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TEST REPORT

COMPANY	:	**DADVANCE AGARWOOD SOLUTIONS SDN BHD**
PROJECT NO.	:	**SSBP23-012**
PROJECT TITLE	:	**CONSULTATION FOR VOLATILE COMPOUNDS AND QUALITY ASSESSMENT OF AGARWOOD OIL (DAAS 14)**
SAMPLE	:	**AGARWOOD ESSENTIAL OIL (LOT 1117 OIL)**
PERIOD	:	**21 FEBRUARY 2023 TO 07 MARCH 2023**

PREPARED BY

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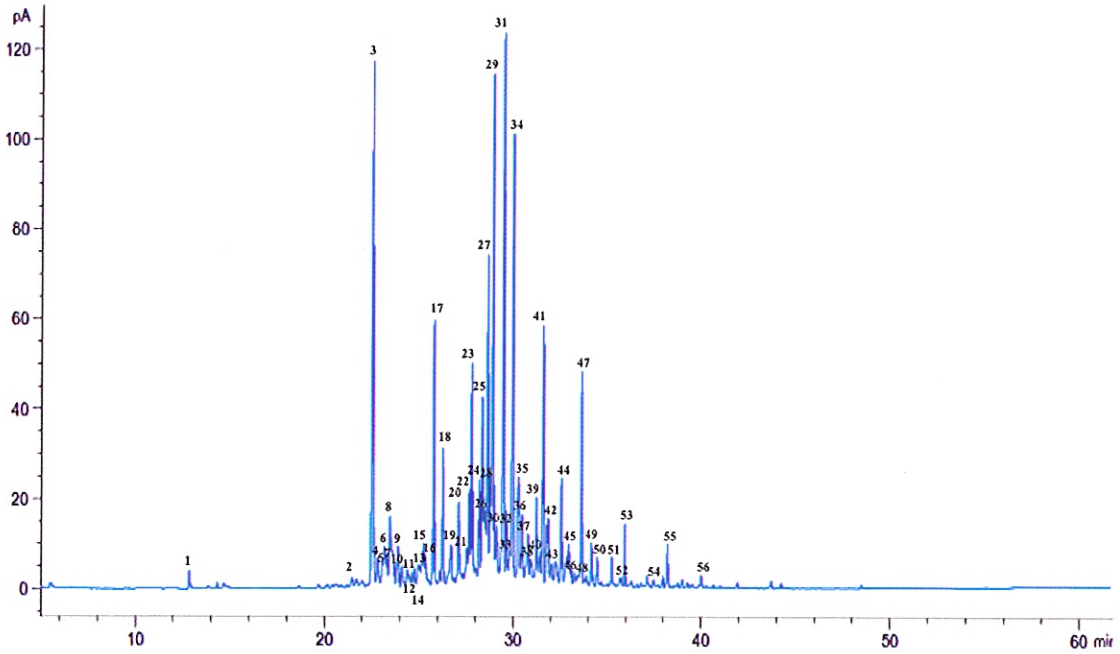
Certificate of Analysis

Reference No.	BA2023/EOAG-017
Customer	DAdvance Agarwood Solutions Sdn Bhd
Product Name	Agarwood essential oil
Sample Marking	Lot 1117 Oil
Scientific Name	*Aquilaria sinensis* [1]
Origin	Tangkak, Johor (Malaysia)
Inducer	DAdvance Agri Tech Vaccine (DATV) [1]
Method of Extraction	Hydrodistillation [1]
Color and Appearance	Light yellow with greenish hue, slightly cloudy liquid, viscous
Odor and Strength	Characteristic woody with slightly sweet, bitter, and spicy aroma, strong odor strength
Solubility	Insoluble in water, soluble in alcohol and oils
Gas Chromatography Analysis	Gas chromatography flame ionization detector (GC-FID) Gas chromatography mass spectrometry (GC-MS)
Date of analysis	23 February 2023
Grade and Quality	Grade A+ (premium high quality)

Chromatogram of the analysis by gas chromatography (GC) for agarwood essential oil (Lot 1117 Oil – DAdvance Agarwood Solutions Sdn Bhd)



No.	Ret. time, t_r (min)	Peak area (%)	Compounds	Ident. mode
1	12.828	0.21	4-Phenyl-2-butanone	FID,MS
2	21.451	0.15	α-Guaiene	FID,MS
3	22.520	9.30	*allo*-Aromadendrene	FID
4	22.797	0.63	α-Curcumene	FID
5	23.053	0.44	γ-Gurjunene	FID
6	23.164	0.75	β-Selinene	FID,MS
7	23.275	0.65	α-Selinene	FID,MS
8	23.456	2.49	Dihydro-β-agarofuran	FID,MS
9	23.873	0.85	δ-Guaiene	FID
10	24.088	0.29	γ-Cadinene	FID
11	24.367	0.35	Kessane	FID,MS
12	24.763	0.22	Selina-3,7(11)-diene	FID
13	24.968	0.37	α-Calacorene	FID
14	25.052	0.23	Dehydro-aromadendrene	FID
15	25.232	0.90	α-Agarofuran	FID
16	25.336	0.46	Elemol	FID
17	25.768	3.75	*cis*-Nerolidol	FID
18	26.250	1.95	*nor*-Ketoagarofuran	FID
19	26.687	0.91	β-Vetivenene	FID,MS
20	27.098	1.31	Caryophyllene oxide	FID
21	27.526	0.66	Tetradecanal	FID
22	27.655	1.42	Guaiol	FID
23	27.787	3.44	10-*epi*-γ-Eudesmol	FID,MS
24	28.182	1.72	γ-Eudesmol	FID,MS
25	28.344	2.94	Agarospirol	FID,MS
26	28.443	1.66	Hinesol	FID,MS
27	28.625	5.12	τ-Cadinol	FID
28	28.765	1.55	τ-Muurolol	FID
29	28.903	8.75	β-Eudesmol	FID
30	29.121	1.41	α-Eudesmol	FID
31	29.485	9.70	Jinkoh-eremol	FID
32	29.638	1.21	Dihydro-eudesmol	FID
33	29.812	0.48	Kusunol	FID

No.	Ret. time, t_r (min)	Peak area (%)	Compounds	Ident. mode
34	29.971	7.03	Bulnesol	FID
35	30.258	2.63	Dehydrojinkoh-eremol	FID
36	30.465	1.38	Cyperotundone	FID
37	30.778	1.19	*epi*-α-Bisabolol	FID
38	30.916	0.64	α-Bisabolol	FID
39	31.234	1.56	Selina-3,11-dien-9-one	FID
40	31.434	0.73	Rotundone	FID
41	31.582	3.44	Valerenol	FID,MS
42	31.836	1.05	Selina-3,11-dien-9-ol	FID
43	32.240	0.75	Selina-4,11-dien-14-oic acid	FID
44	32.557	1.70	9,11-Eremophiladien-8-one	FID,MS
45	32.942	0.90	Aristolone	FID
46	33.267	0.23	Guaia-1(10),11-dien-9-one	FID
47	33.639	3.32	Dehydrofukinone	FID,MS
48	33.895	0.30	Selina-3,11-dien-14-oic acid	FID
49	34.164	0.67	Sinenofuranol	FID
50	34.466	0.41	Dihydrokaranone	FID
51	35.263	0.40	Guaia-1(10),11-dien-15-oic acid	FID
52	35.781	0.20	*oxo*-Agarospirol	FID
53	35.966	0.80	Dihydrocolumellarin	FID,MS
54	37.493	0.10	Columellarin	FID,MS
55	38.243	0.60	Methyl palmitate	FID
56	40.025	0.14	1,5-Diphenyl-3-pentanone	FID,MS

FID	Identification by linear retention indices, determined relative to the retention times on DB1 column of homologous series of C_7-C_{20} n-alkanes having difference in I value of ±10 between calculated Kovats retention index (I_{cal}) and reference Kovats retention index (I_{ref}).
MS	Identification by comparison of mass spectrum generated from sample analysis with library of National Institute of Standards and Technology (NIST) with acceptance similarity ≥ 80%

Results and Discussion

A total of 56 compounds were found and classified into three (3) groups, namely other compounds, sesquiterpene and sesquiterpenoid. The chemical composition for agarwood oil sample was shown in Table 1.

Table 1 Chemical composition of agarwood oil (Lot 1117 Oil) identified through GC analysis.

Compounds	Molecular formula	Area, %	Ident. mode
Other compounds			
4-Phenyl-2-butanone	$C_{10}H_{12}O$	0.21	FID,MS
Tetradecanal	$C_{14}H_{28}O$	0.66	FID
Methyl palmitate	$C_{17}H_{34}O_2$	0.60	FID
1,5-Diphenyl-3-pentanone	$C_{17}H_{18}O$	0.14	FID,MS
Sesquiterpene			
α-Guaiene	$C_{15}H_{24}$	0.15	FID,MS
allo-Aromadendrene	$C_{15}H_{24}$	9.30	FID
α-Curcumene	$C_{15}H_{22}$	0.63	FID
γ-Gurjunene	$C_{15}H_{24}$	0.44	FID
β-Selinene	$C_{15}H_{24}$	0.75	FID,MS
α-Selinene	$C_{15}H_{24}$	0.65	FID,MS
δ-Guaiene	$C_{15}H_{24}$	0.85	FID
γ-Cadinene	$C_{15}H_{24}$	0.29	FID
Selina-3,7(11)-diene	$C_{15}H_{24}$	0.22	FID
α-Calacorene	$C_{15}H_{20}$	0.37	FID
Dehydro-aromadendrene	$C_{15}H_{22}$	0.23	FID
β-Vetivenene	$C_{15}H_{22}$	0.91	FID,MS
Sesquiterpenoid			
Dihydro-β-agarofuran	$C_{15}H_{26}O$	2.49	FID,MS
Kessane	$C_{15}H_{26}O$	0.35	FID,MS
α-Agarofuran	$C_{15}H_{24}O$	0.90	FID
Elemol	$C_{15}H_{26}O$	0.46	FID
cis-Nerolidol	$C_{15}H_{26}O$	3.75	FID
nor-Ketoagarofuran	$C_{14}H_{22}O_2$	1.95	FID
Caryophyllene oxide	$C_{15}H_{24}O$	1.31	FID
Guaiol	$C_{15}H_{26}O$	1.42	FID
10-epi-γ-Eudesmol	$C_{15}H_{26}O$	3.44	FID,MS
γ-Eudesmol	$C_{15}H_{26}O$	1.72	FID,MS
Agarospirol	$C_{15}H_{26}O$	2.94	FID,MS
Hinesol	$C_{15}H_{26}O$	1.66	FID,MS
τ-Cadinol	$C_{15}H_{26}O$	5.12	FID
τ-Muurolol	$C_{15}H_{26}O$	1.55	FID
β-Eudesmol	$C_{15}H_{26}O$	8.75	FID
α-Eudesmol	$C_{15}H_{26}O$	1.41	FID
Jinkoh-eremol	$C_{15}H_{26}O$	9.70	FID
Dihydro-eudesmol	$C_{15}H_{28}O$	1.21	FID
Kusunol	$C_{15}H_{26}O$	0.48	FID
Bulnesol	$C_{15}H_{26}O$	7.03	FID
Dehydrojinkoh-eremol	$C_{15}H_{24}O$	2.63	FID
Cyperotundone	$C_{15}H_{22}O$	1.38	FID
epi-α-Bisabolol	$C_{15}H_{26}O$	1.19	FID
α-Bisabolol	$C_{15}H_{26}O$	0.64	FID
Selina-3,11-dien-9-one	$C_{15}H_{22}O$	1.56	FID
Rotundone	$C_{15}H_{22}O$	0.73	FID
Valerenol	$C_{15}H_{24}O$	3.44	FID,MS
Selina-3,11-dien-9-ol	$C_{15}H_{24}O$	1.05	FID
Selina-4,11-dien-14-oic acid	$C_{15}H_{22}O_2$	0.75	FID
9,11-Eremophiladien-8-one	$C_{15}H_{22}O$	1.70	FID,MS
Aristolone	$C_{15}H_{22}O$	0.90	FID
Guaia-1(10),11-dien-9-one	$C_{15}H_{22}O$	0.23	FID
Dehydrofukinone	$C_{15}H_{22}O$	3.32	FID,MS
Selina-3,11-dien-14-oic acid	$C_{15}H_{22}O_2$	0.30	FID
Sinenofuranol	$C_{14}H_{24}O_2$	0.67	FID
Dihydrokaranone	$C_{15}H_{22}O$	0.41	FID
Guaia-1(10),11-dien-15-oic acid	$C_{15}H_{22}O_2$	0.40	FID
oxo-Agarospirol	$C_{14}H_{24}O_2$	0.20	FID
Dihydrocolumellarin	$C_{15}H_{22}O_2$	0.80	FID,MS
Columellarin	$C_{15}H_{26}O_2$	0.10	FID,MS
Total of other compounds		**1.61**	
Total of sesquiterpene		**14.79**	
Total of sesquiterpenoid		**80.04**	

Generally, the quality of essential oils in the market are following the guidelines provided by International Fragrance Association (IFRA). However, there is no established international standard for agarwood oil up to date. The current grading on agarwood is still relies heavily on consumer perception and preference, therefore leading to adulteration in agarwood trading. Study conducted by CITES team (2010) on agarwood market in United Arab Emirates (UAE) identified some important criteria used for quality assessment of agarwood oil are listed in Table 2.

Table 2 Summary of criteria in the current market to determine agarwood oil quality.
Source: Antonopoulou et al., 2010

Survey by the CITES team on the criteria for agarwood oil quality assessment in UAE
1 Country of origin In UAE market, the origin of agarwood is ranked (such that 'brand names' or having particular aroma): (1) India; (2) Cambodia; (3) Malaysia; (4) Laos-Myanmar; (5) Indonesia However, customers from other Middle East country, Europe and Asia may have their own preferences. There were also reports mentioned that lesser quality oils are likely to contain mixed 'country of origin', as well as different ages or vintages of oil
2 Aroma The more distinctive and spicier the aroma, the better the oil is considered to be.
3 Duration of fragrance Good quality agarwood oil can be identified based on the duration of the fragrance lasts on the skin or clothes, with good quality ones lasting for up to three days.
4 Color/thickness/density The color was reported to be connected with the age of the tree which the chips (and then the oil) was extracted, while the thickness (viscosity) of the oil depends on the years that the oil was stored. This relates to the years the distilled oil has been stored and thus matured: a process analogous to that of the different 'vintages' associated with wine.

Since 2007, UMP team worked together with academic institution, industrial partners, and agarwood players to identify key marker compounds that contribute to the unique aroma for agarwood. Therefore, we propose that agarwood should be classified according to their chemical composition, mainly sesquiterpenes and sesquiterpenoids (Table 3). Various study has identified these two groups to be the major factor to produce strong woody smell in agarwood (Chen et al., 2012; Deep & Tajuddin, 2019; Ishihara & Tsuneya, 1993; Naef, 2010; Tajuddin et al., 2016).

Table 3 The proposed agarwood grading based on sesquiterpene and sesquiterpenoid content in pure essential oil and burnt wood chip.

Grade	Minimum sesquiterpene and sesquiterpenoid content (%)	Quality description
A+	80	Premium high
A	70	High
B+	60	Premium medium
B	40	Medium
C	20	Low
D	0	Very low

Disclaimer
The proposed agarwood grading system is protected by copyright of UMP and should not be claim or publish or use for commercial purposes without our permission. Any misuse of these information will be subjected to legal action.

Agarwood oil sample (Lot 1117 Oil) provided by DAdvance Agarwood Solutions Sdn Bhd contains amount of 94.83% sesquiterpene and sesquiterpenoid content identified through GC analysis. This indicates that agarwood oil sample reach the A+ grade (premium high quality). Figure 1 shows the region of sesquiterpene and sesquiterpenoid that contribute to strong woody aroma in agarwood essential oil.

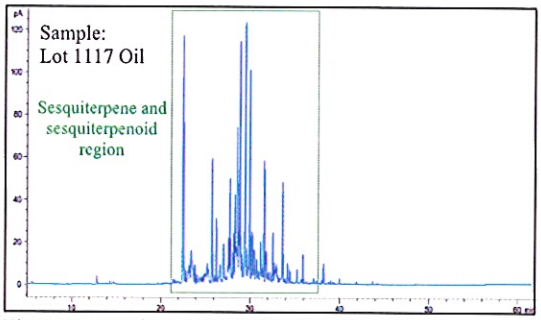


Figure 1 Woody aroma region of Lot 1117 Oil agarwood oil sample by DAdvance Agarwood Solutions Sdn Bhd.

Conclusion

In conclusion, chemical composition in agarwood essential oil was successfully identified using gas chromatography (GC) analysis. The agarwood essential oil Lot 1117 Oil is premium high quality according to our recommended grading system, reached the A+ grade with sesquiterpene and sesquiterpenoid content of 94.83%. There is no contaminant detected indicating that this oil is a pure agarwood oil.

Disclaimer

The proposed grading system based on scientific method (gas chromatography) can be used as one of indicator or reference purposes to assess the quality of agarwood oil or wood chip. As the buyer evaluation is subjective (influence by personal preferences), we do not take responsibility for any disagreement or misinterpretation. In addition, we still recommend physical observation to be done by both party during business engagement.

References

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