

A Suggested Method for Evaluation of Sandalwood Essential oil Quality

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Assume that we have Sandalwood essential oil extracted by hydrodistillation technique or by a modified hydrodistillation, for example Microwave HydroDistillation (MHD) or Microwave Air-Hydro Distillation (MAHD) [1]. After making GC-MS analysis on this Sandalwood essential oil we have a data set of volatile and semi-volatile compounds. From these compounds we should pay attention to the following entities:

Let s be the total content of all sesquiterpenes ($C_{15}H_{24}$) and their derivatives

Let s_o be the total content of all oxygenated sesquiterpenes and their derivatives

Let m be the total content of all monoterpenes ($C_{10}H_{14}$, $C_{10}H_{16}$) and their derivatives

Let m_o be the total content of all oxygenated monoterpenes and their derivatives

Let e be the total content of all fatty acids and their derivatives

Let f be the total content of all allergens

Let g be the total content of all toxins

Let S be the total content of all compounds listed in the GC-MS Test Report

Similar to our previous finding [2], we first derive from experiences and sensory comments.

Practical experiences and intuitional consideration

The higher s_o (in comparison with s) the better aromatic scent and therapeutic effects of sandalwood essential oil [3]. The smaller m (in comparison with s) the better quality of sandalwood essential oil. For a normal sandalwood essential oil, we obviously require: e is small, $s + s_o$ is big, $f=g=0$ and $S \geq 75\%$.

We hereby propose a suggested method for evaluation of sandalwood essential oil quality (in chemical composition):

Let $\alpha = \frac{s_o + m_o}{s + m}$ then the bigger the α , the higher the quality of sandalwood essential oil on condition that $\beta = s + s_o \geq 65\%$ (this constrain of β is also mentioned in [2]. This criteria can applicable to agarwood essential oil (not only to sandalwood essential oil).

We try to apply α to evaluate the quality of essential oils mentioned in the following article: H.S. Kusuma and M. Mahfud [1] extracted sandalwood (*santalum album*) essential oils from different techniques: Microwave hydrodistillation (MHD), see figure 1, and Microwave air-hydrodistillation (MAHD), see figure 2. After making GC-MS analysis they obtained two sets of data, each set consists of 59 compound names together with their corresponding content (%). Sum of 59 contents $S=100\%$. From these two sets of data we extracted a list of monoterpenes and oxygenated monoterpenes, see table 1, and a list of sesquiterpenes and oxygenated sesquiterpenes, see table 2.

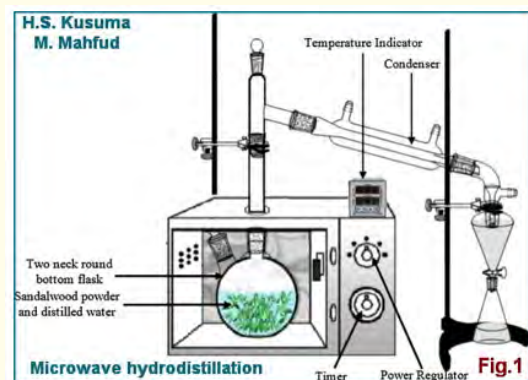


Figure 1

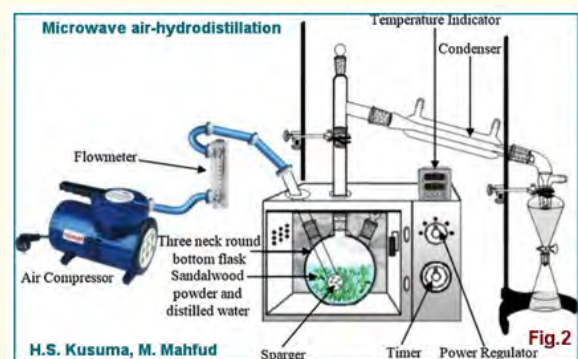


Figure 2

No	Compound name	Molecular Formula	Classification	Content (%)	
				MHD	MAHD
1	Camphene	C ₁₀ H ₁₆	monoterpene	0.95	0.82
2	Alpha-Pinene	C ₁₀ H ₁₆	monoterpene	0.06	nd
3	Santolina triene	C ₁₀ H ₁₆	monoterpene	0.07	nd
4	Beta-ocimene	C ₁₀ H ₁₆	monoterpene	0.58	nd
5	cis-ocimene	C ₁₀ H ₁₆	monoterpene	1.87	0.09
6	(Z)-alloocimene	C ₁₀ H ₁₆	monoterpene	0.06	nd
7	Alpha-terpinene	C ₁₀ H ₁₆	monoterpene	1.04	1.11
8	1-cyclohexylidene-2-methylpropene	C ₁₀ H ₁₆	monoterpene	nd	1.19
9	Isoterpinolene	C ₁₀ H ₁₆	monoterpene	0.31	nd
	Sum		m	4.94	3.21
1	8-methylene-2-exo-noradamantanol	C ₁₀ H ₁₄ O	Oxygenated monoterpene	nd	0.04
2	3a,6-methano-3aH-inden-7(4H)-one, hexahydro-7a-d-, (3aa,6a,7ab)-	C ₁₀ H ₁₄ O	Oxygenated monoterpene	0.72	nd
3	Teresantalol	C ₁₀ H ₁₆ O	Oxygenated monoterpene	4.58	1.45
4	Sabinene hydrate	C ₁₀ H ₁₈ O	Oxygenated monoterpene	0.10	nd
	Sum		m_o	5.4	1.49

Table 1: List of monoterpenes and oxygenated monoterpenes.

nd: not detected

No	Compound name	Molecular Formula	Classification	Content (%)	
				MHD	MAHD
1	Alpha-farnesene	C ₁₅ H ₂₄	Sesquiterpene	0.50	1.88
2	Beta-patchoulene	C ₁₅ H ₂₄	Sesquiterpene	0.62	nd
3	Alpha-santalene	C ₁₅ H ₂₄	Sesquiterpene	nd	0.03
4	Alpha-cedrene	C ₁₅ H ₂₄	Sesquiterpene	nd	0.05
5	Gamma-curcumene	C ₁₅ H ₂₄	Sesquiterpene	nd	0.17
6	Alpha-guaiene	C ₁₅ H ₂₄	Sesquiterpene	0.66	0.11
7	Isosativene	C ₁₅ H ₂₄	Sesquiterpene	0.18	nd
8	Beta-santalene	C ₁₅ H ₂₄	Sesquiterpene	0.05	0.07
9	Seychellene	C ₁₅ H ₂₄	Sesquiterpene	0.77	nd
10	Alpha-patchoulene	C ₁₅ H ₂₄	Sesquiterpene	0.38	nd
11	Germacrene B	C ₁₅ H ₂₄	Sesquiterpene	5.50	0.10
12	alpha-selinene	C ₁₅ H ₂₄	Sesquiterpene	0.06	nd
13	Delta-guaiene	C ₁₅ H ₂₄	Sesquiterpene	0.48	0.15
14	Gamma-elemene	C ₁₅ H ₂₄	Sesquiterpene	nd	3.69
15	Alpha-bergamotene	C ₁₅ H ₂₄	Sesquiterpene	nd	0.20
16	Bicyclogermacrene	C ₁₅ H ₂₄	Sesquiterpene	0.64	0.45
17	2-methyl-6-(4-methylcyclohex-3-en-1-ylidene)hept-2-ene	C ₁₅ H ₂₄	Sesquiterpene	nd	0.71
18	Acoradiene	C ₁₅ H ₂₄	Sesquiterpene	1.39	0.59
19	Bicycloelemene	C ₁₅ H ₂₄	Sesquiterpene	nd	1.36

20	Viridiflorene (ledene)	C ₁₅ H ₂₄	Sesquiterpene	0.91	nd
	Sum		s	12.14	9.56
1	Beta-santalol	C ₁₅ H ₂₄ O	Oxygenated sesquiterpene	22.67	24.80
2	Alpha-santalol	C ₁₅ H ₂₄ O	Oxygenated sesquiterpene	27.81	28.73
3	Alpha-bergamotol	C ₁₅ H ₂₄ O	Oxygenated sesquiterpene	10.82	10.18
4	cis-alpha-copaene-8-ol	C ₁₅ H ₂₄ O	Oxygenated sesquiterpene	1.86	nd
5	cis-lanceol	C ₁₅ H ₂₄ O	Oxygenated sesquiterpene	3.42	2.74
6	Alpha-cedrol	C ₁₅ H ₂₆ O	Oxygenated sesquiterpene	nd	2.65
7	Caryophylla-3,8(15)-dien-5alpha-ol	C ₁₅ H ₂₆ O	Oxygenated sesquiterpene	0.47	0.52
8	Isolongifolol	C ₁₅ H ₂₆ O	Oxygenated sesquiterpene	0.21	0.59
	Sum		s_o	67.26	70.21

Table 2: List of sesquiterpenes and oxygenated sesquiterpenes.
nd: not detected

So, we have

	For MHD	For MAHD
$\beta = s + s_o$	67.26%+12.14% = 79.40%	70.21%+9.56%= 79.77%
$\alpha = \frac{s_o + m_o}{s + m}$	= 4.254	= 5.615

Conclusion

MAHD technique is (chemically) better than MHD technique.

Usually we want both α and β to be large, but in practice when β grows (for example when $s > s_o$), it makes the α smaller, then we need to choose an acceptable compromise of α and β . For a possible compromise between α and β we can choose two positive numbers x and y , ($x + y = 1$), for forming the function $\omega = x \cdot \alpha + y \cdot \beta$. So, the bigger ω the better (chemically) quality of sandalwood essential oil.

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