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Identification of Aroma-active Compounds in Essential Oil from Uncaria Hook by Gas Chromatography- Mass Spectrometry and Gas Chromatography-Olfactometry

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Abstract: The chemical composition of essential oil extracted from Uncaria Hook ("Chotoko" in Japanese), the branch with curved hook of the herbal medicine *Uncaria rhynchophylla* has been investigated by GC and GC-MS analyses. Eighty-four compounds, representing 90.8% of the total content was identified in oil obtained from Uncaria Hook. The main components i were (*E*)-cinnamaldehyde (13.4%), α-copaene (8.0%), methyl eugenol (6.8%), δ-cadinene (5.3%), and curcumene (3.6%). The important key aroma-active compounds in the oil were detected by gas chromatography-olfactometry (GC-O) and aroma extract dilution analysis (AEDA), using the flavor dilution (FD) factor to express the odor potency of each compounds. Furthermore, the odor activity value (OAV) has been used as a measure of the relative contribution of each compound to the aroma of the Uncaria Hook oil. The GC-O and AEDA results showed that α-copaene (FD = 4, OAV = 4376), (*E*)-linalool oxide (FD = 64, OAV = 9.1), and methyl eugenol (FD = 64, OAV = 29) contributed to the woody and spicy odor of Uncaria Hook oil, whereas furfural (FD = 8, OAV = 4808) contributed to its sweet odor. These results warrant further investigations of the application of essential oil from Uncaria Hook in the phytochemical and medicinal fields.

Key words: Uncaria Hook, *Uncaria rhynchophylla*, crude drug, essential oil, GC-O, AEDA, GC-MS

1 INTRODUCTION

According to Japanese Pharmacopoeia 16th edition, the Uncaria Hook ("Chotoko" in Japanese) is composed of the branch with curved hook of *Uncaria rhynchophylla*, *Uncaria macrophylla*, and *Uncaria sinensis plants*[1]. Owing to its natural healing power, Uncaria Hook has been used as crude drugs and in Chinese herbal medicines ("Kampo" in Japanese) for more than 2000 years, to cure various diseases (such as "Raynaud's" phenomenon,- and rheumatism, among the others) or as analgestic in Japan, China, and Korea. Uncaria Hook is the most common ingredient and the predominant component of the traditional Kampo formulas "Yokukansan" and "Chotosan". Recent clinical studies, have reported the effectiveness of these formulas for the treatment of headaches and dizziness caused by hypertension for relieving the symptoms of Alzheimer's disease[2-5].

The pharmacological activitiy of crude drug is attributed to their active ingredients, including not only the extraction compounds, but also essential oils and volatile compounds which impart aroma and flavor. We have been involved in the study of the flavoring compounds, such as essential oils and volatile compounds of several crude drugs for a long time[6-14]. Therefore, in this study investigated about essential oil from Uncaria Hook used as a crude drug in Japan.

Uncaria Hook belongs to the genus *Uncaria*, family Rubiaceae, which is widely distributed in Japan, China, and Korea. Previous chemical studies[15-19] have isolated indole and oxindole alkaloids (rhynchophylline, geissoschizine methyl ether, and hirsutine) as the active compoundsin Uncaria Hook. These compounds have been shown to lowering of blood pressure induce vasodilatation and sedation, and protect against ischemia-induced neuronal damage.

However, the volatile composition and aroma-active compounds from Uncaria Hook has not been elucidated

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before, for instance using sensory evaluation. In flavor analysis, gas chromatography-olfactometry (GC-O) is the most common method used for evaluation of odorants; in particular, GC-O combined with aroma extract dilution analysis (AEDA) has emerged as the most useful method for estimating the contribution of most aroma-active compounds[20]. The odor potency is expressed as the flavor dilution (FD) factor, is the ratio of the concentration of a compound in the initial concentration to the most diluted concentration in which the odor could be detected by GC-O[21]. The significant contribution of each odorant to the characteristic flavor of a sample can be determined by the corresponding odor activity value (OAV), which is the ratio between the concentration of the compound and its odor threshold: it is well accepted that compounds with high OAV give a greater contribution to the sample aroma[22].

Based on the above, the chemical composition of essential oil from Uncaria Hook was investigated by the gas chromatography (GC) and GC-mass spectrometry (GC-MS), with main aims to evaluate the key aroma-active compounds in the oil by GC-O and AEDA methods.

2 EXPERIMENTAL

2.1 Plant material

Uncaria Hook (air-dried branch with curved-hook of *U. rhynchophylla*) was purchased from Ohsugi Pharmaceutical Co., Ltd. Osaka, Japan and used for extracting essential oil.

2.2 Isolation of essential oil

Uncaria Hook (100 g) was subjected to hydrodistillation for 3 h with a Likens-Nickerson-type apparatus, using diethyl ether to yield 0.03% of the yellowish oil, which was dried over anhydrous sodium sulfate prior. The oil was kept in a sealed tube and stored at 4℃ in a freezer prior to the GC and GC-MS analyses.

2.3 Gas chromatography

The GC analysis was performed using an Agilent Technologies 6890 gas chromatograph equipped with a flame ionization detector (FID). The oil was analyzed on a HP-5MS (Agilent Technologies, USA) fused silica capillary column (5% phenylmethylpolysiloxane, 30 m length × 0.25 mm internal diameter, 0.25 μm film thickness) and a DB-WAX (Agilent Technologies) fused silica capillary column (15 m engthh × 0.25 mm internal diameter, 0.25 μm film thickness). The temperature was programmed to increase from 40 to 260℃ at a rate of 4℃/min and then held at 260℃ for 5 min (HP-5MS column), or to increase from 40 to 240℃ at 4℃/min and then held at 240℃ for 10 min (DB-WAX column). Helium was used as the carrier gas at a flow rate of 1.5 mL/min; the injector port and detector temperatures were 270 and 280℃, respectively.

2.4 Gas chromatography- mass spectrometry

The GC-MS analysis was performed using an Agilent Technologies-5973-MSD apparatus equipped with a HP-5MS (Agilent Technologies) fused silica capillary column (% phenylmethylpolysiloxane, 30 m length × 0.25 mm internal diameter, 0.25 μm film thickness) and a DB-WAX (Agilent Technologies) fused silica capillary column (15 m engthh × 0.25 mm internal diameter, 0.25 μm film thickness). The temperature gradient was programmed as above. For the HP-5MS column, the column temperature was programmed to increase from 40 to 260℃ at a rate of 4℃/min and held at 260℃ for 5 min. For the DB-WAX column, the column temperature was increased from 40 to 240℃ at 4℃/min and held at 240℃ for 10 min. The flow rate of the carrier gas (He) was 1.5 mL/min for both columns. The injector and detector temperatures were 270 and 280℃, respectively; the actual temperature in the MS source reached up to approximately 230℃, and the ionization energy was 70 eV. The mass scan range was 40–450 *m/z* at a sampling rate of 2.4 scan/s. After diluting 10 mg of the sample oil with 500 μL of diethyl ether, 1 μL of the diluted sample was injected into the instrument, with a split ratio 1:40.

2.5 Gas chromatography-olfactometry

The GC-O analysis was performed on a Hewlett-Packard 6890/Hewlett-Packard 5973A-Olfactory Detection port 2. The GC condition was equipped on capillary columns (HP-5MS, 30 m length × 0.25 mm internal diameter). The oven temperature was programmed to increase 40 to 260℃ at a rate of 4℃/min and then held at 260℃ for 5 min. The flow rate of the He was 1.5 mL/min. The injector energy was 70 eV, and 1 μL of the oil was injected. At the exit of the capillary column, the effluent was split into the channels to the mass detector and the sniffing port., with a 1:1 (*v/v*) split ration. The Chemistation software was connected to two channels from the olfactometer signal board.

2.6 Aroma extract dilution analysis

The highest sample concentration (10 mg/mL) was assigned a Flavor Dilution (FD) factor of 1. The essential oil was diluted stepwise with diethylether (1:1, *v/v*), and aliquots were then analyzed by GC-O on the HP-5MS capillary column. The process stopped when aromas could no longer be detected by a group of assessors. The results were expressed through the FD-factor, which is the ratio of the concentration of the odorant in the initial essential oil to its concentration in the most diluted essential oil in which the odor is still detectable by GC-O[20]. An odorant with high FD-factor can be considered as an important contributor to the characteristic flavor. On the basis of the AEDA results, the odor activity value (OAV) was calculated using the

equation reported by Guth and Grosch[22].

2.7 Identification and quantification of compounds

The compounds present in the oil were confirmed by comparing with the present data to published mass spectral data[23], to our previous studies[13, 21, 24–36], to Kovats retention indices (RI), and to digital libraries (Wiley, Mass Finder 4, NIST02, and Aroma Office version 3.0, Nishikawa-Keisoku Co. Ltd., which includes 72,120 entries of RI of aroma compounds and their literature sources.) with those of the standards or RI reported in the literature. The RI for the present samples were calculated using a series of *n*-alkanes (C_5-C_{29}) on two columns of different polarities.

The quantitative composition of the oil was determined by GC (FID) by assuming the total of the oil to be 100%. The quantitative analysis of aroma-active compounds (FD ≥ 8) in the oil was performed on the basis of calibration curves for furfural (**1**), hexanoic acid (**5**), (*E*)-linalool oxide (**12**), linalool (**14**), menthone (**18**), α-terpineol (**24**), estragol (**26**), methyl eugenol (**45**), and paeonol (**50**) within a concentration range of 0.5-1000 μg/mL. When the specific standard was not available, a the corresponding data for the available compound with the closet physical chemical properties were used; α-copaene for γ-muurolene (**54**), and δ-cadinene (**62**), myristicin for asaricin (**59**), nerolidol for β-eudesmol (**71**), and ligustilide for (*Z*)-ligustilide (**74**).

3 RESULTS AND DISCUSSION

The essential oil obtained by hydrodistillation from Uncaria Hook had a yellowish color and a woody, spicy, and sweet odor. The yield of the oil was 0.03% (w/w). The oil was analyzed using GC and GC-MS, whose total ion chromatograms (TIC) are shown in Fig. 1.

Eighty-four compounds, representing 90.8% of the total fraction, were detected in the oil, and their percent fractions are listed in Table 1. The main components were (*E*)-cinnamaldehyde (**32**; 13.4%), α-copaene (**41**; 8.0%), methyl eugenol (**45**; 6.8%), δ-cadinene (**62**; 5.3%), and curcumene (**56**; 3.6%). The characteristic components detected in essential oil from Uncaria Hook were phenylpropanoids, such as estragol (**26**), (*E*)-anethol (**33**), safrole (**34**), eugenol (**38**), methyl eugenol (**45**), croweacin (**53**), asaricin (**59**), and elemicin (**65**) (Fig. 2). The total phenylpropanoids content 31.8%. The classification of essential oil by the functional groups is summarized in Table 2. The oil was mainly consisted of aromatic hydrocarbons (30.2%), and also contained significant amounts of oxygenated compounds, such as ethers (18.8%), alcohols (11.5%), ketones (5.6%), and esters (4.7%). In particular, the oil was rich in sesquiterpenes, with 24 sesquiterpenes present, accounting for 29.0% of the oil.

The AEDA and GC-O analysis were employed to identify

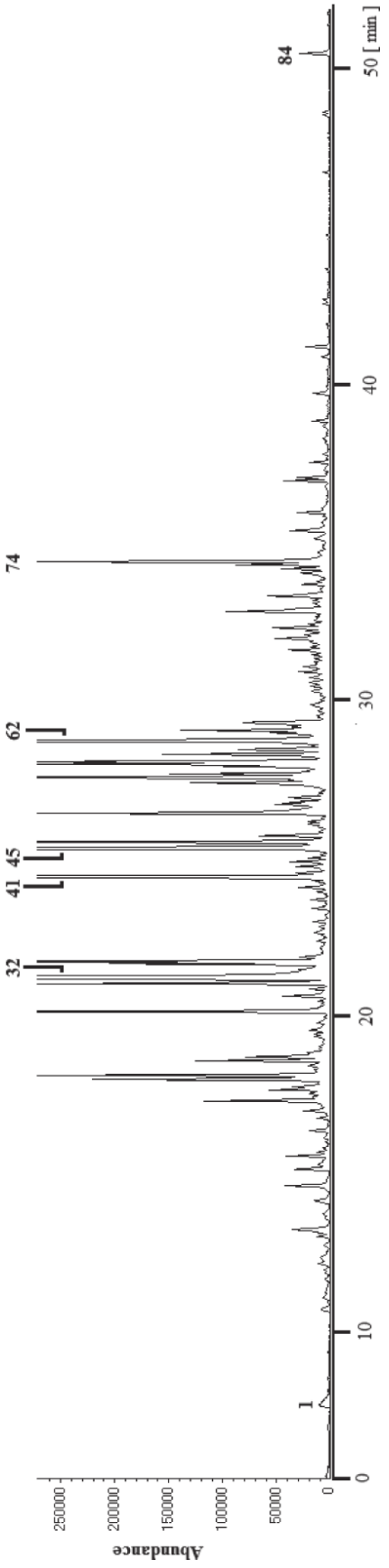

Fig. 1 Total ion chromatograms (TIC) of essential oil from Uncaria Hook.

Table 1 Chemical composition of essential oil from Uncaria Hook.

No.	Compounds[a]	RI[b] HP-5MS	RI[b] DB-WAX	Peak area (%)[c]	Identification method[d]	Reference source[e]
1	furfural	829	1371	1.5	RI, MS	TCI
2	3-methylcyclohexanone	946	-	0.2	RI, MS	TCI
3	benzaldehyde	958	1424	0.2	RI, MS	TCI
4	5-methylfurfural	962	1477	0.3	RI, MS	Aldrich
5	hexanoic acid	1000	1740	0.3	RI, MS	TCI
6	*p*-cymene	1022	1280	0.3	RI, MS	TCI
7	eucalyptol	1028	1215	1.0	RI, MS	Aldrich
8	phenylacetaldehyde	1042	1546	0.2	RI, MS	TCI
9	γ-hexalactone	1053	-	0.1	RI, MS	Aldrich
10	γ-terpinene	1056	-	0.3	RI, MS	TCI
11	(*Z*)-linalool oxide	1070	1377	0.6	RI, MS	Wako
12	(*E*)-linalool oxide	1086	1407	0.5	RI, MS	Wako
13	*p*-guaiacol	1090	-	0.2	RI, MS	TCI
14	linalool	1099	1553	0.3	RI, MS	TCI
15	nonanal	1102	1379	0.1	RI, MS	Wako
16	nopinone	1135	1586	0.2	RI, MS	Aldrich
17	camphor	1142	1506	0.2	RI, MS	TCI
18	menthone	1152	1388	1.0	RI, MS	TCI
19	(2*E*)-nonenal	1158	-	0.2	RI, MS	TCI
20	isomenthone	1162	-	0.4	RI, MS	Wako
21	borneol	1165	1603	0.3	RI, MS	Aldrich
22	menthol	1172	1566	1.4	RI, MS	TCI
23	terpinen-4-ol	1176	1522	2.5	RI, MS	TCI
24	α-terpineol	1190	1640	0.9	RI, MS	Aldrich
25	methyl salicylate	1193	1755	0.9	RI, MS	TCI
26	estragol	1197	-	0.2	RI, MS	Wako
27	(*Z*)-cinnamaldehyde	1219	-	0.4	RI, MS	Other
28	pulegone	1238	1546	2.5	RI, MS	Fluka
29	piperitone	1253	-	0.3	RI, MS	TCI
30	(2*E*)-decenal	1260	-	0.2	RI, MS	Aldrich
31	3,5-dimethoxy toluene	1265	1726	2.2	RI, MS	Wako
32	(*E*)-cinnamaldehyde	1273	1905	13.4	RI, MS	Wako
33	(*E*)-anethol	1285	1711	1.5	RI, MS	TCI
34	safrole	1288	1741	2.2	RI, MS	Wako
35	2-undecanone	1291	1596	0.3	RI, MS	TCI
36	carvacrol	1307	-	0.1	RI, MS	Wako
37	silphinene	1341	-	0.2	RI, MS	Other
38	eugenol	1358	2028	0.2	RI, MS	Wako
39	cyclosativene	1363	-	0.3	RI, MS	Fluka
40	α-ylangene	1369	1490	0.1	RI, MS[f]	
41	α-copaene	1375	1425	8.0	RI, MS	Aldrich
42	modheph-2-ene	1378	-	0.2	RI, MS	Other
43	β-elemene	1389	-	0.3	RI, MS[f]	

Table 1 Continued.

No.	Compounds[a]	RI[b]		Peak area (%)[c]	Identification method[d]	Reference source[e]
		HP-5MS	DB-WAX			
44	sativene	1393	-	0.2	RI, MS	Aldrich
45	methyl eugenol	1404	1992	6.8	RI, MS	TCI
46	3,4,5-trimethoxy toluene	1411	2041	2.8	RI, MS	TCI
47	β-caryophyllene	1417	1628	0.6	RI, MS	TCI
48	β-gurjunene	1430	-	0.3	RI, MS[f]	
49	(*E*)-α-bergamotene	1433	-	0.2	RI, MS[f]	
50	paeonol	1442	-	2.9	RI, MS	Wako
51	α-humulene	1452	1667	0.5	RI, MS	TCI
52	β-farnesene	1454	1574	0.3	RI, MS	Wako
53	croweacin	1459	-	0.4	RI, MS	Other
54	γ-muurolene	1474	1594	1.3	RI, MS	Other
55	β-guaiene	1477	1619	0.3	RI, MS[f]	
56	curcumene	1481	1678	3.6	RI, MS[f]	
57	α-selinene	1485	-	1.1	RI, MS[f]	
58	α-zingiberene	1493	-	0.9	RI, MS[f]	
59	asaricin	1495	-	2.0	RI, MS	Other
60	α-muurolene	1498	1633	1.8	RI, MS[f]	
61	β-bisabolene	1506	1642	1.2	RI, MS[f]	
62	δ-cadinene	1522	1660	5.3	RI, MS[f]	
63	(*E*)-cadina-1,4-diene	1531	-	0.9	RI, MS[f]	
64	α-calacorene	1542	-	1.1	RI, MS[f]	
65	elemicin	1555	-	0.1	RI, MS[f]	
66	(*E*)-nerolidol	1561	2022	0.2	RI, MS	Fluka
67	β-vetivenene	1563	-	0.2	RI, MS[f]	
68	cedrol	1600	-	0.3	RI, MS	Aldrich
69	τ-muurolol	1641	2206	0.5	RI, MS[f]	
70	α-muurolol	1645	2219	0.2	RI, MS[f]	
71	β-eudesmol	1650	-	0.2	RI, MS[f]	
72	butylidene phthalide	1673	2449	0.8	RI, MS	Aldrich
73	2,2',5,5'-tetramethyl-1,1'-biphenyl	1676	-	0.3	RI, MS	Other
74	(*Z*)-ligustilide	1736	2618	2.3	RI, MS	Other
75	benzyl benzoate	1763	2549	0.2	RI, MS	TCI
76	anthracene	1773	2607	0.4	RI, MS	Wako
77	hexahydrofarnesyl acetone	1839	-	0.4	RI, MS[f]	
78	methyl palmitate	1920	-	0.3	RI, MS	TCI
79	methyl linoleate	2087	-	0.1	RI, MS	TCI
80	methyl oleate	2094	-	0.1	RI, MS	TCI
81	tetracosane	2400	2400	0.1	RI, MS	TCI
82	pentacosane	2500	2500	0.5	RI, MS	TCI
83	heptacosane	2700	2600	1.2	RI, MS	TCI
84	nonacosane	2900	2900	1.1	RI, MS	TCI
	total identified			90.8		

[a] Compounds are listed in order of their elution time from a HP-5MS column. Presence of compound is indicated by its GC/FID percentage.
[b] RI = retention indices determined on HP-5MS and DB-WAX columns, using the homologous series of *n*-alkanes (C_5-C_{29}).
[c] Peak area (%) was related to total detected compounds by GC-MS.
[d] Identification methods: RI, retention indices; MS, mass spectrum.
[e] Reference materials were obtained from commercial source and our previous studies: Wako,Wako Pure Chemical Industries Ltd. (Osaka, Japan); TCI, Tokyo Kasei Kogyou Co. Ltd. (Tokyo, Japan); Aldrich, Sigma-Aldrich, St. Louis; Fluka, Sigma-Aldrich, St. Louis, MO; other, reference mass spectrum and retention indices were measured outside the author's laboratory (the identification is therefore considered to be tentative).
[f] our previous studies (**40** from Miyazawa *et al*. (2006); **43** from Miyazawa *et al*. (2009); **48**, **49**, and **65** from Utsunomiya *et al*. (2005); **55**, **58**, **60**, **68**, and **70** from Miyazawa *et al*. (2010); **56** and **71** from Kashima *et al*. (2011); **57** from Kawata *et al*. (2007); **61**, **62**, **63**, **64**, and **69** from Miyazawa *et al*, (2013); **77** from Takahashi *et al*. (2010)).

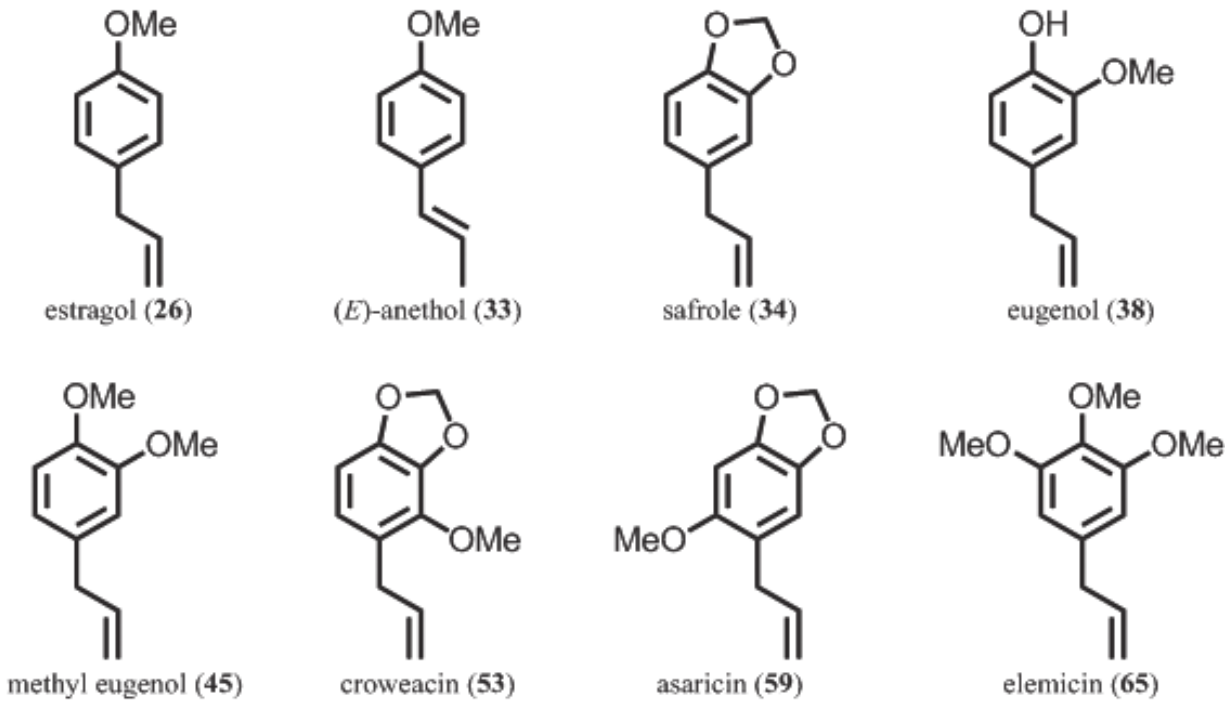

Fig. 2 Structure of characteristic phenylpropanoids from essential of Uncaria Hook.

Table 2 Classification of the compounds of essential oil from Uncaria Hook.

Compounds		Peak area (%)[a)]
Hydrocarbons		
	Alipthatic	2.9
	Aromatic	30.2
Aldehydes		
	Alipthatic	1.6
	Aromatic	14.8
Alcohols		
	Alipthatic	
	Aromatic	11.5
Ketones		5.6
Esters		4.7
Ethers		18.8
Acids		0.7
Total identified		90.8

[a)] These values were calculated from GC peak area.

the most potent odorants contributing to the characteristic woody, spicy, and sweet odor of Uncaria Hook oil. The key aroma-active compounds and their odor properties are listed in Table 3. As a result, 19 aroma-active compounds were detected in the oil. A comparison of the oil composition obtained by GC and the corresponding FD chromatogram of the odor-contributing compounds is shown in Fig. 3. On the basis of the FD-factors (*E*)-linalool oxide (FD = 64; woody), methyl eugenol (FD = 64; spicy), linalool (FD = 32; woody), estragol (FD = 32; sweet), asaricin (FD = 32; spicy), β-eudesmol (FD = 32; woody), and (*Z*)-ligustilide (FD = 32; woody) were intense compounds among the 19 aroma-active compounds detected by AEDA. The highest FD factor was attributed to (*E*)-linalool oxide and methyl eugenol whose odor was descriced as woody and spicy, respectively, by sniffinf test. Thus, these compounds were detected in essential oil from Uncaria Hook as the key aroma-active compounds. Several compounds with a high FD-factor (FD = 64 or FD = 32) emitted a woody or spicy odor. Moreover, most of the 19 aroma-active components were oxygenated compounds and mainly contained C_{10} compounds. These compounds produced the woody, spicy, and sweet odor of Uncaria Hook oil, except *p*-menthone (FD = 16; mint), α-terpineol (FD = 16; floral), and piperitone (FD = 4; fresh). These results indicated that low FD-factor compounds seem to contribute less to the characteristic odor of Uncaria Hook oil, although they still give a small contribution.

Although the content of copaene (41) was significant (8.0%), its FD factor was low, as show in Fig. 3. This compound was less importance as the aroma-active compounds of Uncaria Hook oil. In fact, even though a higher FD-factor was often related to the aroma-active compounds, a high FD-factormay may also be caused by the high content in oil. Therefore, in order to clarify this issue, the odor activity value (OAV) was calculated. The OAV of the key aroma-active compounds of Uncaria Hook oil is shown in Table 3. In

Table 3 Aroma-active compounds of essential oil from Uncaria Hook.

No.	Compounds[a)]	RI	Odor[b)]	FD-factor[c)]	Conc. (ppb)[d)]	OT (ppb)[e)]	OAV[f)]
1	furfural	829	sweet	8	4808	1	4808
3	benzaldehyde	958	sweet	2	743	35	21
4	5-methylfurfural	962	sweet	2	693	N/A*	N/D**
5	hexanoic acid	1000	sweet	8	785	1000	0.8
11	(*Z*)-linalool oxide	1070	woody	4	1828	100	18.3
12	(*E*)-linalool oxide	1086	woody	64	1736	190	9.1
14	linalool	1099	woody	32	1056	1	1056
18	menthone	1152	mint	16	3254	170	19
24	α-terpineol	1190	floral	16	3059	5000	0.6
26	estragol	1197	sweet	32	686	16	43
29	piperitone	1253	fresh	4	1106	N/A*	N/D**
41	α-copaene	1375	woody, spicy	4	26255	6	4376
45	methyl eugenol	1404	spicy	64	22486	775	29
50	paeonol	1442	woody, spicy	16	9653	N/A*	N/D**
54	γ-muurolene	1474	woody	8	4422	N/A*	N/D**
59	asaricin	1495	spicy	32	6491	N/A*	N/D**
62	δ-cadinene	1522	woody	8	17388	N/A*	N/D**
71	β-eudesmol	1650	woody	32	2792	N/A*	N/D**
74	(*Z*)-ligustilide	1736	woody	32	7610	N/A*	N/D**

a) Compounds are listed in order of their elution time from a HP-5MS column.
b) Odor description at the GC-sniffing port.
c) FD-factor = Flavor dilution factor using AEDA method (FD-factor 1 = 10 mg/mL).
d) Conc. = Concentration.
e) Odor threshold in water. These values were according to reference[36-41].
f) The OAV was obtained by dividing the concentrations of the odorants by their thresholds.
* Data not available.
** Not determined.

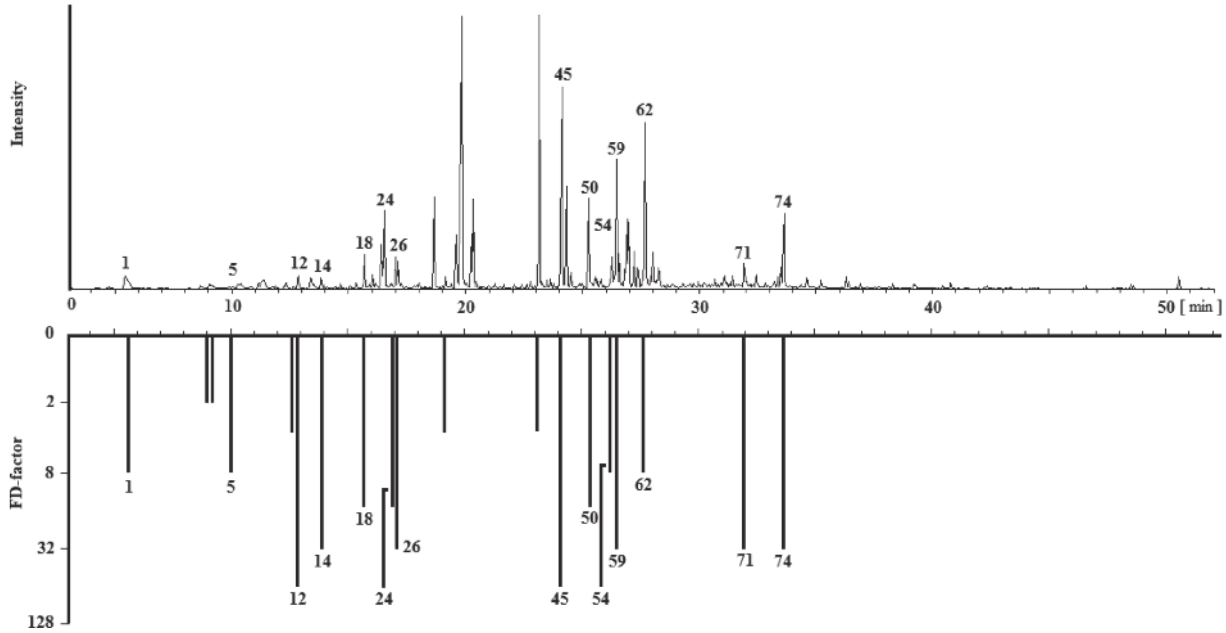

Fig. 3 Gas chromatogram and aromagram (FD-factor) of essential oil from Uncaria Hook.
1, furfural (FD = 8); **5**, hexanoic acid (FD = 8); **12**, (*E*)-linalool oxide (FD = 64); **14**, linalool (FD = 32); **18**, menthone (FD = 16); **24**, α-terpineol (FD = 16); **26**, estragol (FD = 32); **45**, methyl eugenol (FD = 64); **50**, paeonol (FD = 16); **54**, γ-muurolene (FD = 8); **59**, asaricin (FD = 32); **62**, δ-cadinene (FD = 8); **71**, β-eudesmol (FD = 32); **74**, (*Z*)-ligustilide (FD = 32).

spite of a high FD-factor of methyl eugenol (FD = 64, spicy), OAV was low at 29. It could thus be inferred that the high FD-factor of methyl eugenol might be due to its high concentration in the sample. With regard to the OAV values, furfural (OAV; 4808, sweet), α-copaene (OAV; 4376, woody, spicy), and linalool (OAV; 1056, woody) were the key aroma-active compounds of essential oil from Uncaria Hook.

In conclusion, we have investigated the key aroma-active compounds of Uncaria Hook by sensory evaluation and using the concept of OAV. The data obtained here indicate that (*E*)-linalool oxide (FD = 64; woody) and methyl eugenol (FD = 64; spicy) are the main contributors to the woody and spicy odor of the oil based on the sniffing test. Furthermore, the OAV analysis showed that furfural, α-copaene, and linalool contributed to the sweet, woody, and spicy odor. On the basis of AEDA, OAV, and sensory evaluations, we thus identified these compounds as the key aroma-active compounds of essential oil from Uncaria Hook. Following these the present results, further investigations would be need to explore the phytochemical and medicinal applications of the essential oil from Uncaria Hook.

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