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Chemical Composition and Antibacterial Activity of *Plumeria alba* L., *Polianthes tuberosa* L., and *Cananga ordorata* L. Flowers Essential Oils as Bioadditives in Transparent Solid Bath Soap

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ABSTRACT. This study aimed to analyze the chemical components and antibacterial activity of essential oils from *kamboja* (*Plumeria alba* L.), *sedap malam* (*Polianthes tuberosa* L.), and *kenanga* (*Cananga ordorata* L.) flowers against *Staphylococcus aureus* ATTC 25923. Additionally, the study explored the application of these essential oils as bio additives in transparent solid bath soap. The research consisted of several stages: isolation and identification of chemical components of essential oils using the GC-MS Method, transparent solid bath soap formulation, antibacterial activity test of essential oils and transparent solid bath soaps against *Staphylococcus aureus* ATTC 25923, organoleptic test (color, aroma, transparency, solidity, and foam) and quality test of transparent solid bath soaps (pH, water content, foam stability, saponification number, and transparency). The essential oils extracted from *kamboja, sedap malam*, and *kenanga* flowers were found to contain 17, 20, and 20 compounds, respectively. Based on the result of GC-MS analysis showed that the predominant chemical components in each essential oil were 1,1'-oxydi-2-propanol (21.01%) for *kamboja,* benzyl ethanoate (24.52%) for *sedap malam*, and caryophyllene (43.77%) for *kenanga.* Transparent solid bath soaps with the highest antibacterial activity against *S. aureus* ATTC 25923 were obtained in the formula added with *kamboja, sedap malam* and *kenanga* flowers essential oils at 3.0%, 3.0%, and 3.0%, respectively, with respective inhibitory power of 14.48 mm (strong), 13.73 mm (strong) and 13.56 mm (strong) in diameter. Organoleptic tests revealed that each soap type exhibited characteristic of the respective flower. All soap types demonstrated good quality based on parameters such as pH, water content, foam stability, saponification number and transparency.

Keywords: *Cananga ordorata* L., essential oil, *Plumeria alba* L., *Polianthes tuberosa* L., transparent solid bath soap

INTRODUCTION

Indonesia has the second-highest land biodiversity globally, surpassed only by Brazil, and houses approximately 25% of the world's flowering plant species. The country ranks seventh in terms of the number of flowering plant species, with 20,000 species, of which 40% are unique to or indigenous to Indonesia (Kusmana & Hikmat, 2015). It is rich in diverse local flowers, such as *kamboja* (*Plumeria alba* L.), *sedap malam* (*Polianthes tuberosa* L.), and *kenanga* (*Cananga ordorata* L.). Notably, all three, in addition to serving as natural fragrances instead of synthetic alternatives, have antibacterial properties due to the compounds present in the essential oils derived from each flower. These three flowers, abundantly found in Indonesia, have not been fully optimized, particularly in their use as additives for bath soap with fragrance and antibacterial properties.

Soap serves as a self-cleaning agent, effectively removing dirt from the skin's surface and thereby preventing various diseases caused by bacteria. Its indispensable role in personal hygiene makes it a necessity for almost every individual (Rahmi, 2020). As the population increases, the demand for soap is expected to rise accordingly (Widyasanti et al., 2017). In 2020, Indonesia witnessed a notable 304% increase in soap consumption, contributing to a 4.67% growth in demand within the soap chemical industry (Azhari & Lesmana, 2022).

An innovative product in the realm of bath soaps is transparent solid bath soap, designed to enhance the appeal of traditional soap products. Distinguished by its clear color, glossy surface, and the production of softer foam compared to non-transparent alternatives, transparent solid bath soap is valued for its moisturizing properties that promote skin health and facial beauty (Sukeksi et al., 2018; Widyasanti & Hasna, 2016). Consumers are increasingly drawn to transparent solid bath soap due to these advantages, leading to its growing popularity (Lubena et al., 2022). Beyond its functional benefits, the attractive shape and color of transparent solid bath soap also make it a popular choice for decoration, souvenirs, and room fresheners (Uzwatania et al., 2020).

In contemporary times, there is a public preference for antibacterial soap, believed to effectively cleanse the skin and prevent diseases caused by bacteria (Pananginan et al., 2020). Among pathogenic bacteria, *Staphylococcus aureus* stands out, naturally inhabiting the skin surface and contributing to 80% of skin surface diseases. Many commercially available soaps contain the antibacterial substance triclosan, a synthetic active ingredient. Triclosan, however, poses adverse effects on the body, including disruptions to brain growth and reproduction hormones, antibiotic resistance, and the elimination of normal skin flora (Noordia & Nurita, 2018). Given the negative impacts associated with synthetic antibacterial substances, the substitution of synthetic ingredients with natural alternatives possessing antibacterial properties becomes crucial. Essential oils are one such natural ingredient that can serve this purpose. Essential oils contain antibacterial compounds, making them suitable for integration into bath soap. Additionally, essential oils offer the benefit of acting as natural fragrances, replacing synthetic counterparts to provide a pleasing aroma in bath soap (Hidayati & Khaerunisa, 2018).

According to research findings Erliyanti et al. (2020), *kamboja* flower essential oil serves as a fragrance due to the presence of compounds such as farsenol, geraniol, phenethyl alcohol, citronellol, and linalool. *Sedap malam*, and *kenanga* flowers can be utilized in the form of essential oils for aromatherapy and as fragrances (Rugayah et al., 2017). In addition to their aromatic qualities, *kamboja, sedap malam* and *kenanga* flowers act as antibacterials due to the compounds found in their essential oils. *Kamboja* flowers, for instance, contain fulvoplumierin, a compound with antibacterial properties (Nurcahyo & Purgiyanti, 2017). *Sedap malam* flowers contain alcohol group compounds, such as benzyl alcohol, eugenol, and linalool, known for their antibacterial effects (Hetik et al., 2013). *Kenanga* flowers, rich in antibacterial compounds like polyphenols, *ß*-karyophyllene, *α*-terpineol, and *ß*-linalool, also contribute to antibacterial activity (Pujiarti et al., 2015). The primary objective of this research is to identify the chemical components and antibacterial activity of essential oils extracted from kamboja (*P. alba* L.), sedap malam (*P. tuberosa* L.), and kenanga (*C. ordorata* L.) flowers against *Staphylococcus aureus* ATTC 25923, as well as to explore their application as bio additives in transparent solid bath soap.

EXPERIMENTAL SECTION

Plant Materials

Kamboja (*P. alba* L.), sedap malam (*P. tuberosa* L.), and kenanga (*C. ordorata* L.) flowers were sourced from Mojosongo, Jebres, Surakarta, Jawa Tengah Indonesia (110 45′ 15″ - 110 45′ 35″ East Longitude and 70′ 36″ – 70′ 56″ South Latitude). The identification of plants was conducted at the Biology Department of the FMIPA of Universitas Sebelas Maret, Surakarta.

Sample Preparation

The samples, consisting of *kamboja* (*P. alba* L.), *sedap malam* (*P. tuberosa* L.), and *kenanga* (*C. ordorata* L.) were collected and carefully sorted to ensure good quality from Mojosongo, Jebres, Surakarta, Jawa Tengah, Indonesia. Subsequently, the fresh sample weights of *kamboja* (3600 g), *sedap malam* (3400 g), and *kenanga* (3300 g) were washed, finely chopped, and left to dry, each dried sample of *kamboja, sedap malam and kenanga* had a weight of 2000 g and then covered with a thin black cloth for a period of 4 days. Following the drying process, the samples were stored in a jar, prepared for essential oil isolation (Ariani et al., 2021; Ariani,t al., 2022).

Isolation of Essential Oils

The essential oil from each flower was extracted using the Steam-Water Distillation method. In this process, a 2.0 kg dry weight (DW) of each sample was placed in a distillation kettle, undergoing four cycles of distillation, each lasting 6 hours with 500 grams of the sample. The obtained *P. alba* L., *P. tuberosa* L., and *C. ordorata* L., essential oils were then separated from residual water using anhydrous Na_2SO_4 and subsequent filtration. The volume of each isolated essential oil was measured, while its color and aroma were observed for quality assessment (Ariani, et al., 2022; Ariani, et al., 2023; Chilviana et al., 2022).

Identification of Chemical Components of Essential Oils Using the GC-MS Method

Identification of chemical components of *P. alba* L., *P. tuberosa* L., and *C. ordorata* L. flowers essential oils using GC-MS QP-2010 SE Shimadzu instrument, featuring an MS detector. The analysis employed helium as the carrier gas with a flow rate of 0.75 ml/minute and utilized an Rtx-5MS capillary column with a diameter of 0.25 mm, a length of 30 m, and a thickness of 0.25 μm. The instrument settings included an interface temperature of 250°C and injector and detector temperature of 200°C. The column temperature was programmed, starting at 60°C and gradually increased at a rate of 10°C/minute until it reached the final temperature of 200°C. Next, the mass spectrum of the chemical components obtained were identified by comparing it with the data bank in the Wiley7 Library (Ariani, et al., 2023; Guimaraes et al., 2019; Habibi, 2020).

Transparent Solid Bath Soap Formulation

The formulation of transparent solid bath soap can be seen in **Table 1** below.

Antibacterial Activity Test of Essential Oils and Transparent Solid Bath Soaps Against *Staphylococcus aureus* ATTC 25923

The evaluation of antibacterial activity against *S. aureus* ATCC 25922 was conducted on *kamboja, sedap malam* and *kenanga* flowers essential oils, as well as the complete formulation of transparent solid

Table 1. Transparent solid bath soap formulation

Materials	Composition (%)										
	F1	F2	F3	F4	F5	F6	F7	F8	F9	F10	F11
Basic soap	100.0	99.0	99.0	99.0	97.0	97.0	97.0	95.0	95.0	95.0	
Essential oil added:											
1.0% *Kamboja*	-	1.0	-	-	-	-	-	-	-	-	
1.0% *Sedap malam*	-	-	1.0	-	-	-	-	-	-	-	UNKNOWN
1.0% *Kenanga*	-	-	-	1.0	-	-	-	-	-	-	
3.0% *Kamboja*	-	-	-	-	3.0	-	-	-	-	-	
3.0% *Sedap malam*	-	-	-	-	-	3.0	-	-	-	-	
3.0% *Kenanga*	-	-	-	-	-	-	3.0	-	-	-	
5.0% *Kamboja*	-	-	-	-	-	-	-	5.0	-	-	
5.0% *Sedap malam*	-	-	-	-	-	-	-	-	5.0	-	
5.0% *Kenanga*	-	-	-	-	-	-	-	-	-	5.0	

Notes: Basic soap: coconut oil (20 mL), palm oil (6 mL), olive oil (6 mL), stearic acid (6.8 g), NaOH 30% (6 g), distilled water (14 mL) , ethanol (15 mL), glycerin (10 mL), sucrose (13.5 g), distilled water (13.5 mL) and NaCl (0.4 g)

bath soaps. The paper disc diffusion method (Kirby Bauer) was employed for the test, with 20 μg/mL vancomycin as the positive control and distilled water as the negative control. The diameter of the inhibition zone was measured using a caliper around the blank disc. This method allows for a comprehensive assessment of the antibacterial efficacy of the essential oils and the bath soap formulation (Ariani et al., 2023; Ariani et al., 2022; Handayani et al., 2021; Mith et al., 2014; Salni & Marisa, 2020).

Organoleptic Test of Transparent Solid Bath Soaps

The organoleptic test of transparent solid bath soap included color, aroma, transparency, solidity and foam (Karimah & Kristiana, 2020; Supriadi & Cahyani, 2022).

Quality Test of Transparent Solid Bath Soaps

The soap quality test included pH, water content, foam stability, saponification number, and transparency. The pH test was carried out using a pH meter (Lubena et al., 2022; Prasetiyo et al., 2020). The water content test was done using the gravimetric method (Surilayani et al., 2019). Foam stability test was performed using the Cylinder Shake method (Leny et al., 2022; Sukeksi et al., 2021; Sukmawati et al., 2017). Testing the saponification number run under the titration method (Sukeksi et al., 2018). The transparency test was carried out by placing 0.25 inch thick soap on paper with writing in font sized 14 (Wibowo, 2014).

RESULTS AND DISCUSSION

Plant Determination

Plant determination in this research was carried out at the Biology Department, FMIPA, Universitas Sebelas Maret. The results obtained from plant determination stated that the samples used in this research were truly *P. alba* L. (registration number 076/UN27.9.6.4/Lab/2023), *P. tuberosa* L. (registration number 060/UN27.9.6.4/Lab/2023), and *C. odorata* L. (registration number 037/UN27.9.6.4/Lab/2023).

Isolation of Essential Oils

The results of testing the characteristics and content of each sample's essential oil can be seen in **Table 2.**

Identification of Chemical Components of Essential Oils Using the GC-MS Method

The chemical components of *kamboja* flower essential oil

The GC chromatogram of *kamboja* flower essential oil can be seen in **Figure 1.** The chemical components in *kamboja* flower essential oil are presented in **Table 3.**

Table 2. Results of testing the characteristics and contents of isolated essential oils.

Flower	Weight (g)	Essential Oil			
		Volume (mL)	Color	Aroma	Content (mL/g)
Kamboja	2000	29.40	Yellow	Kamboja	0.0147
Sedap malam	2000	25.30	Dark yellow	Sedap malam	0.0127
Kenanga	2000	21.34	Light yellow	Kenanga	0.0107

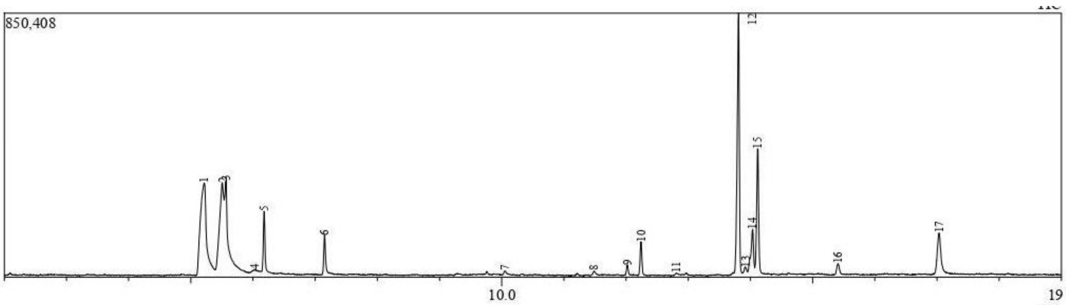


Figure 1. The GC chromatogram of *kamboja* flower essential oil

The GC-MS identified 17 compounds in *kamboja* essential oil, with 1,1′-oxydi-2-propanol being the predominant compound, constituting 21.01% of the essential oil composition. 1,1'-oxydi-2-propanol is a natural compound which belongs to the alcohol ether group which is also found in many tobacco (*Nicotiana tabacum*) essential oil. The compound structure of 1,1′-oxydi-2-propanol is depicted in **Figure 2.**

The essential oil content of *kamboja* flower in this study can be seen in **Table 3**. Erliyanti et al. (2020) stated that *kamboja* flower essential oil contained farsenol, geraniol, phenethyl alcohol, citronellol, and linalool. The same chemical content in the essential oils of the two *kamboja* flowers was linalool. The differences in the chemical content of essential oils from the same species but growing in different locations are caused by differences in the growing environmental factors of the two types of *kamboja* plants, such as light intensity, temperature, soil fertility, humidity, and rainfall (de Sa Filho et al., 2022; Luz et al., 2020; Stevovic et al., 2011).

The chemical components of *sedap malam* essential oil

The GC chromatogram of *sedap malam* flower essential oil can be seen in **Figure 3.** The chemical components of *sedap malam* flower essential oil are presented in **Table 4.**

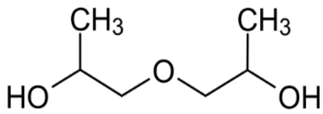


Figure 2. 1,1′-Oxydi-2-propanol

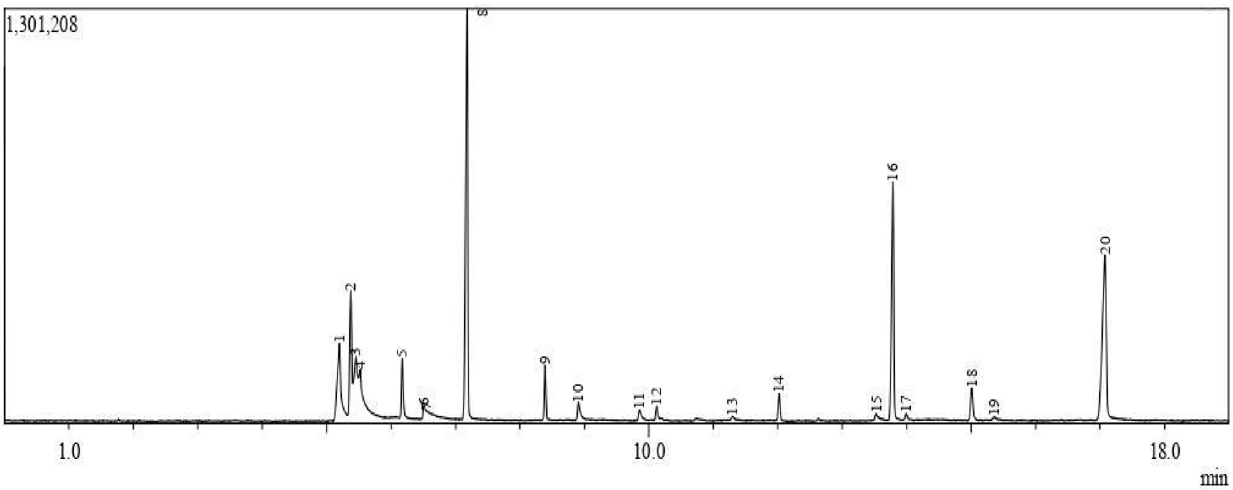


Figure 3. The GC chromatogram of *sedap malam* flower essential oil

Table 3. The result of identifying chemical components of *kamboja* flower essential oil

Peak No	Simmilarity Index	Retention Time (Minute)	Retention Index Lit.	% Area	Molecular Weight	Data MS : m/z (Relative Intensity)									Compound Name
1	96	5.216	1037	21.01	134	45 (100)	47 (15)	55 (5)	59 (52)	61 (3)	69 (2)	71 (8)	89 (48)	115 (2)	1,1'-Oxydi-2-propanol
2	95	5.505	1064	14.45	192	41 (25)	43 (12)	45 (30)	55 (2)	57 (8)	59 (100)	61 (4)	75 (3)	103 (25)	Tripropylene glycol
3	95	5.564	1075	12.94	192	41 (25)	42 (13)	43 (15)	45 (30)	57 (5)	58 (4)	59 (100)	72 (2)	103 (20)	1,1'-(propylenedioxy)dipropan-2-ol
4	86	6.020	1094	0.52	162	41 (28)	42 (3)	43 (12)	45 (48)	55 (2)	57 (8)	59 (100)	85 (2)	103 (28)	Dibutylene glycol
5	99	6.179	1102	3.74	154	43 (88)	51 (5)	55 (68)	69 (45)	71 (100)	80 (35)	83 (18)	93 (70)	121 (18)	L-Linalool
6	97	7.151	1174	2.50	150	43 (60)	51 (20)	63 (8)	65 (25)	79 (35)	88 (2)	91 (78)	105 (5)	108 (100)	Benzyl ethanoate
7	95	10.047	1186	0.30	156	41 (15)	53 (2)	56 (13)	69 (3)	83 (2)	85 (100)	100 (3)	114 (2)	128 (2)	Prunolide
8	96	11.486	1192	0.31	170	41 (15)	53 (3)	55 (13)	69 (4)	81 (3)	85 (100)	95 (3)	100 (4)	110 (2)	α -Hexyl-γ –utyrolacton
9	95	12.020	1269	0.67	220	41 (18)	57 (40)	81 (7)	91 (15)	105 (13)	161 (5)	177 (15)	205 (100)	220 (28)	Ional
10	93	12.240	1294	2.18	204	41 (28)	77 (8)	91 (38)	105 (18)	117 (35)	131 (50)	189 (100)	190 (10)	204 (25)	Lily aldehyde
11	90	12.805	1378	0.23	192	50 (3)	51 (18)	63 (4)	77 (35)	105 (5)	122 (4)	135 (100)	164 (5)	192 (20)	Helional
12	97	13.809	1394	20.38	226	41 (24)	53 (5)	55 (24)	67 (10)	83 (100)	96 (8)	109 (4)	137 (2)	153 (20)	Dihydro methyl jasmonate
13	75	13.916	1447	0.58	150	41 (58)	43 (60)	53 (19)	79 (80)	91 (51)	103 (2)	105 (100)	107 (88)	117 (12)	Myrtenal
14	87	14.034	1556	4.51	220	41 (60)	55 (100)	67 (78)	68 (5)	82 (88)	92 (28)	120 (90)	121 (85)	138 (40)	Hexenyl salicylate
15	82	14.117	1670	9.08	208	41 (23)	43 (28)	65 (18)	81 (4)	92 (18)	109 (3)	120 (100)	122 (3)	138 (40)	Isoamyl salicylate
16	73	15.409	1743	1.01	225	41 (25)	68 (80)	81 (22)	115 (55)	116 (18)	129 (75)	130 (100)	155 (25)	168 (20)	4-(4-Propyl-1-cyclohexen-1-yl)benzonitrile
17	94	17.034	1857	5.59	228	41 (2)	51 (4)	65 (15)	77 (3)	91 (100)	92 (10)	121 (3)	228 (5)	229 (2)	Benzyl o-hydroxybenzoate

Chemical Component Group:	
Alcohol (Numbers 1, 2,3, 4, 5, 9)	53.33 %
Esther (Numbers 6, 12, 14, 15, and 17)	42.06 %
Aldehyde (Numbers 7, 10,11, and 13)	3.29 %
Nitril (Number 16)	1.01 %
Ketone (Number 8)	0.31 %
Total identified chemical components	100.00 %

Table 4. The result of identifying chemical components of *sedap malam* flower essential oil

Peak No	Simmilarity Index	Retention Time (Minute)	Retention Index Lit.	% Area	Molecular Weight	Data MS : m/z (Relative Intensity)										Compound Name
1	96	5.199	1037	8.24	134	42 (60)	43 (35)	45 (100)	47 (15)	59 (50)	61 (3)	71 (5)	72 (4)	83 (2)	89 (45)	1,1'-Oxydi-2-propanol
2	97	5.374	1043	7.70	108	40 (3)	51 (28)	55 (2)	61 (3)	73 (2)	77 (58)	79 (100)	91 (15)	107 (48)	108 (70)	Phenylmethyl alcohol
3	93	5.455	1064	6.47	134	41 (22)	42 (10)	43 (12)	45 (30)	57 (5)	58 (5)	59 (100)	75 (2)	77 (3)	103 (20)	Tripropylene glycol
4	95	5.519	1097	6.19	134	41 (22)	42 (8)	43 (12)	45 (32)	57 (5)	58 (3)	59 (100)	75 (2)	103 (28)	104 (3)	Dipropylene glycol
5	97	6.173	1102	3.09	154	41 (83)	43 (85)	53 (15)	55 (68)	67 (13)	69 (45)	71 (100)	80 (33)	93 (70)	121 (18)	L-Linalool
6	97	6.506	1117	0.81	122	41 (3)	49 (4)	51 (8)	63 (5)	65 (25)	77 (18)	89 (15)	91 (100)	92 (58)	122 (23)	Phenethyl alcohol
7	30	6.550	1157	0.39	150	53 (15)	62 (63)	69 (10)	81 (39)	84 (41)	96 (25)	122 (100)	123 (59)	151 (18)	152 (28)	9-9-Dideuteropyrazolyl(4,5) cyclooctane
8	97	7.178	1174	24.52	150	43 (60)	51 (18)	63 (8)	65 (25)	74 (3)	75 (2)	79 (35)	91 (70)	108 (100)	150 (28)	Benzyl ethanoate
9	98	8.391	1267	2.43	273	41 (53)	43 (88)	53 (10)	55 (25)	67 (15)	69 (28)	71 (18)	80 (40)	93 (100)	121 (25)	Linalyl anthranilate
10	97	8.909	1294	1.24	172	41 (25)	43 (58)	55 (15)	59 (100)	69 (13)	71 (38)	81 (10)	96 (10)	111 (3)	121 (4)	Lilyl aldehyde
11	96	9.856	1343	0.88	151	41 (5)	52 (8)	63 (10)	64 (13)	65 (40)	76 (2)	92 (70)	119 (100)	121 (5)	151 (50)	Methyl o-aminobenzoate
12	91	10.122	1354	0.86	178	43 (50)	51 (8)	63 (3)	65 (13)	77 (10)	91 (45)	103 (7)	105 (9)	117 (100)	118 (80)	Hydrocinnamyl acetate
13	93	11.300	1365	0.23	164	41 (8)	55 (43)	77 (50)	91 (40)	103 (41)	121 (25)	131 (28)	149 (35)	164 (100)	165 (10)	p-Eugenol
14	95	12.021	1483	1.38	220	41 (19)	57 (40)	67 (5)	81 (8)	91 (10)	105 (12)	145 (6)	177 (5)	205 (100)	220 (30)	Topanol
15	94	13.523	1604	0.52	170	43 (11)	51 (8)	63 (15)	77 (16)	87 (3)	101 (9)	115 (55)	127 (100)	155 (88)	170 (45)	Methyl 2-naphthyl ketone
16	96	13.786	1645	14.43	202	41 (28)	51 (15)	65 (18)	77 (25)	91 (98)	115 (95)	117 (93)	129 (100)	145 (50)	202 (35)	Jasminaldehyde
17	89	13.992	1687	0.35	202	41 (30)	51 (19)	65 (11)	77 (25)	91 (98)	115 (100)	117 (95)	129 (85)	145 (50)	202 (35)	Amyl cinnamic aldehyde diethyl acetal
18	96	15.010	1747	2.25	216	41 (33)	55 (18)	77 (20)	91 (95)	104 (15)	115 (90)	129 (100)	145 (45)	159 (10)	216 (30)	2-Hexyl-3-phenyl-2-propenal
19	85	15.365	1760	0.18	212	41 (3)	51 (25)	65 (18)	77 (40)	90 (10)	91 (58)	105 (100)	122 (2)	167 (9)	194 (15)	Benzyl benzoate
20	95	17.076	1857	17.84	228	41 (1)	51 (4)	63 (5)	65 (18)	77 (2)	89 (3)	91 (100)	92 (2)	121 (6)	150 (1)	Benzyl o-hydroxybenzoate

Chemical Component Group :	
Esther (Numbers 8, 9, 11, 12, 19, and 20)	46.71 %
Alcohol (Numbers 1, 2, 3, 4, 5, 6, 13, and 14)	34.11 %
Aldehyde (Numbers 10, 16, and 18)	17.92 %
Ketone (Number 15)	0.52 %
Pyrazole (Number 7)	0.39 %
Eter (Number 17)	0.35 %
Total identified chemical components	100.00 %

Table 5. The result of identifying chemical components of *kenanga* essential oil

Peak No	Simmilarity Index	Retention Time (Minute)	Retention Index Lit.	% Area	Molecular Weight	Data MS : m/z (Relative Intensity)										Compound Name
1	96	5.119	1031	0.58	122	41 (2)	51 (21)	63 (10)	77 (65)	91 (30)	107 (40)	108 (4)	121 (50)	122 (100)	128 (2)	p-Methoxytoluene
2	99	6.177	1102	11.76	154	41 (80)	43 (83)	55 (65)	59 (5)	69 (43)	71 (100)	80 (30)	83 (7)	93 (71)	121 (18)	L-Linalool
3	97	10.196	1353	1.55	196	41 (71)	43 (67)	53 (2)	67 (18)	69 (100)	77 (1)	80 (13)	93 (25)	121 (15)	136 (8)	Geranyl ethanoate
4	95	10.259	1377	1.38	204	41 (33)	43 (8)	55 (23)	67 (10)	77 (7)	81 (30)	93 (50)	105 (100)	119 (97)	161 (70)	α-Copaene
5	95	10.452	1397	0.63	204	41(85)	55 (50)	65 (18)	67 (77)	81 (98)	93 (100)	107 (58)	119 (36)	147 (35)	161 (40)	β-Elemene
6	97	10.945	1416	43.77	204	41 (100)	55 (38)	67 (37)	69 (76)	77 (35)	79 (63)	91 (68)	93 (79)	120 (30)	133 (60)	Caryophyllene
7	93	11.023	1431	0.42	204	41 (43)	55 (25)	67 (18)	77 (28)	79 (35)	91 (60)	105 (65)	119 (38)	133 (18)	161 (100)	Germacrene-D
8	97	11.385	1449	10.55	204	41 (28)	51 (3)	67 (15)	79 (20)	80 (35)	93 (100)	105 (22)	121 (25)	147 (14)	161 (2)	Humulene
9	90	11.629	1475	1.84	204	41 (64)	43 (15)	53 (19)	55 (28)	67 (25)	69 (23)	79 (60)	119 (78)	133 (30)	161 (100)	α-Amorphene
10	94	11.736	1481	8.33	204	41 (65)	55 (33)	67 (28)	77 (45)	79 (33)	91 (80)	105 (90)	119 (51)	133 (29)	161 (100)	Germacrene-A
11	94	11.881	1511	1.57	204	41 (13)	43 (20)	55 (58)	69 (53)	79 (50)	91 (45)	93 (100)	107 (40)	119 (38)	135 (4)	Farnesene
12	91	11.943	1512	5.57	204	41 (68)	43 (26)	55 (30)	69 (31)	79 (32)	91 (40)	93 (100)	107 (48)	119 (60)	133 (10)	α-Bergamotene
13	92	12.135	1514	0.68	204	41 (48)	43 (11)	55 (20)	67 (15)	77 (30)	91 (58)	105 (65)	119 (45)	133 (28)	161 (100)	γ-Cadinene
14	95	12.220	1528	4.00	204	41 (49)	55 (22)	69 (15)	81 (43)	91 (58)	105 (85)	119 (90)	134 (70)	161 (100)	204 (48)	Δ-Cadinene
15	95	13.096	1580	1.43	220	41 (100)	43 (92)	55 (43)	69 (50)	79 (75)	93 (58)	105 (29)	109 (30)	121 (18)	135 (5)	Caryophyllene oxide
16	85	13.416	1604	0.39	220	41 (65)	43 (100)	53 (28)	67 (80)	77 (25)	79 (35)	81 (27)	96 (66)	109 (63)	138 (34)	Humulene oxide
17	80	13.601	1623	0.31	222	41 (48)	55 (38)	69 (25)	77 (19)	82 (40)	93 (28)	105 (78)	119 (100)	147 (8)	161 (65)	Diepi- α -cedrene
18	90	13.783	1645	1.50	222	41 (48)	43 (100)	55 (30)	69 (28)	79 (40)	95 (75)	105 (42)	119 (38)	134 (8)	161 (62)	Torreyol
19	87	13.938	1653	1.43	222	43 (100)	55 (27)	57 (22)	71 (32)	79 (40)	81 (39)	95 (99)	105 (35)	121 (70)	161 (30)	α -Cadinol
20	99	15.352	1760	2.31	212	41 (2)	51 (20)	63 (4)	65 (15)	77 (40)	90 (8)	91 (55)	105 (100)	194 (10)	212 (15)	Benzyl benzoate

Chemical Component Group :	
Hydrocarbon Sesquiterpene (Numbers 5, 6, 7, 8, 9, 10, 11, 12,	77.36 %
13, and 14)	13.19 %
Alcohol (Numbers 2 and 19)	5.36 %
Esther (Numbers 3, 18, and 20)	2.13 %
Oxygeneted Sesquiterpene (Numbers 15, 16, and 17)	1.38 %
Alkene (Number 4)	0.58 %
Eter (Number 1)	100 %
Total identified chemical components	

According to the GC-MS identification, *sedap malam* flower essential oil consists of 20 compounds, with benzyl ethanoate being the predominant compound, constituting 24.52% of the essential oil composition. Benzyl ethanoate is a naturally occurring compound in flowers and is commonly used as an additive in perfumes, soaps, and cosmetic products (Hetik et al., 2013; Rugayah et al., 2017). The structure of benzyl ethanoate is illustrated in **Figure 4.** When compared with research Hetik et al. (2013), there were several compounds contained in *sedap malam* flower essential oil that were same, namely compounds in the alcohol group (benzal alcohol, eugenol, and linalool). This difference is because the samples used by researchers were obtained from the Mojosongo, Jebres, Surakarta, Jawa Tengah, whereas in the research of Hetik et al. (2013), *sedap malam* flower was obtained from Rembang, Pasuruan, Jawa Timur. Benzyl ethanoate, also known as benzyl acetate, is a compound that belongs to the fragrance group and the simple acid ester group. This compound is commonly found in flowers, imparting a fragrant aroma. Therefore, whether in its pure form or as an essential oil, it is frequently utilized as an ingredient in perfumes and cosmetics (McGinty et al., 2012; Sahlan & Rahman, 2016).

The chemical components of *kenanga* flower essential oil

The GC chromatogram of *kenanga* flower essential oil can be seen in **Figure 5.** The chemical components of *kenanga* flower essential oil are presented in **Table 5.** According to the GC-MS identification, *kenanga* flower essential oil comprises 20 compounds, with caryophyllene being the predominant compound, constituting 43.77% of the essential oil composition. The results of research by Pujiarti et al. (2015) revealed that *kenanga* flower essential oil from the Boyolali area contains chemical components, including caryophyllene (36,44%), â-linalool (5,97%), á-caryophyllene (9,61%), germacrene D (17,23%), dan benzyl benzoate (7,18%). The essential oil of *C. ordorata* L. flower from Surakarta and Boyolali contains the same main chemical component, namely caryophyllene, with different levels for each, namely 43.77% and 36.44% respectively. Santos et al. (2021) in their research stated that caryophyllene shows antibacterial activity against *S. aureus* and can strengthen the action of norfloxacin against *S. aureus*, *P. aeruginosa* and *E. coli*. Caryophyllene and its derivatives find various applications, including medicinal and perfumery uses. The structure of caryophyllene is depicted in **Figure 6.**

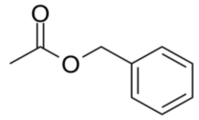


Figure 4. Benzyl ethanoate

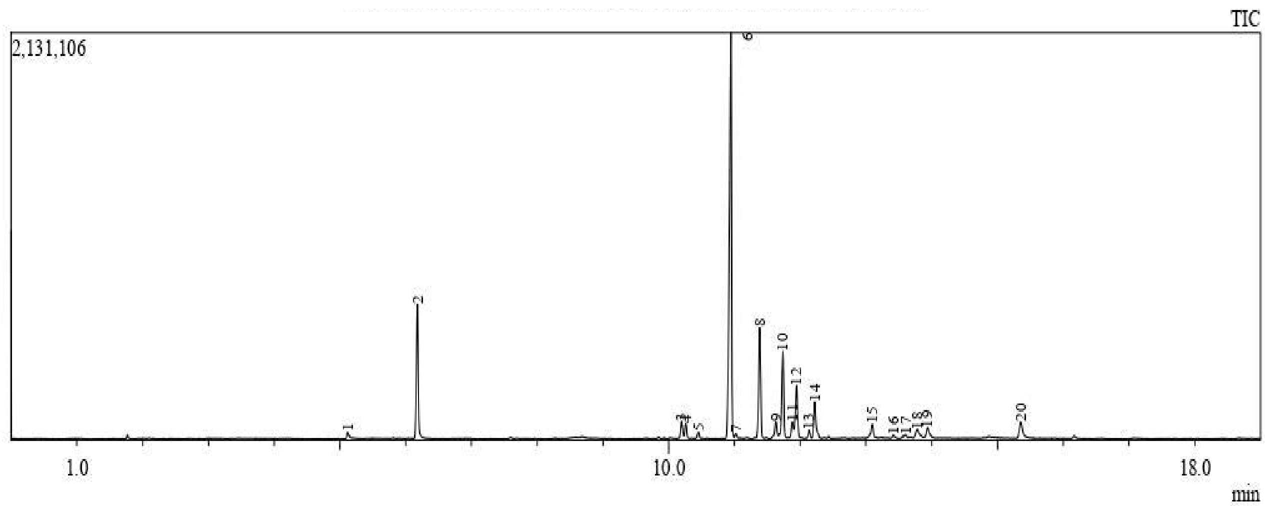


Figure 5. The GC chromatogram of *kenanga* flower essential oil

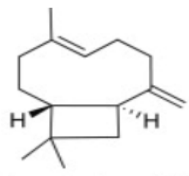


Figure 6. Caryophyllene

Antibacterial Activity Test of Essential Oils Against *Staphylococcus aureus* ATCC 25923

In this study, antibacterial activity was calculated based on the diameter of the inhibition zone formed in each treatment group. Not calculating MIC because it is adjusted to the daily use of soap that used 100% soap concentration (without going through the dilution process). The results of the antibacterial activity test of essential oils *against S. aureus* ATCC 25923 bacteria are presented in **Table 6.**

The antibacterial activities are categorized based on the diameter of the inhibition zone formed: weak (diameter < 5.00 mm), medium (diameter = 5.00-10.00 mm), strong (diameter = 10.00-20.00 mm), and very strong (diameter > 20.00 mm) (Atun et al., 2020; Davis & Stout, 1971; Haque et al., 2022). The antibacterial activity test on the three types of flowers and all transparent solid bath soap products against the growth of *S. aureus* ATCC 25922 bacteria was carried out using the paper disc diffusion method. In this study, researchers used a positive control in the form of a paper disk containing 20 µg/mL of vancomycin/disk. The positive control was used to compare the inhibition zones with each other, while the negative control used was distilled water which has no inhibitory power against bacteria. Vancomycin was used as a positive control because it is a broad spectrum antibiotic that is active against gram-positive bacteria (Zhang et al., 2023). *S. aureus* ATCC 25922 is a gram-positive bacteria in the form of a coccus. The way the antibiotic vancomycin works in killing bacteria is by inhibiting the synthesis of peptidoglycan from cell wall components by binding to the terminal D-ananyl-D-alanine of the peptidoglycan formed (Garde et al., 2021; Wang et al., 2018). In this study, the inhibition zone of vancomycin as a positive control was 13.03 mm (strong). *Kamboja, sedap malam and kenanga* flowers essential oils showed larger inhibition zones than the positive control, respectively 15.16 (strong), 14.61 mm (strong) and 14.32 mm (strong).

The ability of an essential oil as an antibacterial is related to the chemical components it contains. The results of this study indicated that *kamboja, sedap malam and kenanga* contain 1,1'-Oxydi-2-propanol, benzyl ethanoate and caryophyllene with levels of 21.01%, 24.52% and 43.77% respectively. %. 1,1'-Oxydi-2-propanol is an alcohol group compound, benzyl ethanoate is an ester compound and caryophyllene is an alkene compound. This is in accordance with the theory which states that based on the functional groups in chemical compounds, the order of compounds according to the level of antibacterial activity is alcohol> ester> hydrocarbon (Romero et al., 2015). The results of this study also showed that the antibacterial activity of *kamboja* oil is contributed by compounds from the alcohol (53.33%), esther (24.06%), and aldehyde (5.29%) groups; *sedap malam* oil's antibacterial activity is contributed by compounds from the ester (46.71%), alcohol (34.11%), aldehyde (17.92%), and ketone (0.53%) groups; and the antibacterial activity of *kenanga* oil is contributed by compounds from the alcohol (13.19%), esther (5.36%), and oxygenated sesquiterpene (2.13%) groups.

Antibacterial Activity Test of Transparent Solid Bath Soaps Against *Staphylococcus aureus* ATCC 25923

The results of the antibacterial activity test of transparent solid bath soaps against *Staphylococcus aureus* ATCC 25923 are presented in **Table 7.** In this research, the basic transparent solid bath soap (F1) used did not contain any additional essential oils. This research also investigated a sample of freely traded transparent solid bath soaps (F11), whose brand was kept undisclosed, to compare the soaps produced in this research with those that have been marketed and used by consumers.

The transparent solid bath soap containing any essential oil from *kamboja, sedap malam and kenanga* flowers essential oils with a concentration of 1.0%, exhibited an improvement compared to the basic soap. Furthermore, the addition of *kamboja, sedap malam and kenanga* flowers essential oils with a concentration of 3.0% demonstrated a further enhancement compared to both the basic soap and the soap containing essential oil as much as 1.0%. However, incorporating any essential oil from those flowers with a concentration of 5.0% showed an increase compared to the basic soap containing essential oil as much as 1.0% but resulted in a decrease when compared to the addition of essential oil as much as 3.0%. Notably, all soap products with the addition of any essential oil of *kamboja, sedap malam and kenanga* flowers essential oils with a concentration of 3.0% displayed optimal results.

Table 6. The antibacterial activity test of essential oils *against Staphylococcus aureus* ATCC 25923 bacteria

No	Flower Essential Oil	Inhibition Zone (mm)			Average	Category
		1	2	3		
1.	*Kamboja*	15.15	15.18	15.14	$15.16^{c} \pm 0.02$	Strong
2.	*Sedap malam*	14.63	14.62	14.59	$14.61^{b} \pm 0.02$	Strong
3.	*Kenanga*	14.31	14.34	14.32	$14.32^{a} \pm 0.02$	Strong
4.	Positive Control	13.03	13.03	13.03	$13.03^{b} \pm 0.00$	Strong
5.	Negative Control	0.00	0.00	0.00	$0.00^{a} \pm 0.00$	No activity

Table 7. The antibacterial activity test of transparent solid bath soap formulas *against S. aureus* ATCC 25923 bacteria

No	Sample	Inhibition Zone (mm)			Average of Inhibition Zone (mm)	Category
		1	2	3		
1.	F1	9.66	9.70	9.64	$9.67^{b} \pm 0.03$	Moderate
2.	F2	13.27	13.24	13.26	$13.26^{f} \pm 0.02$	Strong
3.	F3	12.98	12.94	12.95	$12.96^{d} \pm 0.02$	Strong
4.	F4	11.93	11.89	11.90	$11.91^{c} \pm 0.02$	Strong
5.	F5	14.50	14.45	14.48	$14.48^{i} \pm 0.03$	Strong
6.	F6	13.74	13.75	13.71	$13.73^{h} \pm 0.02$	Strong
7.	F7	13.59	13.55	13.53	$13.56^{g} \pm 0.03$	Strong
8.	F8	13.45	13.47	13.43	$13.45^{f} \pm 0.02$	Strong
9.	F9	13.23	13.25	13.22	$13.23^{d} \pm 0.02$	Strong
10.	F10	12.87	12.86	12.89	$12.87^{c} \pm 0.02$	Strong
11.	F11	13.40	13.38	13.40	$13.39^{i} \pm 0.02$	Strong
12.	C^{+}	13.06	13.06	13.06	$13.06^{e} \pm 0.00$	Strong
13.	C^{-}	0.00	0.00	0.00	$0.00^{a} \pm 0.00$	No activity

Notes:

F1 = Basic soap (essential oil 0.0%)
F2 = Soap + *kamboja* essential oil (1.0%)
F3 = Soap + *sedap malam* essential oil (1.0%)
F4 = Soap + *kenanga* essential oil (1.0%)
F5 = Soap + *kamboja* essential oil (3.0%)
F6 = Soap + *sedap malam* essential oil (3.0%)
F7 = Soap + *kenanga* essential oil (3.0%)
F8 = Soap + *kamboja* essential oil (5.0%)
F9 = Soap + *sedap malam* essential oil (5.0%)
F10 = Soap + *kenanga* essential oil (5.0%)
F11 = Unknown transparent solid banth soap
C+ = Positive Contol
C- = Negative Control

The same superscript in the table shows that the data is not significantly different (P > 0.05) when analyzed using One Way Anova.

The inhibitory power values for these formulations were 14.48 mm, 13.73 mm, and 13.56 mm, respectively. These values were also greater than those of the positive control (13.06 mm), basic soap (9.67 mm), and the commercially available transparent solid bath soap whose brand kept undisclosed (13.39 mm). Meanwhile, among the three soap products with the addition of 3.0% essential oil concentration each, the soap with the addition of 3.0% *kamboja* flower essential oil had the best inhibition zone (14.48 mm).

Organoleptic Test of Transparent Solid Bath Soaps

The color of the transparent solid bath soap became darker with an increase in the essential oil concentration. Similarly, the aroma of the soap became stronger as the essential oil concentration increases. The organoleptic test results for the transparent solid bath soap products are presented in **Table 8.**

Quality Test of Transparent Solid Bath Soaps

pH Test

The pH test is a crucial quality parameter for solid soap since it directly interacts with the skin during use. As per SNI 01-2346-2006, solid bath soap considered safe for the skin falls within the range of 9.0 to 11.0. The pH test results are outlined in **Table 9**.

Based on Table 8, the pH test results for transparent solid bath soap fall within the range of 9.3 to 10.3. All soap products comply with the SNI 01-2346-2006 standard, which stipulates that solid bath soap considered safe for the skin should be in the range of 9.0 to 11.0. This aligns with the findings of Zulbayu et al. (2020), indicating that transparent solid bath soaps produced have a pH range of 9.0-10.0. Human skin has resilience and can adapt to products with pH levels between 8.0-10.8 (Korompis et al., 2020).

Water Content Test

Water content can serve as a parameter for determining the shelf life of a product (Setiawati & Ariani, 2020). The higher the water content in transparent solid bath soap, the lower the soap hardness. Additionally, soap with high water content tends to shrink more rapidly as it depletes quickly during use. The results of the water content test are presented in **Table 10.**

The comprehensive water content test results for transparent solid bath soap ranged from 12.07% to 13.17%. The water content falls within the quality standards outlined by SNI, which stipulate a maximum of 15%. Consequently, it can be inferred that the bath soap manufactured adheres to SNI quality standards, as all the soap variants exhibit a content below the 15% threshold. This study aligns with the findings of Widyasanti & Hasna (2016), where the water content in transparent solid bath soap ranged from 11.47% to 12.67%.

Foam Stability Test

Foam stability is assessed by the resistance of the foam after standing for 5 minutes; it should retain 60.00% to 70.00% of the initial volume (Kusuma et al., 2022). According to SNI 01-2346-2006, high-quality soap should have a foam stability value of less than 95.00%. The results of the foam stability test are detailed in **Table 11.**

Table 8. Descriptive organoleptic test results for transparent solid bath soap

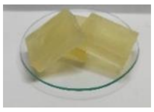
No	Sample	Photo Product	Aroma	Color	Transparency	Solidity	Foam
1	F1		Typical soap	Light yellow	Transparent	Solid	Foamy
2	F2		*Plumeria alba* L.	Light yellow	Transparent	Solid	Foamy
3	F3		*Polianthes tuberosa* L.	Light yellow	Transparent	Solid	Foamy
4	F4		*Cananga ordorata* L.	Yellow	Transparent	Solid	Foamy
5	F5		*Plumeria alba L.*	Yellow	Transparent	Solid	Foamy
6	F6		*Polianthes tuberosa* L.	Yellow	Transparent	Solid	Foamy
7	F7		*Cananga ordorata* L.	Yellow	Transparent	Solid	Foamy
8	F8		*Plumeria alba L.*	Yellow	Transparent	Solid	Foamy
9	F9		*Polianthes tuberosa* L.	Yellow	Transparent	Solid	Foamy
10	F10		*Cananga ordorata* L.	Yellow	Transparent	Solid	Foamy
11	F11		Typical soap	Yellow	Transparent	Solid	Foamy

Table 9. Transparent solid bath soap pH test results

Sample Code	Replication of pH values			Average pH value
	1	2	3	
F1	9.3	9.4	9.2	9.3[a] ± 0.10
F2	9.4	9.5	9.6	9.5[bc] ± 0.10
F3	9.3	9.4	9.5	9.4[ab] ± 0.06
F4	9.3	9.2	9.4	9.3[a] ± 0.10
F5	9.7	9.5	9.8	9.7[de] ± 0.06
F6	9.5	9.7	9.6	9.6[cd] ± 0.10
F7	9.7	9.6	9.5	9.6[cd] ± 0.06
F8	10.4	10.3	10.2	10.3[g] ± 0.10
F9	10.2	10.1	10.0	10.1[f] ± 0.10
F10	9.8	9.9	9.7	9.8[e]± 0.10
F11	9.6	9.5	9.4	9.5[bc] ± 0.06

Table 10. Transparent solid bath soap water content test results

Sample	Water Content Test Replication (%)			Average Water Content (%)
	1	2	3	
F1	12.12	12.13	12.14	12.13[b] ± 0.04
F2	13.17	13.20	13.18	13.19[e] ± 0.01
F3	13.19	13.18	13.14	13.17[e] ± 0.03
F4	13.17	13.16	13.15	13.16[e] ± 0.02
F5	13.04	13.02	13.03	13.10[c] ± 0.02
F6	13.06	13.07	13.08	13.07[d] ± 0.01
F7	12.98	12.96	12.95	12.96[b] ± 0.02
F8	12.75	12.72	12.76	12.74[b] ± 0.02
F9	12.67	12.65	12.66	12.66[b] ± 0.01
F10	12.09	12.05	12.06	12.07[a] ± 0.02
F11	13.25	13.24	13.23	13.24[f] ± 0.01

Table11. Transparent solid bath soap foam stability test results

Sample	Foam Stability Test Replication (cm)			Foam Stability (%)
	1	2	3	
1	62.67	62.65	62.68	62.67[a] ± 0.01
F2	64.68	64.66	64.69	64.67[ab] ± 0.01
F3	64.02	64.00	63.99	64.00[ab] ± 0.02
F4	64.68	64.67	64.65	64.67 [ab] ± 0.03
F5	65.99	66.01	66.00	66.00 [ab] ± 0.02
F6	68.00	68.02	67.98	68.00[b] ± 0.02
F7	67.31	67.33	67.35	67.33[b] ± 0.03
F8	68.21	68.25	68.22	68.23[b] ± 0.04
F9	67.78	67.81	67.82	67.80[b] ± 0.02
F10	68.10	68.11	68.13	68.12[b] ± 0.02
F11	62.68	62.67	62.69	62.67[a] ± 0.01

The stability test values for all soap products fall within the range of 62.67% to 68.23%. This aligns with the findings of research conducted by Widyasanti & Hasna (2016), where the soap stability test resulted in 68.06%. The foam stability values are also consistent with the research conducted by (Murti et al., 2017), where the foam stability is better in the range from 60.00% to 70.00%.

The Saponification Number Test

The saponification number is an important indicator of soap quality; a high saponification number indicates small fatty acids, so the quality of the soap is better, while a low saponification number indicates large fatty acids, so the soap quality is low (Hasibuan et al., 2019). The transparent solid bath soap saponification number test results are presented in **Table 12.**

Table 12. Transparent solid bath soap saponification number test results

Sample Code	Saponification Number Test (mL/g) Replication			Average of Saponification Number Test (mL/g)
	1	2	3	
F1	198.05	198.06	198.07	198.06[c] ± 0.01
F2	197.66	197.64	197.68	197.66[b] ± 0.02
F3	198.27	198.29	198.26	198.27[d] ± 0.02
F4	196.44	196.49	196.48	196.47[a] ± 0.03
F5	203.89	203.91	203.90	203.90[g] ± 0.01
F6	204.31	204.33	204.36	204.33[h] ± 0.03
F7	201.70	201.73	201.71	201.71[f] ± 0.02
F8	205.46	205.48	205.42	205.45[i] ± 0.03
F9	205.98	205.93	205.95	205.95[i] ± 0.03
F10	204.87	204.86	204.88	204.87[h] ± 0.01
F11	199.41	199.43	199.47	199.44[e] ± 0.03

The saponification number test results for the eleven formulas of transparent solid bath soap ranged from 196.47 to 205.98 mg/g. According to SNI (2016), transparent solid bath soap should have a standard soaping number within the range of 196.00-206.00 mg/g, indicating that the research findings aligned with SNI standards. This is consistent with the study of Momuat & Wuntu (2017), where transparent solid bath soap enriched with tomato carotenoids showed a saponification number of 225.37 mg/g. Similarly, Prasetiyo et al. (2020) research on transparent solid bath soap from palm kernel oil reported saponification numbers ranging from 244-245 mg/g for samples weighing 2.09 g, 2.10 g, and 2.10 g. Another study by Sukeksi et al. (2018) indicated that transparent solid bath soap, with the addition of 30 g of noni fruit and 26% NaOH, had a saponification number of 200 mg/g.

Transparency Test

A solid soap is considered transparent if a writing on paper with a font sized 14 behind the 0.25-inch thick soap is clear and readable (Widyasanti & Hasna, 2016). This research's findings indicated that all formulas of solid bath soap exhibit transparency. Based on the color produced by each additional concentration of essential oil, it can be concluded that the greater the concentration of essential oil added, the more intense the color of the solid bath soap produced.

This aligns with Saputri et al. (2022) research, which noted that the solid bath soap formula with the addition of salak bark extract can distinctly display writing on paper with a font sized 14 when the soap thickness is 0.25 inches. The transparency of soap is attributed to the influence of sucrose addition. Zulbayu et al. (2020) affirmed that transparent solid bath soap with the addition of citronella oil is transparent, allowing clear reading of a writing with a font sized 14. The level of transparency in soap increases with a higher sucrose content, as also observed in a study by Dhara et al. (2023), where solid bath soap with the addition of red dragon fruit flesh extract demonstrated transparency under the same parameter.

CONCLUSIONS

The essential oils extracted from *kamboja, sedap malam*, and *kenanga* flowers were found to contain 17, 20, and 20 compounds, respectively. The predominant chemical components in each essential oil were 1,1'-oxydi-2-propanol (21.01%) for *kamboja,* benzyl ethanoate (24.52%) for *sedap malam*, and caryophyllene (43.77%) for *kenanga.* Transparent solid bath soaps with the highest antibacterial activity against *S. aureus* ATTC 25923 were obtained in the formula added with *kamboja, sedap malam* and *kenanga* flowers essential oils at 3.0%, 3.0%, and 3.0%, respectively, with respective inhibitory power of 14.48 mm (stong), 13.73 mm (strong) and 13.56 mm (strong) in diameter. Organoleptic tests revealed that each soap type exhibited characteristic of the respective flower. All soap types demonstrated good quality based on parameters such as pH, water content, foam stability, saponification number and transparency.

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