phenolics and their derivatives provide antibacterial effects[9]. Flavonoid secondary metabolites have antibacterial activity[10,11], while strong antibacterial activity compounds are owned by oxygenated Terpene compounds showing strong antibacterial activity[12]. Saponin and tannin compounds also have antimicrobial effects[13,14].

The study showed that agarwood leaves have antibacterial, antidiabetic, anti-inflammatory, antioxidant, and sedative effect. Several studies have shown that agarwood leaf extract can inhibit the growth of *Pseudomonas aeruginosa, Escherichia coli, Staphylococcus aureus,* and *Propionibacterium acnes* bacteria[15,16]. Ethanol extract of agarwood leaves also has anti-inflammatory and anti-acne effects[17]. Antiseptics are chemical compounds used to kill or inhibit the growth of microorganisms on living tissues such as the skin surface and mucosa[18]. Agarwood is one of Indonesia's mainstay commodities in local and international markets[19]. The use of agarwood leaves in various fields is increasing, such as in the cosmetics sector, processed into soap, perfume, aromatherapy, and lotion.

Soap, which originated in ancient Babylonian culture from animal fats and alkali[20], is now used in everyday life[21]. Antiseptic materials are needed to prevent the transmission of infectious diseases. With just a touch, a hand contaminated with bacteria can transmit diseases to frequently touched locations like stair railings, chairs, and door handles[22]. However, the frequent use of antiseptics can lead to skin irritation and pathogen resistance. Similarly, using chemical ingredients can cause toxicity, hypersensitivity, and irritation[23]. Antiseptic products from natural sources, such as plants, could be a solution[24]. Leaves from the plants have a long history in traditional medicine, where their juice and extracts are applied directly to the skin to treat skin diseases, thanks to their antimicrobial and anti-inflammatory properties[25].

Antiseptic soap could clean, protect, and prevent infections from bacteria and germs[26]. 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. The transparent solid and liquid soaps 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[27].

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.

MATERIALS AND METHODS:

Materials:

Agarwood leaves were obtained from an agarwood plantation in Lubuk Village, Central Bangka Regency, Bangka Belitung Islands Province. The plant collected by Septiani with Plant Identification voucher number 2220/IPH.1.01/If.07/X/2016. Virgin coconut oil, Stearic acid, olive oil, NaOH, glycerin, ethanol, sucrose, Butyl Hydroxy Toluene, tetrasodium edetate, citric acid, Sodium Lauryl Sulfate (SLS), triethanolamine, coconut oil, KOH, Butyl Hydroxy Toluene (BHT), stearic acid, glycerin, Hydroxy Propyl Methyl Cellulose (HPMC), Benzyl alcohol, FeCl3 1%, eter, anhydrate acetic acid, H_2SO_4, Natrium nitrite, $AlCl_3$, NaOH 1N, disc paper, 96% ethanol, McFarland No. 0.5 suspension, Mueller-Hinton agar, and aquadest. Commercial antiseptic liquid soap and commercial antiseptic solid soap as positive control.

Preparation of Agarwood leaf extract (ALE) and phytochemical screening:

Agarwood leaf powder (1,000 g) 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 [28]. The phytochemical screening of ALE is using the methods adopted by Munira (2018)[29]

Antibacterial Activity Assay:

The antibacterial activity of the extract and soap formulations are assayed by disc diffusion method adopted from Munira (2016). The antibacterial activity assay began with the comparative determination of the extract's antibacterial efficacy (50%, 25%, 12.5%, 6.25%, 3.12% and 1.56%) against both commercial solid and liquid soaps. Subsequently, the minimum inhibitory concentration (MIC) of the extract within the soap formulation was determined. The MIC will guide the selection of extract concentrations for the soap

formulations, which will then be evaluated for the extract's efficacy. The minimum inhibitory concentration (MIC) of the test substances were determined using the dilution method, by observing the growth of the test bacteria from the lowest extract concentration that produced a clear inhibition zone. Bacterial medium was mixed with 0.5 mL ALE. After the mixture solidified, 0.5 µL of 10^6 CFU/mL test bacteria was added to the surface of the medium and incubated at 37°C for 24 hours. The lowest concentration of the antibacterial solution that inhibited bacterial growth was determined as the minimum inhibitory concentration (MIC).

Liquid soap and solid soap were prepared. 0.5 mL of a 10^6 CFU/mL *S. aureus* suspension was pipetted and poured into solidified Mueller-Hinton Agar medium, then gently swirled to ensure even distribution. Any excess suspension was pipetted off and discarded into a test tube. 5 g of solid soap base (FS0), ALE solid soap (FS1 0.2%, FS2 0.5%, FS3 1%) solid soap formulas dissolved with 10 mL of distilled water. Paper discs, pre-soaked for 5 minutes in 1% (FL1), 2% (FL2), and 3% (FL3) liquid soap and solid soap base (FL0). The paper discs were placed on top of the medium. All procedures were performed aseptically inside a laminar air flow cabinet. The experiment was conducted in triplicate. After 24 h incubation at 37°C, observations were made by checking for the presence or absence of an inhibition zone (clear zone) around the paper discs. Calipers (mm) is used to measure the inhibition zone is calculated by calipers (mm). The inhibition zone value is measured in horizontal and vertical areas[29].

Preparation and evaluation of ALE transparent solid:

The ALE was made into four transparent solid soap preparations with 0.2%, 0.5%, and 1% extract (Table 1). Stearic acid is melted in olive oil, coconut oil, and BHT (which has been dissolved in the oil) using an evaporating dish at 60-80°C for 5 minutes over a water bath, and then stirred until homogeneous. The NaOH solution is added gradually until a thick mass forms, producing a soap base. The soap base is melted at 60-80°C for 10 minutes until completely liquefied. It is then stirred until homogeneous. A 50% sucrose solution and tetrasodium edetate (which has been dissolved in water) are added to the mixture. Glycerin and triethanolamine are then added and stirred homogeneously for 10 minutes. Sodium lauryl sulfate is dissolved in 96% ethanol and citric acid (which has been dissolved in water) is added to the mixture and stirred until homogeneous. ALE (0.2%, 0.5%, and 1%) at 40°C is added to the soap base and stirred until homogeneous. The mixture is poured into soap molds and left at room temperature until it hardens. Once solid soap is hardened, it was removed from the molds. ALE transparent solid soap was evaluated, including organoleptic, pH, hardness, water content. The antibacterial activity using disc diffusion method against against *Staphylococcus aureus*[27,30,31,29].

Preparation and evaluation of ALE liquid soap:

A base soap is prepared by mixing coconut oil and BHT, which have been stirred homogeneously. Subsequently, KOH, dissolved in distilled water, is added. The mixture is stirred until a base soap is formed. After a slightly thickened base soap is achieved, stearic acid, which has been melted in a water bath, is added. HPMC, previously cultured with hot distilled water, is then incorporated into the mixture and stirred until homogeneous. Benzyl alcohol, dissolved in glycerin, is subsequently added, and the mixture is stirred homogeneously. Once the temperature has cooled, ALE (1%, 2%, and 3%) were added and stirred until homogeneous. Finally, a sufficient amount of fragrance is added, and distilled water is incorporated until the total volume of the mixture reaches 100 mL. 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*[2732].

Table 1: The agarwood leaf extract transparent solid and liquid soap formula.

Material	Composition (% w/v)*							
	FS0	FS1	FS2	FS3	FL0	FL1	FL2	FL3
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: S : Solid soap, L : liquid Soap, 0 : Base Soap. FL1, FL2,and FL3 are the formulas of liquid soap.
FS1, FS2, and FS3 are the formulas of solid soap.

RESULTS AND DISCUSSIONS:

A thick extract weighing 162.2 g with a yield of 32.4% was obtained from the maceration process of 1000 g of dried Agarwood leaf powder. ALE is a thick liquid form, dark green to blackish, has a distinctive aromatic odor, bitter astringent taste, and has a pH of 4.61.

Table 2: The antibacterial activities of Agarwood Leaf Extract.

Samples	Inhibition Diameter (mm)					
	1,56%	3,12%	6.25%	12.5%	25%	50%
Agarwood Leaf Extract	10.78 ± 0.57	12.79 ± 0.58	15.15 ± 1.05	16.84 ± 0.59	18.85 ± 1.16	15.15 ± 1.05
CLS (PC)	*	*	32.00 ± 2.83	34.50 ± 2.12	35.50 ± 0.71	32.00 ± 2.83
CSS (PC)	*	*	29.00 ± 1.41	31.50 ± 4.94	33.50 ± 2.12	29.00 ± 1.41

n = triplicate, CLS: Commercial Liquid Soap, CSS: Commercial Solid Soap, PC: Positive Control, * not applicable

Table 3. The bacterial growth tests on ALE solid and ALE liquid soap.

Solid Soap		**Liquid Soap**	
Extract (%)	***S. aureus* growth**	**Extract (%)**	***S. aureus* growth**
3	-	3	-
2	-	2	-
1	-	1	+
0.5	-	0.5	+
0.25	-	0.25	+
0.12	+	0.12	+

The assay for antibacterial activity started by assessing the extract's antibacterial efficacy in comparison to both commercial solid and liquid soaps. The results shows that the extract in concentration of 50%, 25%, 12.5%, 6.25%, 3.12% and 1.56% gave the antibacterial activity (Table 2). The antibacterial assay for determining the minimum inhibitory concentration (MIC) of the extract used a range of concentrations: 3%, 2%, 1%, 0.5%, 0.25%, and 0.12%. For the soap formulations, the MIC test revealed that the ethanol extract of agarwood leaves was effective against *S. aureus* at 0.2% for solid soap and 2% for liquid soap (Table 3). Based on these results, specific extract concentrations were selected for preparing the final soap formulations. Solid soap formulations were prepared with extract concentrations of 0.1%, 0.2%, and 0.5%. For liquid soap formulations, concentrations of 1%, 2%, and 3% were chosen and prepared. The different result between experiment for solid soap and liquid soap may happen due to differences in soap formulation (liquid and solid type) ingredients, which can affect microbial growth rates and susceptibility[33].

The antibacterial activity of the ethanol extract of Agarwood leaves can be caused by chemical compounds, namely alkaloids, steroids, saponins, flavonoids, and tannins[10,18,34]. The diameter of an obstacle zone does not always increase in proportion to an increase in antibacterial concentration, this possibility occurs due to differences in the speed of diffusion of antibacterial compounds on agar media and the type and concentration of antibacterial compounds used. Different types also provide different inhibition zone diameters for certain periods[35].

Both dry powdered Gaharu leaves and their thick extracts contained 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[36,3738]. This condition causes bacterial cells to experience lysis easily, both physically and cosmetically, and causes membrane permeability[18,39]. Flavonoids are reported to work as antibacterials by forming complex compounds against extracellular proteins that can disrupt the integrity of bacterial cell membranes[10,18,39,40,41]. 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[42]. Saponins can hemolyze cells by increasing membrane permeability [34]. So, the antibacterial solid soap preparations using ALE 0.2%, 0.5% and 1%.

Table 4: The Organoleptic Test Results.

Formula	**Form**	**Odor**	**Color**
FS0	Solid Transparent	Odorless	yellow
FS1	Solid Transparent	Agarwood leaves	light brown
FS2	Solid Transparent	Agarwood leaves	brown
FS3	Solid Transparent	Agarwood leaves	dark brown
FL0	quite thick	Odorless	white
FL1	quite thick	Agarwood leaves	brownish white
FL2	quite thick	Agarwood leaves	light brown
FL3	quite thick	Agarwood leaves	dark brown

Notes: S : Solid soap, L : liquid Soap, 0 : Base Soap.

All ALE liquid and solid soap formulas have an odor like agarwood leaves. All solid soaps were transparent. 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 Agarwood leaves, white on the blank, brownish white in FL1, light brown in FL2, and dark brown in FL3. The color of transparent soap is yellow for FS0, light brown for FS1, brown for FS2, and dark brown for FS3. This is because the color of the ethanol extract of Agarwood leaves contains phenolic and flavonoid compounds[418]. Cosmetic coloring can be added to the formula to make transparent soap more attractive.

Table 5. The pH, Height, Stability Foam and Antibacterial Activity.

Samples	Foam height (cm)		pH	Hardness (mm/s)	Water content (%)	Antibacterial Activity (mm)
	0 min	5 min				
FS0	7.30 ± 0.58	6.67 ± 0.29	9.81 ± 0.17	2.10 ± 0.20	14.19 ± 0.17	11.22 ± 0.69
FS1	7.00 ± 0.50	6.17 ± 0.89	9.72 ± 0.16	2.49 ± 0.52	14.30 ± 0.26	14.11 ± 3.91
FS2	7.33 ± 0.76	6.33 ± 0.58	9.61 ±0.11	2.21 ± 0.45	13.93 ± 0.16	18.78 ± 1.02
FS3	6.33 ± 0.29	5.17 ± 0.29	8.84 ± 0.09	3.13 ± 0.40	14.47 ± 0.29	13.67 ± 2.60
FL0	11.16 ± 0.29	9.83 ± 0.76	8.58 ± 0.02	-	-	24.66 ± 0.58
FL1	10.00 ± 1.32	7.16 ± 1.04	9.67 ± 0.02	-	-	24.33 ± 0.58
FL2	9.33 ± 1.15	8.50 ± 0.87	9.54 ± 0.05	-	-	26.00 ± 1.73
FL3	8.83 ± 1.26	8.16 ± 1.26	9.69 ± 0.05	-	-	24.33 ± 1.15
CS (P)	-	-	-	-	-	33.00 ± 1.73
CL (P)	-	-	-	-	-	28.00 ± 5.19

S: Solid soap, L: liquid Soap, O: Base Soap, P: Positive Control, CS = Commercial Solid Soap, CL = Commercial Liquid Soap

Table 5 shows the results of the foam tests for transparent solid and liquid soap. The four solid soap formulas show a foam height of 5.17-7.33 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 showed a foam height of 7.16-11.16 cm. Both solid and liquid soap produces foam level that meets soap manufacturing standards. The customer would like to prefer more foam public assumes soap with a lot of foam has faster cleaning power[30,27]. 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 5, 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 FS0, FS1, FS2, and FS3 preparations meet the requirements, with the FS2 preparation being the closest to the optimal pH of commercial transparent soap[27]. So all the formulas in this study are expected to provide optimal cleansing and antiseptic benefits without causing adverse side effects.

The evaluation results of the hardness of transparent solid soap can be seen in Table 5. The hardness values for FS1, FS2, and FS3 are 2.10-3.13 mm/second. The SIII hardness is lower than FS1, FS2, and FS0. 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[27]. Therefore, all of the transparent solid soap formulas in this study are expected to provide optimal cleansing and antiseptic benefits without causing adverse side effects.

The water content of transparent solid soap is 13.93-14.47% (Table 5). According to SNI, the water content is not more than 15%, so all transparent solid soap formulas have met SNI standards[27]. 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.

The saponification process between lauric acid and oleic acid will produce sodium oleate, sodium laurate, and glycerol[43]. 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[44].

The extract could improve the soap organoleptic properties by maintaining the acidity level (pH), water content, texture, soap foam level. These properties are needed for soap based preparations to withstand moisture, temperature, skin protection from bacterial infection. Some secondary metabolite compounds such as saponins, alkaloids, phenolic and flavonoids help reduce the surface tension of water[29]. Surface tension if the force that allows the water lump on the surface to hold its shape from spreading[45]. This activity is related to the hydrophobic molecule and the solution's ionic activity. This process called micelles process. Soap in

form of micelles, besides the ability to clean dirty oil substances.

The extract could maintain the balance of water content in soap to affect the foam produced by the soap. This is because of how soap molecules are structured. The hydrophilic (water-attracting) head of a soap molecule binds with water, while its hydrophobic (water-repelling) tail attaches to greasy and oily dirt[46]. Beside antibacterial activity of the extract, the hydrophilic nature of soap causes the antibacterial compounds to diffuse in a polar medium. The lipophilic properties of soap would help the penetration of antibacterial compounds into bacterial cell membrane[29].

Table 5 shows the results of the antibacterial activity test of solid and liquid soap. The inhibition diameter of solid soap increases from S-0 to FS2, while FS2 is below the inhibition diameter of FS1. Antibacterial activity can be divided into three categories based on the value of the inhibition zone diameter. More than 20 mm inhibition zone diameter is considered strong, 10-20 mm is considered moderate, and less than 10 mm is considered weak[27,47]. So, all clear solid soaps are included in the category of solid soaps with moderate antibacterial power, and FS2 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 FL2 has an optimum inhibition diameter (26.00±1.016) mm. The decrease in the diameter of the inhibition power in FS3 and FL3 compared to FS2 and FL2 is likely due to an increase in the amount of ALE, so that the pH decreases to 8.84 ± 0.092 (pH FS3) and 9.54 ± 0.051 (pH FL3).

It was also reported on the antibacterial activity of chloroform fraction of *A. malaccensis* leaves extract (concentration 300 mg/mL) on *S. aureus* tested at potentially due to the presence of alkaloid and terpenoid[48]. Previous research in gas chromatography-mass spectroscopy (GC-MS) analysis proved that the ethanolic extract of agarwood leaves contain hexadecenoic acid. It is potentially a major compound contributing to the strong antibacterial activity against Gram-negative bacteria[49,50]. Hexadecanoic acid is one of the most common saturated fatty acids found plants and has been reported widely to possess antibacterial property[51].

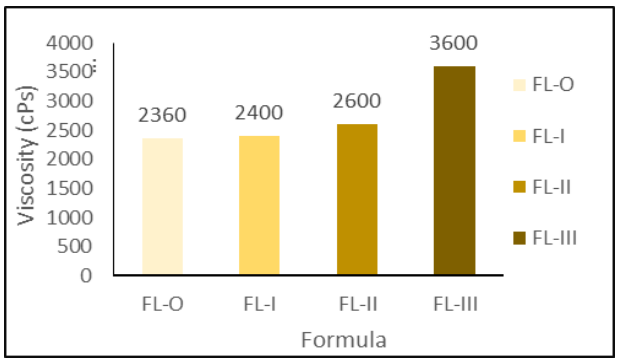

Figure 1: Liquid soap Viscosity.

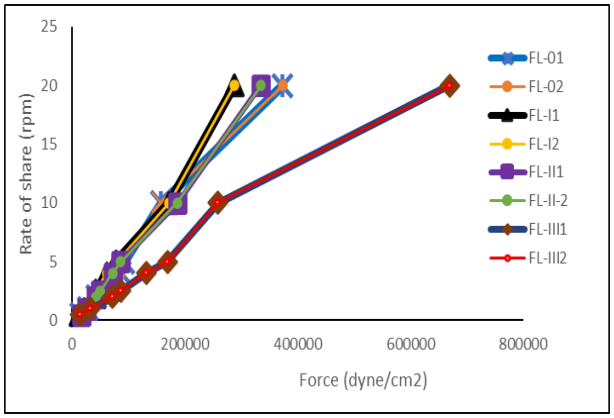

Figure 2: Flow Propertes of ALE Liquid Transparent Soaps.

The results of viscosity and flow properties measurements are shown in Figures 1 and 2. The increase in viscosity from L-0 to FL3 (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. Te concentration of agarwood leaf extract increases in the formulations, the viscosity of the final product also increases.

The observed increase in viscosity from FL-0 to FFL3, ranging from 2200 cPs to 3600 cPs, is directly attributed to the increasing concentration of Agarwood Leaf Extract (ALE) in the formulations. This suggests that components within the agarwood extract, such as polysaccharides or other macromolecules, contribute to the intermolecular forces and structural entanglement within the soap matrix, thereby increasing the internal resistance to flow. This finding is significant as all formulated samples fall within the viscosity requirements stipulated by SNI 2588:2017, which typically specifies a range (e.g., 400-4000 cPs for liquid hand soap), thus confirming the suitability of these formulations for their intended application in terms of consistency and dispense characteristics.

Furthermore, the rheological analysis revealed that all tested formulas exhibit Newtonian flow properties. This indicates that the viscosity of the soap remains constant irrespective of the applied shear rate. This characteristic is highly desirable for liquid soap products, as it ensures predictable flow behavior during dispensing, spreading, and general handling. Unlike non-Newtonian fluids whose viscosity changes with agitation, these Newtonian formulations provide a consistent user experience and simplify manufacturing processes such as pumping and filling, contributing to overall product stability and consumer satisfaction[52,53].

CONCLUSION:

The formulation of solid soap and liquid soap complied with Indonesian National Standards. The best antibacterial activity on soap formulations are 2% ALE liquid soap and 0.5% ALE transparent solid soap. The formulation of transparent solid antiseptic soap with ALE has moderate antibacterial activity, while the liquid soap with ALE has strong antibacterial activity. These results highlight the potential of ALE soap as effective antiseptic products that meet national quality benchmarks, opening avenues for further investigation into optimizing their antimicrobial efficacy and evaluate the clinical test for both antiseptic products.

REFERENCES:

1. Ulfah Z, Prastiwi R, Hayati H. Gaharu Plant (Aquilaria malaccensis Lam.) in terms of Pharmacognosy, Phytochemicals, and Pharmacology Activity. Farmasains : Jurnal Ilmiah Ilmu Kefarmasian 2021; 8(2): 105–114.
2. Hegde K, Lobo AR, Gopikrishna U V. Phytochemical Investigation of The Leaves Extract of The Plant Aquilaria malaccensis. Research Journal of Pharmacognosy and Phytochemistry 2019; 11(1): 34.
3. Hidayat H, Siburian R, Indah Yuliana C. Natural Agarwood, Trading Networks and Gaharu Cultivation: Review on Policy Study in East Kalimantan. J Biologi Indones 2020; 16(1): 99–110.
4. Derouiche S, Zeghib K, Gherbi S, Khelef Y. Protective effects of Aristolochia longa and Aquilaria malaccensis against lead-induced oxidative stress in rat cerebrum. Asian Journal of Research in Pharmaceutical Science 2019; 9(1): 57.
5. Jihadi NIM, Hashim YZHY, Rahim NA, et al. Antibacterial Activity of Ethanolic Leaf Extract of Aquilaria malaccensis against Multidrug-Resistant Gram-Negative pathogen. Food Res 2020; 4(6): 1962–1968.
6. Xie C, Dong JZ, Lu BS, et al. Pharmacology and therapeutic potential of agarwood and agarwood tree leaves in periodontitis. Front Pharmacol 2024; 15(1468393).
7. Hegde K, Shree DPM, Sajjan PC. Evaluation of Immunomodulatory Potentials of the Leaves of Aquilaria malaccensis. Research Journal of Pharmacology and Pharmacodynamics. 2019; 11(1): 32.
8. Takó M, Kerekes EB, Zambrano C, et al. Plant phenolics and phenolic-enriched extracts as antimicrobial agents against food-contaminating microorganisms. Antioxidants. 2020; 9(165): 1–21.
9. Walsh DJ, Livinghouse T, Goeres DM, Mettler M, Stewart PS. Antimicrobial Activity of Naturally Occurring Phenols and Derivatives Against Biofilm and Planktonic Bacteria. Front Chem 2019; 7(653): 1–13.
10. Shamsudin NF, Ahmed QU, Mahmood S, et al. Antibacterial Effects of Flavonoids and Their Structure-Activity Relationship Study: A Comparative Interpretation. Molecules 2022; 27(1149): 1–43.
11. Herlina T, Akili AWR, Nishinarizki V, Hardianto A, Latip JB. Review on antibacterial flavonoids from genus Erythrina: Structure-activity relationship and mode of action. Heliyon 2025; 11(1).
12. Guimarães AC, Meireles LM, Lemos MF, et al. Antibacterial activity of terpenes and terpenoids present in essential oils. Molecules 2019; 24(2471): 1–12.
13. Li J, Monje-Galvan V. In Vitro and In Silico Studies of Antimicrobial Saponins: A Review. Processes 2023; 11(10).
14. Farha AK, Yang QQ, Kim G, et al. Tannins as an alternative to antibiotics. Food Biosci 2020;38:1–4.
15. Indrawati T, Bahri S, Pradita M, Fadia AN, Muhammad AA. Formulasi Sabun Cair Antibakteri Dari Kombinasi Ekstrak Daun Sirih Merah Dan Ekstrak Kulit Lidah Buaya. Pharmaceutical Journal of Indonesia [homepage on the Internet] 2022; 7(2): 97–104. Available from: http://.pji.ub.ac.id
16. Amri AU, Asmaliani I. Uji Aktivitas Antibakteri Ekstrak Etanol Daun Gaharu (Aquilaria malaccensis) Dengan Menggunakan Metode KLT-Bioautografi. Makassar Pharmaceutical Science Journal 2024; 1(31): 281–294. Available from: https://journal.farmasi.umi.ac.id/index.php/mpsj
17. Hidayah N, Ruga R, Saleh C. Anti-Inflammatory Effect Of Extract And Fractions Of Gaharu (Aquilaria malaccensis Lamk.) Leaves. Jurnal Kimia Mulawarman. 2023; 21(1): 62–66. Available from: https://jurnal.kimia.fmipa.unmul.ac.id/index.php/JKM
18. Chen X, Lan W, Xie J. Natural phenolic compounds: Antimicrobial properties, antimicrobial mechanisms, and potential utilization in the preservation of aquatic products. Food Chem 2024; 440(May): 1–8.
19. Lai K wai, Zhang H, Yang F, Gale SW. Using global trade data to identify priorities for agarwood conservation and trade management. Glob Ecol Conserv 2025;59(January).
20. Pawar AP, Pawar DN, Dalvi Y V. Formulation and Evaluation of Polyherbal Soap. Research Journal of Topical and Cosmetic Sciences. 2019; 10(1): 23.
21. Shashank NN, Akanksha A, Ashwini SK, et al. Formulation and evaluation of antibacterial Moringa soap prepared by Melt pour and Cold process method. Research Journal of Topical and Cosmetic Sciences. 2024; 15(1): 20–26.
22. Patel A, Kanwar M, Rana P, Thakur S, Jha S. Effectiveness of Timing for Hand Washing With Soap and Water in Reducing the Germs among Nursing Students in Selected Hospital at Jagdalpur, Bastar C.G. 2015. International Journal of Advances in Nursing Management. 2016; 4(3): 273.
23. Shah RR, Patil PJ, Adnaik PR, Adnaik RS. Biochemical profiling of antifungal soap activity of betel leaf (Piper betle L.) extract and garlic oil by In vitro method. Asian Journal of Pharmaceutical Research 2020; 10(4): 260–262.
24. Debnath S, Niranjan Babu M, Dega M, Kumar KT. Formulation and Evaluation of Liquid Soap Containing Herbal Antimicrobial Agent. Research Journal of Pharmacognosy and Phytochemistry 2011; 3(5): 225–231.
25. R Karnavat D, Amrutkar S V., R. Patil A, K. Ishikar S. A Review on Herbal Soap. Research Journal of Pharmacognosy and Phytochemistry 2022; 208–213.
26. Pillai K, Rashmi. Effectiveness of Antiseptic soap hand washing on reduction of Bacteriological growth among B. Sc. Nursing Students posted in Medical Ward. International Journal of Nursing Education and Research. 2020; 8(3): 331.
27. Nova JF, Smrity SZ, Hasan M, et al. Comprehensive evaluation of physico-chemical, antioxidant, and antimicrobial properties in commercial soaps: A study on bar soaps and liquid hand wash. Heliyon 2025; 11(4): 1–14.
28. Hidayah N, Ruga R, Saleh C. Anti-Inflammatory Effect Of Extract And Fractions Of Gaharu (Aquilaria malaccensis Lamk.) Leaves. Jurnal Kimia Mulawarman 2023; 21(1): 62.
29. Munira M, Miko A, Nasir M, Gani BA. The Mixing of Ethanol Extract of Terminalia catappa L in Transparent Soap Base to

maintaining it's the Organoleptic properties, Solid quality and Inhibition of Staphylococcus aureus. Research J Pharm and Tech 2022; 15(8): 3423–3428.
30. Moaddel T, Hill MI. Transparent and Translucent Soaps. 2nd ed. Elsevier Ltd., 2016;
31. Andri Prasetiyo, Lungguk Hutagaol LL. View of Formulation of Transparent Solid Soap from Palm Kernel Oil.pdf. 2020;
32. Indrawati T, Bahri S, Pradita M, Nur Fadia A, Azmi Muhammad A. Antibacterial Liquid Soap Formulation From A Combination Of Red Betel Leaf Extract And Aloe Vera Skin Extract. Pharmaceutical Journal of Indonesia 2022; 7(2): 97–104.
33. Guan XL, Chang DPS, Mok ZX, Lee B. Assessing variations in manual pipetting: An under-investigated requirement of good laboratory practice. Journal of Mass Spectrometry and Advances in the Clinical Lab 2023; 30: 25–29.
34. Alina P, Kiełb Ewa P, František Z. Antimicrobial activity of saponin-containing plants: review. Journal of Dairy, Veterinary and Animal Research 2023; 12(2): 121–127.
35. Indrawati A, Baharuddin S, Isnaeni D. Antibacterial Potential of Agarwood Leaf Extract (Aguilaria Microcarpa Baill) Against Salmonella Typhi. International Journal of Scientific Multidisciplinary Research. 2024; 2(8): 957–972.
36. Hou W, Liu P, Liu Y, et al. Chi-Nan agarwood germplasms constitute a new chemotype of Aquilaria sinensis (Lour.) Spreng. Ind Crops Prod 2022;187(PB):115494.
37. Hashim YZHY, Kerr PG, Abbas P, Mohd Salleh H. Aquilaria spp. (agarwood) as source of health beneficial compounds: A review of traditional use, phytochemistry and pharmacology. J Ethnopharmacol. 2016; 189: 331–360.
38. Stiani SN, Susanti L, Indriatmoko DD. Formulation and Anti-bacterial Activity Test for Liquid Soap Betel Nut Extract (Areca catechu L.) against Staphylococcus aureus. Research J Pharm and Tech. 2022; 15(3): 1003–1007.
39. Li W, Chen HQ, Wang H, Mei WL, Dai HF. Natural products in agarwood and: Aquilaria plants: Chemistry, biological activities and biosynthesis. Nat Prod Rep. 2021; 38(3): 528–565.
40. Takó M, Kerekes EB, Zambrano C, et al. Plant phenolics and phenolic-enriched extracts as antimicrobial agents against food-contaminating microorganisms. Antioxidants 2020; 9(2).
41. Herlina T, Rizaldi Akili AW, Nishinarizki V, Hardianto A, Latip JB. Review on antibacterial flavonoids from genus Erythrina: Structure-activity relationship and mode of action. Heliyon 2025; 11(1).
42. Farha AK, Yang QQ, Kim G, et al. Tannins as an alternative to antibiotics. Food Biosci 2020;38(September).
43. Flick EW. Soaps. Cosmetic and Toiletry Formulations 1992; 743–756.
44. Félix S, Araújo J, Pires AM, Sousa AC. Soap production: A green prospective. Waste Management 2017; 66: 190–195.
45. Maibaum L, Dinner AR, Chandler D. Micelle formation and the hydrophobic effect. J Phys Chem B 2004; 108(21): 6778–6781.
46. Abdelghafar A, Yousef N, Askoura M. Combating staphylococcus aureus biofilm with antibiofilm agents as an efficient strategy to control bacterial infection. Res J Pharm Technol. 2020; 13(11): 5601–5606.
47. Ulpiyah Z, Shita ADP, Wahyukundari MA. Inhibition of namnam (Cynometra cauliflora L.) leaves extract on the growth of Porphyromonas gingivalis. Padjadjaran Journal of Dentistry. 2019; 31(2): 106.
48. Hendra H, Moeljopawiro S, Nuringtyas TR. Antioxidant and antibacterial activities of agarwood (Aquilaria malaccensis Lamk.) leaves. AIP Conf Proc. 2016; 1755.
49. Khalil AS, Rahim AA, Taha KK, Abdalla KB. Characterization of Methanolic Extracts of Agarwood Leaves. Journal of Applied and Industrial Sciences. 2013; 1(3): 78. Available from: https://www.researchgate.net/publication/260087376
50. Hashim YZH-Y, Ali NJ, Zainurin NAA, Abbas P. Profiling of Compounds in Hydrosol extract of Aquilaria (Agarwood) SPECIES using Gas Chromatography-Mass Spectrometry (GCMS). Hashim et al Biological And Natural Resources Engineering Journal 2021;5(1).
51. Aparna V, Dileep K V., Mandal PK, Karthe P, Sadasivan C, Haridas M. Anti-Inflammatory Property of n-Hexadecanoic Acid: Structural Evidence and Kinetic Assessment. Chem Biol Drug Des. 2012; 80(3): 434–439.
52. Widyasanti A, Ariva AN. Karakteristik Fisik, Kimia dan Organoleptik Sabun Cair Pencuci Tangan Handmade Berbahan Ampas Sisa Kopi Ekspresso. Agrisaintifika : Jurnal Ilmu-Ilmu Pertanian. 2020; 4(2): 105–110.
53. Yusan LY, Nailufa Y, Suryadhi. Pembuatan Handwash: Peningkatan Kualitas Sabun UMKM. 1st ed. Surabaya: Scopindo Media Pustaka, 2022; Available from: www.scopindo.com