PHYTOCHEMICAL SCREENING AND Py-GC-MS ANALYSIS OF AGARWOOD LEAVES (*Aquilaria malaccensis* Lamk.) CULTIVATED IN BAHOROK, LANGKAT REGENCY, NORTH SUMATRA, INDONESIA

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ABSTRACT

Agarwood is one of the common plants to be cultivated by the people in Langkat Regency, North Sumatra, Indonesia, with the species name *Aquilaria malaccensis* Lamk. This research aimed to determine the quality parameters of agarwood leaves and to investigate the chemical contents of agarwood leaves simplicia using phytochemical and Py-GC-MS analysis. The collected agarwood leaves were identified and then classified into three types i.e. the young, mature, and mixed leaves. The agarwood leaves were then processed into agarwood leaves simplicia and extracted using ethanol 96%. Phytochemical screening was also performed. The young leaves simplicia contained 8.94% moisture content, 18.39% water-soluble extract, 10.92% ethanol-soluble extract, 6.62% total ash and 0.53% acid insoluble ash. While the mature leave simplicia contained 8.02% moisture content, 22.89% water-soluble extract, 17.93% ethanol-soluble extract, 5.69% total ash and 0.97% acid insoluble ash. The mixed leaves simplicia contained 7.00% moisture content, 20.33% water-soluble extract, 19.67% ethanol-soluble extract, 7.53% total ash, and 0.77% acid insoluble ash. Phytochemical screening results that no significant difference in the young, mature and mixed, leaves, positively containing glycosides, steroids/triterpenoids, flavonoids and tannins. Furthermore, chromatogram data of Py-GC-MS analysis results showed that compounds with the highest concentrations in the young leaves simplicia were hexadecenoic acid (CAS) palmitic acid (28.42%), in the mature leaves simplicia were octadecanoic acid (CAS) stearic acid (26.60%) and in mixed leaves, simplicia were octadecanoic acid (CAS) stearic acid (16.04%).

Keywords: Agarwood leaves, Extract, Characterization, Phytochemical analysis, GCMS

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INTRODUCTION

The development of agarwood utility values encourages the interest of industrialized countries to obtain agarwood at an ever-increasing selling price. The high demand and selling price encourages the community's efforts to change production patterns, from initially only utilizing and/or collecting from nature, to by the means of cultivation. The way to meet the demand and production of agarwood is by mass and sustainable planting of agarwood-producing trees (APT) species. Indonesia is a country that has a high diversity of agarwood-producing tree species (APT) compared to other countries in Asia. Agarwood-producing trees (APT) planted in Indonesia have been recorded and mapped. Furthermore, APT plantations in Indonesia were established on a small scale and traditionally run by farmers.¹

It is possible to produce agarwood from cultivated plants to be engineered through the technology of disease induction/inoculation according to the type of tree and the environment in which it is grown. During the cultivation process, the leaves of *Aquilaria malaccensis* Lamk are a byproduct that has not been optimally utilized and is considered a waste. People have consumed *A. malaccensis* leaves that are cultivated by the

people in Bahorok, Langkat Regency, in the form of tea from boiling the dried leaves. It has been reported that agarwood leaves have antioxidant activity.²⁻⁵

Research results showed that the methanol extract of the old agarwood leaves of *A. malaccensis* Lamk was the most potent extract with an IC value of 19.62 ± 1.49 $\mu\text{g/mL}$ and the combined fraction of chloroform 1: 3: methanol and 100% methanol showed the highest antioxidant activity with IC₅₀ of 17.39 ± 1.43 $\mu\text{g/mL}$.⁶ The results of the study of gel preparations containing *A. microcarpa* leaf extract showed that the IC₅₀ value for the gel extract of 26.39 - 28.94 $\mu\text{g/mL}$, while for the gel fraction was 22.22 - 23.05 $\mu\text{g/mL}$, both of which showed very high antioxidant activity.⁷

The ethanol extract of young leaves and mature leaves of agarwood type *Wikstroemia tenuiramis* Miq contains flavonoids, glycosides, steroids/triterpenoids and tannins.⁴ Agarwood leaves of type *A. malaccensis* that grow naturally from the village of Sigiring-giring contain terpenoids and saponins, while those from the village of S. kalangan II contain tannin and saponin compounds.³ The ethanol, ethyl acetate and n-hexane fractions of *A. malaccensis* leaves contain flavonoids, terpenoids, phenolics, saponins and alkaloids, showing anti-cancer properties.⁸ The results obtained in the phytochemical test reveals that the water extract of agarwood leaves contains phenolic compounds, flavonoids, and steroids.⁹ The phytochemistry of two types of leaves of aloes-producing trees, types *A. microcarpa* and *A. malaccensis*, with and without inoculation by fungi, showed the presence of tannins, steroids, phenols, and flavonoids.¹⁰ The young and mature leaves of Borneo Agarwood (*A. malaccensis*) extracts revealed the presence of alkaloids and carbohydrate.¹¹

Furthermore, agarwood leaves were reported to have antidiabetic, anti-inflammatory, antioxidant, antibacterial, and antiviral activity.^{6,7,12} The methanol extract of agarwood leaves was reported to contain more than a dozen chemical constituents including flavonoids, alkaloids, terpenoids and glycosides, and extractable secondary metabolite.¹³ Finally, the leaves of *A. malaccensis* show the ability to increase glucose uptake by increasing GLUT4 levels in skeletal muscle. Therefore, further research is needed to explore this agarwood leaf as a strong antidiabetic agent.¹²

Research on antioxidant activity of *A. malaccensis* Lamk. mature leaves extract showed that the methanolic extract was the most potent extract with an IC₅₀ value of 19.62 ± 1.49 $\mu\text{g/mL}$, while the combined fraction of chloroform: methanol with a ratio of 1: 3 and the fraction of 100% methanol showed the highest antioxidant activity with IC₅₀ of 17.39 ± 1.43 $\mu\text{g/mL}$.⁶ Another research on antioxidant activity of the gel prepared containing *A. microcarpa* leaves extract showed the IC₅₀ value of 26.39 - 28.94 $\mu\text{g/mL}$ for the gel extract, and the IC₅₀ value of 22.22 - 23.05 $\mu\text{g/mL}$ for the gel fraction, representing very active antioxidant activity.⁸

Several chemical compounds contained in the *Aquilaria* leaves had been identified, including 2-(2-phenylethyl) chromones, phenolic acids, steroids, terpenoids, pyranones, quinones, benzophenone, xanthonoid, flavonoids, and nucleosides.¹⁴ Mangiferin, genkwanin, and iriflophenone glycosides were generally found in *A. crassna* and *A. sinensis* leaves when extracted in ethanol using the maceration method and detected using liquid chromatography-mass spectrometry (LC-MS) and silica gel column chromatography (SGCC).^{13,15-19} Utilization of these leaves requires research series for future development, especially related to raw materials derived from cultivation. Fundamental research that needs to be done is to search for any chemical components contained in the agarwood leaves.

This research was conducted to study the characteristics and chemical components found in mixed, young, and mature leaves of agarwood which came from Bahorok, Langkat, North Sumatra.

EXPERIMENTAL

Sampling Process and Analysis

This research sampling was conducted in Pekan Bahorok Village, Bahorok District, Langkat Regency, North Sumatra, Indonesia. Phytochemical characterization and screening were carried out at the Laboratory of Pharmaceutical Biology, Faculty of Pharmacy, Universitas Sumatera Utara, Indonesia, whereas for determination of moisture content and extraction were carried out at the Forest Products Technology Laboratory of the Faculty of Forestry. Also, the GCMS was carried out at the Forest Product Research and Development Laboratory, Bogor.

Raw Material Preparation

At this stage, the agarwood leaves were cleaned with distilled water, then spread on parchment paper until the water was absorbed. The materials were dried in a drying. The drying process was conducted by artificial drying using a drying cabinet with a temperature of 40 - 50°C. This drying was performed to get a simplicia that is not easily damaged, so it can be stored for a long time. Then, dried leaves were turned into powder using a blender. Simplicia that has become a powder was put into a sun-protected container before extraction and analysis.

Water Content and Simplicia Characteristics

The determination of water content was carried out using the gravimetric method. Simplicia characterization was performed for several investigations, including determination of water-soluble extract content, soluble extract content in ethanol, ash content, and acid insoluble ash content.²⁰

Characterization and Phytochemical Screening

To start with, the moisture content of the sample was analyzed using the gravimetry method. Furthermore, simplicia identification was done by checking and observing macroscopically, water-soluble extract, ethanol-soluble extract, total ash and acid-insoluble ash.¹⁵ Phytochemical screening is a qualitative chemical examination of biologically active compounds found in simplicia and agarwood leaves extract. These compounds are organic compounds; therefore, screening is mainly intended for groups of organic compounds such as alkaloids, glycosides, flavonoids, steroids/terpenoids, tannins and saponins.

Ethanol Extract of Agarwood (*A. malaccensis* Lamk.) Leaves

The extract was made via maceration with ethanol 96%. As much as 200 g of simplicia powder was put into a glass container, poured with 1500 mL of ethanol, covered, and left for 5 days protected from light with the occasional stirring process. After 5 days, the mixture was filtered and the pulp was washed with ethanol sufficiently to obtain 2000 mL, then transferred into a closed vessel and left in a cool place protected from light for 2 days. Finally, it was then poured and filtered. The macerate was concentrated using a rotary evaporator at 40°C until a thick macerate was obtained. Then, it was dried using a freeze dryer to get a dry extract. Finally, The GC-MS analysis was conducted in Forest Research and Development Department, Bogor, Indonesia by utilizing a GC-MS pyrolysis machine.

RESULTS AND DISCUSSION

Moisture Content and Characterization

The moisture content needs to be determined because it is closely related to the quality of the prepared simplicia. Moisture content represents the water content in the simplicia. Determination of moisture content is also useful for estimating the durability or endurance of samples in storage.

Moisture contents of agarwood leaves after drying are presented in Table 1, the drying process was carried out by differentiating among young, mature and mixed leaves. These results had fulfilled SNI requirements that are not to exceed 12% maximum. These results also met POM standards, that the simplicia moisture content does not exceed 10%.²¹ Agarwood leaves simplicia samples were occupied the standardization requirements of simplicia moisture content which were not more than 10%, where the highest moisture content was in young leaves samples which equal to 8.94%. While the lowest one was found in the mixed leaves extract which is 7.00%. Moisture content greatly affects the quality and characteristics of the extract and also the extraction process carried out.

Table-1: Simplicia Characterization Results

Characteristics	Simplicia Examination Results (%)		
	Young Leaves	Mature Leaves	Mixed Leaves
Moisture Content	8.94 ± 1.09	8.02 ± 1.26	7.00 ± 0.43
Water Soluble Extract Content	18.39 ± 5.26	22.89 ± 4.89	20.33 ± 0.29
Ethanol Soluble Extract Content	10.92 ± 0.42	17.93 ± 0.77	19.67 ± 0.29
Total Ash Content	6.62 ± 0.46	5.69 ± 0.19	7.53 ± 1.10
Acid Insoluble Ash Content	0.53 ± 0.08	0.97 ± 0.05	0.77 ± 0.23

Determination of water-soluble extract content and ethanol-soluble extract content is aimed to show the amount of yield extract on each water and ethanol solvent one. Water-soluble materials consist of carbohydrates, salts, some vitamins, and some organic ingredients. Determination of this extracted content is very important because it can give descriptions of dissolved material amounts that had medicinal functions.

On the other hand, the determination of ash content aims to describe the amount of metal content in plants, while acid insoluble ash indicates the presence of silicate. Both metal and silicate come from soil and water that are sucked up by plant tissue. The values obtained in this research were under 1%.

Phytochemical Screening Results

Agarwood leaves research was carried out to increase the benefits of the tree. Phytochemical screening was a preliminary study to determine secondary metabolites in plants.²² Phytochemical screening was carried out on both the simplicia powder of fresh agarwood leaves and the ethanol extracts, to know the groups of secondary metabolite compounds contained in agarwood leaves. The results of phytochemical screening can be seen in Table-2.

The results in Table-2 show that there is no difference in chemical compound results through phytochemical screening tests that were carried out on agarwood leaves extract. Phytochemical test results showed that the ethanol extract of agarwood leaves from Bahorok, Langkat regency has a group of secondary metabolites, that consists of flavonoids, tannins, and steroids/triterpenoids that potentially as antioxidants. The same secondary compounds were as well as found in mature, young, and mixed mature and young leaves.

Phytochemical screening results provide important information about the chemical compounds of agarwood leaves. After knowing the chemical compounds, it will be easier in determining the use, especially in advanced utilizations, such as for treatment.

Table-2: Phytochemical Screening Results Data

Compounds	Mixed Leaves		Young Leaves		Mature Leaves	
	Simplicia	Extract	Simplicia	Extract	Simplicia	Extract
Alcaloids	–	–	–	–	–	–
Glycosides	+	+	+	+	+	+
Steroids /triterpenoids	+	+	+	+	+	+
Flavonoids	+	+	+	+	+	+
Tannins	+	+	+	+	+	+
Saponins	–	–	–	–	–	–

Notes: + = present; – = absent

The glycoside compounds were found to be contained in cultivated agarwood leaves of *A. malaccensis* Lamk. Phytochemical investigations on the ethanol extract of *A. sinensis* leaves found five new benzophenone glycosides, aquilarinensides A-E.²³ A new flavonoid glycoside, named aquisiflavoside, has also been obtained from the leaves of *Aquilaria sinensis* (Lour.).²⁴ Glycosides are complex substances that contain sugar when hydrolyzed into glycons and aglycones (genin). Leaf extract of *A. sinensis* (Lour.) Gilg. has anti-analgesic and anti-inflammatory activity.²⁵

Agarwood leaves were also reported to contain steroid / triterpenoid compounds. Steroids are secondary metabolites mostly analyzed in plants, as these are major constituents of plant pigments.²⁶ Furthermore, agarwood leaves also contain flavonoid compounds. Flavonoids are water-soluble polyphenol molecules containing 15 carbon atoms present in plants.²⁷ Flavonoids are polyphenolic compounds that can reduce free radical activity, also have antimutagenic activity and a dose-dependent protective effect against cyclophosphamide - the cause of DNA oxidative damage.²⁸ Flavonoids are one of the best polyphenols, many of which have properties such as antioxidants, antimutagenic, anti-carcinogenic and anti-inflammatory.²⁹

The results of the phytochemical test of agarwood leaves were positive for tannin. The tannin content of *W. tenuiramis* and *A. malaccensis* was 4.95% and 5.62% respectively.³⁰ The young leaves of agarwood *W. tenuiramis* contain tannins $1.079 \pm 0.001\%$ and mature leaves contain $4.645 \pm 0.021\%$ tannins.⁴ The tannins extract of *Aloe vera* showed an antiradical activity with percentage inhibition of about 74.17% at 6 mg

/mL.³¹ This is critical as tannins have the potential to act as chelating agents with plasmolytic effects and interfere with cell permeability.³²

Py GC-MS Analysis Results

Based on the spectrogram data, the fragmentation pattern of each compound was obtained (Fig.-1, Fig.-2, and Fig.-3). Characteristic fragmentation patterns and basic peaks led to the structure of each compound. The fragmentation pattern of each compound showed that each of the young, mature, and mixed leaves extracts contained different and many compounds as shown in Table- 3, 4, and 5.

Fig.-1: GC-MS Chromatogram of Agarwood *A. malaccensis* Young Leaves

Fig.-2: GC-MS Chromatogram of Agarwood *A. malaccensis* Mature Leaves

Based on the chromatogram, there were 30 compounds identified in mature, young, and mixed leaves extracts. The compounds identified were not similar. The compound with the highest concentration in young leaves was hexadecanoic acid (CAS) palmitic acid (28.42%), in mature leaves was octadecanoic acid (CAS) stearic acid (26.60%) and in mixed leaves was octadecanoic acid (CAS) stearic acid (16.04%). The content of the largest compound in the mature and the mixed leaves extracts was similar. The dominant compound that contained was acid, thus contributing to the antioxidant activity strength of agarwood leaves extract.

Fig.-3: GC-MS Chromatogram of Agarwood *A. malaccensis* Mixed Leaves

The dominant compounds detected on more than 3% of concentration for mixed leaves extract were carbon dioxide (CAS) dry ice, carbamic acid, phenyl ester (CAS) phenylcarbamate, decanoic acid (CAS) capric acid, 9-octadecenoic acid (Z) - (CAS) oleic acid, 9,12-octadecadienal (CAS), and octadecanoic acid (CAS) stearic acid. The dominant compounds detected in young leaves extract were trideuteroacetonitrile, carbamic acid, phenyl ester (CAS) phenylcarbamate, 3,4-hexanediol, 2,5-dimethyl- (CAS) 2,5-dimethyl-3,4-hexanediol, 1,12 -tridecadiene (CAS), octadecanoic acid (CAS) stearic acid, 9,15-octadecadienoic acid, methyl ester (CAS) methyl 9,15-octadecad, 1,4-diaza-2,5-dioxo-3-isobutyl bicyclo [4.3.0] nonane and 9-octadecenoic acid (Z) - (CAS) oleic acid. The dominant compounds detected immature leaves were carbon dioxide (CAS) dry ice, carbamic acid, phenyl ester (CAS) phenylcarbamate, 9-octadecenoic acid (Z) - (CAS) oleic acid, 9,12-octadecadienal (CAS), octadecanoic acid (CAS) stearic acid, and 9,12-octadecadienal (CAS).

Tabel-3: Chemical Compounds List from Agarwood *A. malaccensis* Young Leaves

Peak#	R. Time	Area	Concentration (%)	Peak Report TIC Name
1	3.341	55410077	10.71	Trideuteroacetonitrile
2	12.384	32360209	6.25	Carbamic acid, phenyl ester (CAS) Phenyl carbamate
3	12.784	5350027	1.03	1-Octene (CAS) Caprylene
4	13.599	5671592	1.10	Phenol, 2-methyl- (CAS) o-Cresol
5	13.750	4328810	0.84	cis-1,3-Dideutero-1,3-cyclohexandiamine
6	15.251	14269850	2.76	Benzofuran, 2,3-dihydro- (CAS) 2,3-Dihydrobenzofuran
7	15.472	16863555	3.26	3,4-Hexanediol, 2,5-dimethyl- (CAS) 2,5-Dimethyl-3,4-hexanediol
8	15.991	11920398	2.30	Benzonitrile, 2-methyl- (CAS) 1-Methyl-2-cyanobenzene
9	16.167	10504114	2.03	2-Methyl-2,3-divinyloxirane
10	16.325	6724498	1.30	Phenol, 2,6-dimethoxy- (CAS) 2,6-Dimethoxyphenol
11	16.385	8795400	1.70	Undecane, 2-methyl- (CAS) 2-Methylundecane
12	17.249	12868027	2.49	Undecane, 2-methyl- (CAS) 2-Methylundecane
13	17.646	10176427	1.97	Benzoic acid, 3-hydroxy-, methyl ester (CAS) Methyl 3-hydroxybenzoate
14	18.060	15420900	2.98	1-Octene (CAS) Caprylene
15	18.175	7067572	1.37	6,7-Dihydro-3-Nitro-5H-Cyclopenta[B]pyridin-2(1H)-ONE
16	18.827	9196045	1.78	Undecane, 2-methyl- (CAS) 2-Methylundecane
17	19.475	13858728	2.68	Tridecane (CAS) n-Tridecane
18	19.550	3448775	0.67	Tridecane (CAS) n-Tridecane
19	19.864	8066482	1.56	11-Tetradecen-1-ol, acetate, (Z)- (CAS) cis-11-Tetradecenyl acetate
20	20.165	8548339	1.65	11-Tetradecen-1-ol, acetate, (Z)- (CAS) cis-11-Tetradecenyl acetate

21	20.773	17541047	3.39	1,12-Tridecadiene (CAS)
22	20.888	82999997	16.04	Octadecanoic acid (CAS) Stearic acid
23	20.993	53574605	10.35	9,15-Octadecadienoic acid, methyl ester (CAS) Methyl-9,15-octadecad
24	21.074	23054360	4.46	1,4-diaza-2,5-dioxo-3-isobutyl bicyclo[4.3.0]nonane
25	21.142	7061941	1.36	1,4-diaza-2,5-dioxo-3-isobutyl bicyclo[4.3.0]nonane
26	21.226	18776095	3.63	1,4-diaza-2,5-dioxo-3-isobutyl bicyclo[4.3.0]nonane
27	22.125	28539149	5.52	9-Octadecenoic acid (Z)- (CAS) Oleic acid
28	22.275	12902808	2.49	Dodecane, 2-methyl- (CAS) 2-Methylundecane
29	22.494	7632053	1.48	9-Octadecenamide, (Z)- (CAS) Oleoamide
30	22.772	4449810	0.86	9-Octadecenal (CAS) Octadecenyl aldehyde

Tabel-4: Chemical Compounds List from Agarwood *A. malaccensis* Mature Leaves

Peak#	R.Time	Area	Concentration (%)	Peak Report TIC Name
1	3.422	13492326	6.68	Carbon dioxide (CAS) Dry ice
2	1.488	6066675	3.00	Carbamic acid, phenyl ester (CAS) Phenyl carbamate
3	14.535	2155261	1.07	Heptanoic acid (CAS) Heptoic acid
4	15.320	4832637	2.39	Benzaldehyde, 4-methyl- (CAS) p-Tolualdehyde
5	16.025	3608578	1.79	7-Cyano(15N)-Cycloheptatriene
6	17.237	1900815	0.94	Undecane, 2-methyl- (CAS) 2-Methylundecane
7	18.008	10388169	5.14	Decanoic acid (CAS) Capric acid
8	19.055	2418305	1.20	1-Dodecene (CAS) Adacene 12
9	19.395	2778187	1.38	6-Methylbicyclo[4.4.0]dec-2-ene-4,7-dione
10	19.458	1925258	0.95	Undecanoic acid (CAS) Undecylic acid
11	20.153	7107921	3.52	9-Octadecenoic acid (Z)- (CAS) Oleic acid
12	20.225	745288	0.37	Decyl disulfide
13	20.339	4292720	2.13	2,5-Hexanediol, 2,5-dimethyl- (CAS) 2,5-Dimethyl-2,5-hexanediol
14	20.400	525909	0.26	Undecanenitrile (CAS) N-Decylecyanide
15	20.735	7145027	3.54	9,12-Octadecadienal (CAS)
16	20.854	53733537	26.6	Octadecanoic acid (CAS) Stearic acid
17	20.977	12542454	6.21	9,12-Octadecadienal (CAS)
18	21.058	10160056	5.03	9,12-Octadecadienal (CAS)
19	21.183	4908914	2.43	1,4-diaza-2,5-dioxo-3-isobutyl bicyclo[4.3.0]nonane
20	21.300	5883103	2.91	1,6-Heptadiene, 5-deutero-3,3,6-trimethyl-
21	21.468	2458442	1.22	Allyl heptanoate
22	22.095	17957866	8.89	9-Octadecenoic acid (Z)- (CAS) Oleic acid
23	22.208	4524959	2.24	Octadecanoic acid (CAS) Stearic acid
24	22.267	4211912	2.09	Nonadecane, 2-methyl- (CAS) 2-Methylnonadecane
25	22.473	4198023	2.08	9-Octadecenamide, (Z)- (CAS) Oleoamide
26	22.759	2731650	1.35	Cyclopentaneundecanoic acid
27	23.017	1049991	0.52	Decane, 2,9-dimethyl- (CAS) 2,9-Dimethyldecane
28	23.676	2249731	1.11	2L,4L-Dihydroxyeicosane
29	23.850	2563762	1.27	Tetradecane (CAS) n-Tetradecane
30	36.657	3422941	1.69	Dotriacontane (CAS) n-Dotriacontane

Tabel-5: Chemical Compounds List from Agarwood *A. malaccensis* Mixed Leaves

Peak#	R. Time	Area	Concentration (%)	Peak Report TIC Name
1	3.422	13492326	6.68	Carbon dioxide (CAS) Dry ice
2	12.488	6066675	3.00	Carbamic acid, phenyl ester (CAS) Phenyl carbamate
3	14.535	2155261	1.07	Heptanoic acid (CAS) Heptoic acid
4	15.320	4832637	2.39	Benzaldehyde, 4-methyl- (CAS) p-Tolualdehyde
5	16.025	3608578	1.79	7-Cyano(15N)-Cycloheptatriene
6	17.237	1900815	0.94	Undecane, 2-methyl- (CAS) 2-Methylundecane
7	18.008	10388169	5.14	Decanoic acid (CAS) Capric acid
8	19.055	2418305	1.20	1-Dodecene (CAS) Adacene 12
9	19.395	2778187	1.38	6-Methylbicyclo[4.4.0]dec-2-ene-4,7-dione
10	19.458	1925258	0.95	Undecanoic acid (CAS) Undecylic acid
11	20.153	7107921	3.52	9-Octadecenoic acid (Z)- (CAS) Oleic acid
12	20.225	745288	0.37	Decyl disulfide
13	20.339	4292720	2.13	2,5-Hexanediol, 2,5-dimethyl- (CAS) 2,5-Dimethyl-2,5-hexanediol

14	20.400	525909	0.26	Undecanenitrile (CAS) N-Decyccyanide
15	20.735	7145027	3.54	9,12-Octadecadienal (CAS)
16	20.854	53733537	26.6	Octadecanoic acid (CAS) Stearic acid
17	20.977	12542454	6.21	9,12-Octadecadienal (CAS)
18	21.058	10160056	5.03	9,12-Octadecadienal (CAS)
19	21.183	4908914	2.43	1,4-diaza-2,5-dioxo-3-isobutyl bicyclo[4.3.0]nonane
20	21.300	5883103	2.91	1,6-Heptadiene, 5-Deutero-3,3,6-trimethyl
21	21.468	2458442	1.22	Allyl heptanoate
22	22.095	17957866	8.89	9-Octadecenoic acid (Z)- (CAS) Oleic acid
23	22.208	4524959	2.24	Octadecanoic acid (CAS) Stearic acid
24	22.267	4211912	2.09	Nonadecane, 2-methyl- (CAS) 2-Methylnonadecane
25	22.473	4198023	2.08	9-Octadecenamide, (Z)- (CAS) Oleamide
26	22.759	2731650	1.35	Cyclopentaneundecanoic acid (CAS)
27	23.017	1049991	0.52	Decane, 2,9-dimethyl- (CAS) 2,9-Dimethyldecane
28	23.676	2249731	1.11	2L,4L-Dihydroxyeicosane
29	23.850	2563762	1.27	Tetradecane (CAS) n-Tetradecane
30	36.657	3422941	1.69	Dotriacontane (CAS) n-Dotriacontane

The chemical compound detected from Py-GC-MS was carbamic acid. Previous research showed that the carbamic acid ethyl ester compound had antimicrobial and antifungal bioactivity.³³ Phenyl carbamate from the Library has but unspecified activity in modifying hemoglobin form and has anticonvulsant activity in Swiss Mus musculus mice. As a comparison, gas chromatography-mass spectrometry (GC-MS) analysis of the plant extracts led to the identification of 14 components from the two types of agarwood leaves extracts.³⁴

CONCLUSION

The qualities of agarwood leave simplicia extract made from young, mature, or mixed leaves were suitable following MMI standards. Phytochemical analysis results showed that the young, mature, and mixed leaves contain flavonoids, glycosides, tannins, and triterpenoids. Furthermore, GC-MS analysis results of chemical compounds showed that agarwood leaves are potentially available as raw materials for pharmaceutical and antimicrobial therapeutic which need to be further studied.

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