QUALITY AND CHEMICAL COMPOSITION OF ORGANIC AND NON-ORGANIC VETIVER OIL

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ABSTRACT

Vetiver oil (Vetiveria zizanoides) has been used as perfume materials, cosmetics, fragrance soaps, anti-inflammation, repellent, and insecticidal agents. Organic vetiver oil has higher economical value than non-organic vetiver oil and it has been regarded to be able to compete in the global market. Therefore, studies have been carried out using 1 hectare of land and the first generation of organic vetiver oil has produced 0.57% of yield, greater than non-organic (0.50%). The quality of organic and non-organic vetiver oil was analyzed by Indonesian Standard (SNI) parameter, pesticide residue test, chemical composition by GC/MS, and the appearance of vetiver root. In general, the result of organic and non-organic vetiver oil has fulfilled the national standard; the quality of organic vetiver oil was better than non-organic one. Physically, the appearance of organic vetiver root was better than non-organic vetiver root; organic vetiver root was denser, more appealing, and did not have any black spots. The pesticide residue of organic vetiver oil was lower than non-organic vetiver oil. Based on SNI test, vetiverol (oxygen compounds) in organic vetiver oil was higher than non-organic vetiver oil.

Keywords: *Vetiveria zizanoides; organic vetiver oil; vetiverol*

ABSTRAK

Minyak akar wangi (Vetiveria zizanoides) merupakan bahan parfum, kosmetik, fragran, anti-inflamasi, penolak serangga dan insektisida. Minyak akar wangi organik mempunyai nilai jual yang lebih tinggi dibandingkan dengan minyak akar wangi non-organik. Untuk itu, telah dilakukan penelitian terhadap sistem penanaman akar wangi organik dan analisis kualitas minyak akar wangi organik dibandingkan dengan non-organik. Penanaman akar wangi organik dilakukan pada lahan seluas 1 hektar. Minyak akar wangi diperoleh melalui distilasi uap tanaman akar wangi. Perbandingan kualitas minyak akar wangi organik dan non-organik dianalisis dengan GC/MS, tes residu pestisida dan uji SNI. Hasil penelitian menunjukkan yield minyak akar wangi organik 0,57% sedangkan non-organik umumnya kurang dari 0,5%. Kandungan pestisida minyak akar wangi organik lebih rendah dari non-organik. Secara umum, minyak akar wangi organik memenuhi standar SNI dan memiliki kandungan vetiverol lebih besar dibandingkan minyak akar wangi non-organik.

Kata Kunci: *Vetiveria zizanoides; minyak akar wangi organik; vetiverol*

INTRODUCTION

Indonesia is the second largest country in the world after Haiti as vetiver oil exporter and the first exporting country after the earthquake in Haiti in 2010. Vetiver root is an annual plant and usually planted with vegetables as intercropping plant such as cabbage, potato, and peanut.

Essential oil, which is also defined as essence, volatile oil, etheric oil or aetheroleum, is a complex mixture of volatile which is regarded as a biosynthesis constituent of plants [1]. The characteristic aroma is resulted from a variety of complex chemical compounds. The term *essential oil* is concomitant to fragrance or perfumes because these fragrances are *oily* in nature and they represent the *essence* or the active constituents of the plants. They are called *volatile or ethereal oils* as they evaporate when they exposed to air at ordinary temperatures. Essential oils are highly concentrated, low volume, high value products [2].

Essential oils can be liberated from their matrix by water, steam and dry distillation [3-4]. Vetiver oil, which is obtained by steam distillation process from vetiver roots (*Vetiveria zizanoides)*, is widely used for perfumes, cosmetics, fragrance soap, anti-inflammatory, insect repellent and insecticidal agents

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[5-16]. Vetiver oil is one of the most important raw materials in aromatic product especially perfumery both as a fixative and fragrance ingredient [17].

Furthermore, many people are aware of the importance of a healthy life, sustainable land and environment and also promoting the increasing demand of organic product including organic essential oil (aromatic) product. The rate of increase in world demand of organic products is currently accounted for 10-20% per year with the price of organic production of approximately 20-70%, higher than conventional products (non-organic).

The government has long declared "Go Organic Indonesia 2010" and in 2002 had issued guidelines for organic farming by removing the reference to the perpetrator in the form of organic SNI 01-6729-2002 on Organic Food System. However, the current development of organic essential oils in Indonesia has not been optimized.

Currently, organic essential oil products market are more globalized, thus more effort and attention from the manufacturer are required. The market of organic products in the world is still dominated by America and Europe, while countries in Asia and other regions accounted for only about 3%. Along with the increasing global trade, the qualities of essential oil product, such as vetiver oil, are also becoming more important to access export markets.

Therefore, to remain competitive in world markets and to increase the price of vetiver oil, replacing conventional (non-organic) vetiver oil production to organic vetiver oil is needed. The export value of Indonesian essential oils has been moving away from the increasingly volatile world oil imports, which means that the market share in Indonesia has become smaller, for example in 2010 Indonesia's market share is only 1.7%. This suggests that the Indonesia volatile oil market opportunities in international markets are still wide open and the rate of increase in exports of Indonesia volatile oil should be improved. Besides market availability, price of organic essential oil product, including organic vetiver oil, is 20-70% higher than non-organic product.

In Indonesia, the development of organic essential oil products, especially organic vetiver oil, was implemented in Samarang Garut, as the production center of vetiver oil [18]. Vetiver root planting, which used organic fertilizer from dung of goat and cow, produced the first generation of organic vetiver oil. The quality and quantity of the first generation of organic vetiver oil production had been studied and compared with non-organic vetiver oil. It was produced from vetiver root which its plantation used chemical fertilizer and pesticide.

Table 1. The Methods of SNI test for vetiver oil

Parameter	Methods
Color	Visual
Density 25 °/25 °C	Gravimetry
Refraction index 25 °C	Refractometry
Solubility in alcohol 90%	Volumetry
Ester number before acetillation	Volumetry
Ester number after acetillation	Titration metry
Value of vetiverol (%)	Volumetry

This study included determination and evaluation of yield, Indonesian standard (SNI) parameter, pesticide residue, and chemical composition.

EXPERIMENTAL SECTION

Materials

Planting materials: Organic and non-organic vetiver root were obtained from UKM Pulus Wangi Nusantara, which was located in Samarang, Garut, West Java.

Organic vetiver oil was obtained from vetiver root which was planted using organic fertilizer from dung of goat or cow and isolated from other land.

Non-organic vetiver oil was obtained from vetiver root which was planted by farmers using chemical fertilizer and pesticide.

Instrumentation

The instruments used were a set of tools for steam distillation process, SNI test, pesticide residue test, and GC/MS spectrometer. The Indonesian Standard (SNI) test of vetiver oil was determined in Laboratory of *Balai Penelitian Tanaman Obat dan Aromatik* (Balittro) Bogor using several methods (Table 1), which were pesticide residue test by GC spectrometry in Chemical Residue Laboratory in Bogor, analysis and identification of chemical composition of vetiver oil by GC/MS in Instrument Laboratory, Department of Chemistry Education, Faculty of Mathematics and Sciences Education, Indonesia University of Education, Bandung.

Procedure

The steam distillation process

The samples (dried vetiver roots) were loaded into steam distillation kettle. The steam distillation process was 20 h with 2 atmospheres pressured for premium quality and 12 h with 5 atmospheres pressured for regular quality.
Yield was calculated using the following equation:

$$\frac{Total\ of\ vetiver\ oil\ produced}{Total\ of\ dried\ vetiver\ root} x100\%$$

Table2. The SNI regulation and SNI test of organic and non-organic vetiver oil

Parameter	Organic	Non-organic	Regulation
Color	Brown	brown	yellow – brown to red
Density 25 °/25 °C	0.9853	0.9866	0.980 – 1.003
Refraction index 25 °C	1.5305	1.5310	1.520 – 1.530
Solubility in alcohol 90%	Soluble, limpidly 1:2	Soluble, limpidly 1:2	1:1 limpidly, after end
Ester number before acetillation	5.51	13.50	5 – 26
Ester number after acetillation	118.52	112.39	100 – 150
Value of vetiverol (%)	48.71	42.41	Minimum 50

Fig 1. Steam distillation process of vetiver oil

Fig 2. Premium quality of vetiver oil

Fig 3. Regular quality of vetiver oil

Fig 4. Organic and non-organic vetiver root

Analysis and identification of chemical composition of vetiver oil by GC/MS spectrometry

In this study, we used Shimadzu QP-2010 S Mass Spectrometer model with EI mode operating at 70 eV under the following conditions: RTX-5 column (30 m length x 0.25 mm ID). Helium Carrier Gas (36 mL/min). Linear velocity, Pressure, and Split Ratio were 27.3 cm/sec, 22.0 kPa, 153.0, respectively. The injector temperature was 310 °C, column temperature was programmed at 80 °C with 10 °C/min and increased to 310 °C, 0.55 mL/min of samples were injected (split mode) in the column for 25 min. The components were identified based on library by WILEY7 and NIST08.LIB.

Examined parameters and data analysis

Parameters, which were examined in this study, included yield, SNI parameter, pesticide residue, analysis and identification of chemical composition by GC/MS.

Determination of concentration (v/v) for each component was confirmed using an internal standard (chlorobenzene 10%) from Merck and added to samples using digital micropipette Sibata Digipet 2508-100. Concentration of each component which was calculated by the following equation:

$$C_X = \frac{A_X}{A_{IS}} x C_{IS}$$

C_X : Concentration of sample (v/v)
C_{IS} : Concentration of internal standard (v/v)
A_X : Peak area of sample
A_{IS} : Peak area of internal standard

RESULT AND DISCUSSION

Production and Quality of Organic and Non-organic Vetiver Oil

Organic and non-organic vetiver oil was produced by steam distillation from organic and non-organic vetiver root, respectively (Fig. 1). To reduce thermal degradation of sample, steam distillation was set at low pressure [19-20]. Steam distillation at 2 atmospheres produced clear yellow vetiver oil which was called a premium quality (Fig. 2) and at 5 atmospheres resulted reddish brown vetiver oil which was called a regular

Table 3. Pesticide residue test of organic and non-organic vetiver oil

No.	Analysis	Concentration of Residue (µl/ml)		Limit Detection (µl/ml)
		Organic	Non-organic	
I.	**ORGANOCHLORINE**			
	A-BHC	-	-	0.0021
	Γ-BHC (Lindan)	-	-	0.0015
	Aldrine	-	-	0.0014
	Heptachlorine	0.014	0.028	0.0018
	Dieldrine	0.004	0.008	0.0022
	DDT	-	-	0.0019
	Endrine	-	-	0.0017
	Endosulfane	-	-	0.0020
II.	**ORGANOPHOSPHATE**			
	Diazinone	-	-	0.0023
	Fenitrotione	-	0.005	0.0022
	Metidatione	-	-	0.0020
	Malatione	-	-	0.0022
	Chlorpyrifos	0.004	0.005	0.0023
	Paratione	-	-	0.0023
	Profenophose	-	-	0.0017
	Dimetoate	-	-	0.0023
III.	**CARBAMATE**			
	Carbofuran	-	-	0.0137
	MIPC	-	-	0.0149
	BPMC	-	-	0.0143

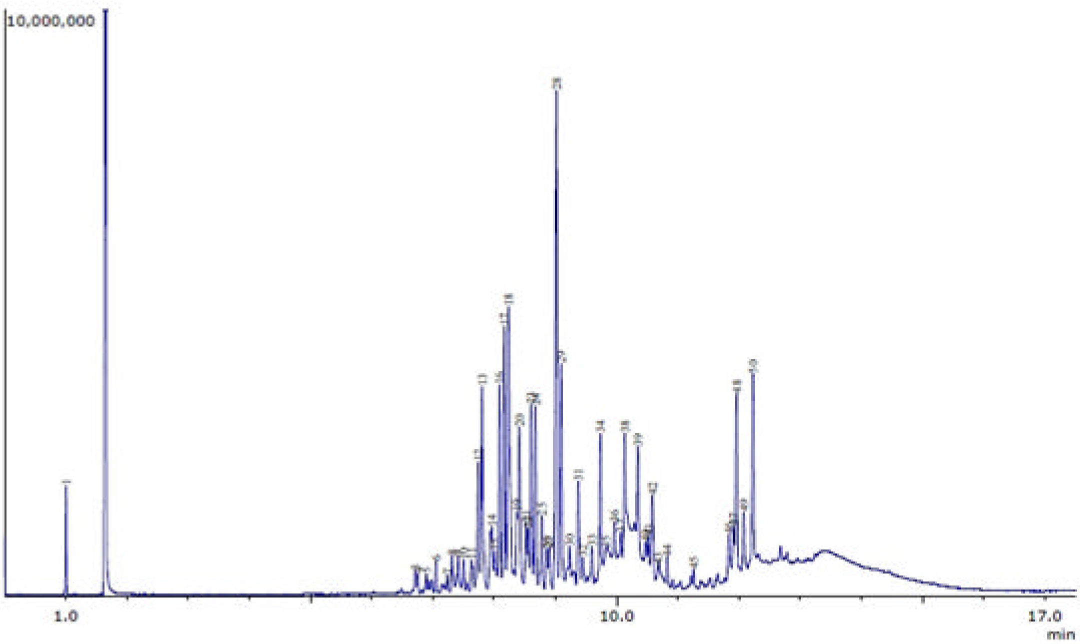

Fig 5. Chromatogram GC of organic vetiver oil

quality (Fig. 3). The results of vetiver oil distillation were 32.7 kg for premium quality and 12.7 kg for regular quality that were resulted from 8,019 kg dried vetiver root.

The quality of organic and non-organic vetiver oil was determined based on the yield, SNI test, pesticides residue, analysis and identification of chemical compounds.

Based on calculations, organic vetiver oil yield was 0.57% that was bigger than non-organic vetiver oil (< 0.50%). Higher yield that was generated indicated that the physical quality of organic vetiver root was better than non-organic vetiver root. It was denser, more

Table 4. Chemical composition of organic vetiver oil by GC/MS analysis

Peak	Molecule Formula	Name	Mol Weight	% Concentration (v/v)	SI
3	$C_{15}H_{24}$	1,2,4-Metheno-1H-indene	204	0.19	92
4	$C_{15}H_{24}$	alpha-Ylangene	204	0,15	84
5	$C_{15}H_{26}$	alpha-Cedrane	206	0.11	92
7	$C_{15}H_{24}$	alpha-Chamigrene	204	0.14	94
8	$C_{15}H_{26}O$	alpha-Cedrol	206	0.43	89
9	$C_{15}H_{24}$	Calarene	204	0.47	88
10	$C_{15}H_{24}$	(+)-Epi-bicyclosesquiphellandrene	204	0.30	91
11	$C_{15}H_{24}$	Aristolene	204	0.46	91
12	$C_{15}H_{24}$	1,4-Methano-1H-indene	202	1.39	85
13	$C_{15}H_{24}$	Khusimene	204	2.38	83
14	$C_{12}H_{18}O$	L-Proline, 1 glycyl	178	1.17	84
15	$C_{15}H_{22}$	8,9-dehydro-Neoisolongifolene	202	0.57	79
16	$C_{15}H_{24}$	alpa-Amorphene	204	2.09	96
18	$C_{15}H_{22}$	Aromadendrene, dehydro-	202	4.29	80
19	$C_{15}H_{24}O$	alpha-Santalol	220	1.04	75
20	$C_{15}H_{24}$	delta-Cadinene	204	1.85	90
21	$C_{15}H_{22}$	Isolongifolene, dehydro	202	0.68	79
22	$C_{15}H_{24}$	Gamma-Elemene	204	0.50	80
23	$C_{15}H_{24}$	Alpha-Gurjunene	204	1.89	89
24	$C_{15}H_{22}$	aromedenedradiene	202	1.45	86
Peak	Molecule Formula	Name	Mol Weight	% Concentration (v/v)	SI
25	$C_{15}H_{24}$	10s,11s-Himachala-3(12),4-diene	204	0.80	92
26	$C_{15}H_{20}$	alpha-Calacorene	200	0.40	84
27	$C_{15}H_{24}$	gamma-Himachalene	204	0.45	81
28	$C_{15}H_{22}$	Cycloisolongifolene	202	5.89	86
31	$C_{15}H_{22}$	Cycloisolongifolene, 9,10-dehydro	202	1.13	82
32	$C_{15}H_{26}O$	Torreyol	222	0.28	88
35	$C_{15}H_{22}O$	Selina-6-en-4-ol	222	0.68	84
36	$C_{15}H_{22}O$	2,2,7,7-tetramethyltricyclo [6.2.1.0(1,6)]undec-4-en-3-one	218	0.42	80
38	$C_{15}H_{24}O$	Longifolenaldehyde	220	1.54	81
39	$C_{15}H_{22}O$	Valerenal	218	0.91	84
40	$C_{15}H_{24}O$	1,4-1,7-ditrans-acorenone	220	0.15	77
41	$C_{21}H_{34}O_2$	Androstan-17-one	318	0.24	80
43	$C_{15}H_{24}$	(-)-Caryophyllene-(11)	204	0.24	84
44	$C_{15}H_{24}$	Cadinene	204	0.22	86
45	$C_{15}H_{24}$	Caryophyllene	204	0.13	85
46	$C_{15}H_{22}O$	Nootkatone	218	0.61	74
47	$C_{15}H_{22}O$	Valerenal	218	0.52	80
49	$C_{15}H_{22}O$	Isovalerenal	218	0.68	85
50	$C_{15}H_{22}O$	Zierone	218	2.00	77

Note: The components were identified based on library by WILEY7 and NIST08.LIB.

appealing, and did not have any black spots (Fig. 4).

SNI test and SNI regulation of vetiver oil are shown in Table 2. Generally, organic and non-organic vetiver oil fulfilled a national standard, although the content vetiverol of vetiver oil did not meet with SNI regulation. However, the vetiverol of organic vetiver oil was still higher than non-organic vetiver oil (48.71% compared to 42.41%).

Pesticide residues on organic vetiver oil were less than non-organic vetiver oil (Table 3). According to Table 3, the pesticide residues detected in organic and non-organic vetiver oil were organochlorine and organophosphate groups. The detected organochlorine groups were heptachlorine and dieldrine; with the concentration of 0.014 and 0.004 µL/mL of organic vetiver oil, 0.028 and 0.008 µl/ml of non-organic vetiver oil. The detected organophosphate group was chlorfiriphose with the concentration of 0.004 µL/mL of organic vetiver oil and 0.005 µL/mL of non-organic vetiver oil. Moreover, non-organic vetiver oil contained 0.005 µL/mL fenitrotione. The results were smaller than other agriculture products (SNI Number 7313:2008).

Chemical Composition of Organic and Non-organic Vetiver Oil

Analysis and identification of chemical composition of vetiver oil (Essential oils) were most

Table 5. Chemical composition of non-organic vetiver oil by GC/MS analysis

Peak	Molecule Formula	Name	Mol Weight	% Concentration (v/v)	SI
3	$C_{16}H_{24}O$	5-methyl-2-(1-methyl-1-phenylethyl) Cyclohexanol	232	0.14	87
5	$C_{15}H_{24}$	alpha-Copaene	204	0.11	86
6	$C_{14}H_{22}$	3,5,7-trimethyl-undecatetraene	190	0.18	83
7	$C_{15}H_{26}$	alpha-Cedrene	206	0.22	91
11	$C_{15}H_{24}$	alpa-Chamigrene	204	0.15	94
12	$C_{15}H_{26}O$	alpha-Cedrol	222	0.29	89
13	$C_{15}H_{24}$	(+)-Calarene	204	0.38	84
16	$C_{15}H_{24}$	Isolongifolene	204	1.34	82
17	$C_{15}H_{24}$	1,4-Methana-1H-indene	204	1.64	85
18	$C_{15}H_{24}$	Khusimene	204	2.46	84
20	$C_{15}H_{18}O$	3-methyl-5-ethyl-4-propylidene-cyclohex-2-ene-1-one	178	0.83	84
21	$C_{15}H_{22}$	8,9-dehydro-neoisolongifolene	202	0.66	79
22	$C_{15}H_{24}$	alpha-Amorphene	204	2.09	95
24	$C_{15}H_{24}$	Cadinene	204	4.13	82
26	$C_{15}H_{24}$	delta-Cadinene	204	1.52	90
28	$C_{15}H_{24}$	gamma-Elemene	204	0.32	81
29	$C_{15}H_{24}$	alpha-Gurjunene	204	1.53	89
Peak	Molecule Formula	Name	Mol Weight	% Concentration (v/v)	SI
30	$C_{15}H_{22}$	Aromadendrene, dehydro	202	3.00	86
32	$C_{15}H_{24}$	gamma-Selinene	205	0.69	90
33	$C_{13}H_{16}$	Calacorene	172	0.58	87
34	$C_{17}H_{26}O_2$	(Z)-Valerenyl acetate	262	0.42	78
35	$C_{15}H_{22}$	Cycloisolongifolene	202	5.11	86
36	$C_{15}H_{22}$	Isolongifolene, 4,5-dehydro	202	2.54	85
39	$C_{15}H_{24}$	gamma-Himachalene	204	0.26	84
40	$C_{15}H_{22}$	Neoisolongifolene	202	1.43	79
42	$C_{15}H_{24}$	Caryophyllene	204	0.18	75
44	$C_{15}H_{24}O$	1,4-1,7-ditrans-acorenone	220	0.17	84
45	$C_{15}H_{22}O$	Valerenal	218	0.81	84
46	$C_{15}H_{24}O$	Longifolenaldehyde	220	0.33	81
47	$C_{15}H_{22}O$	Longiverbenone	218	0.30	79
48	$C_{15}H_{24}$	Cedrene-V6	204	0.92	81
49	$C_{15}H_{24}$	delta-Selinene	204	0.26	86
50	$C_{15}H_{22}O_2$	Isokhusenic acid	234	0.94	73
51	$C_{15}H_{22}O_2$	Isocurcumenol	234	1.57	68
53	$C_{15}H_{22}O$	Aristolene	218	0.61	81
54	$C_{15}H_{22}O$	Zierone	218	1.99	77

Note: The components were identified based on library by WILEY7 and NIST08.LIB.

widely used gas chromatography/mass spectrometry (GC/MS) [21-40]. The chromatograms GC of organic and non-organic vetiver oil are shown in Fig. 3 and 4, whereas the chemical compositions of organic and non-organic vetiver oil are shown in Table 4 and 5.

According to Table 4, organic vetiver oil indicated 50 components with the following main components; cyclo-isolongifolene (5.89%), aromadendrene, dehydro (4.29%), khusimene (2.38%), alpha-amorphene (2.09%), and zierone (2.00%). There were 54 components of non-organic vetiver oil; with the following major components; cyclo-isolongifolene (5.11%), cadinene (4.13%), aromadendrene-dehydro (3.00%), isolongifolene, 4,5-dehydro (2.54%), khusimene (2.46%), and alpha-amorphene (2.09%) (Table 5).

CONCLUSION

In general, the results of organic and non-organic vetiver oil fulfilled SNI parameter and the quality of organic was better than non-organic vetiver oil. The major components of vetiver oil were cyclo-isolongifolene, aromadendrene-dehydro, khusimene, alpha-amorphene.

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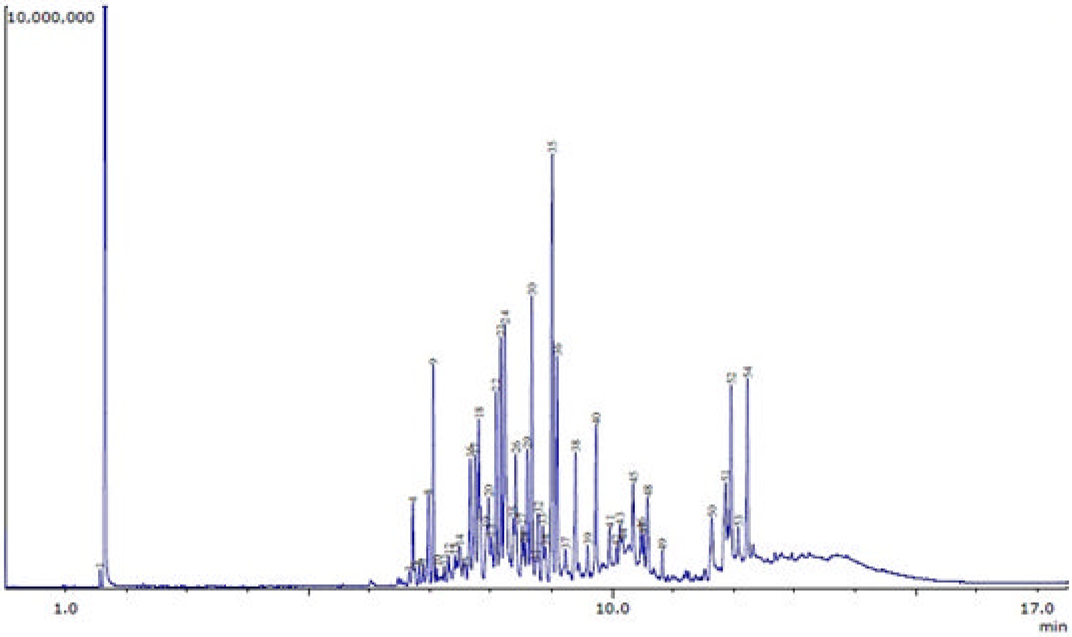

Fig 6. Chromatogram GC of non-organic vetiver oil

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