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# Essential Oil Composition and Antimicrobial Activities of *Tanacetum* chiliophyllum (Fisch. & Mey.) Schultz Bip. var. monocephalum Grierson from Turkey Kaan Polatoğlu<sup>1,3,\*</sup>, Fatih Demirci<sup>2</sup>, Betül Demirci<sup>2</sup>, Nezhun Gören<sup>3</sup> and Kemal Hüsnü Can Baser<sup>4</sup>

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**Abstract:** Water-distilled essential oils from aerial parts of *Tanacetum chiliophyllum* (Fisch. & Mey.) Schultz Bip. var. *monocephalum* Grierson from Turkey were analyzed by GC and GC/MS. The flower and stem oils were characterized by camphor (17.3%, 10.4%), 1,8-cineole (8.3%, 2.5%) and unknown compounds M<sup>+</sup> 218 (6.6%, 10.4%), M<sup>+</sup> 220 (Stem: 9.2%). Root oil was characterized with hexadecanoic acid (37.5%), alismol (6.3%), geranyl isovalerate (5.3%). Antibacterial activity of the flower and stem oils were evaluated on *Escherichia coli, Staphylococcus aureus, Pseudomonas aeruginosa, Enterobacter aerogenes, Proteus vulgaris, Salmonella typhimurium, Staphylococcus epidermis, Bacillus cereus, Bacillus subtilis, and Meticillin resistant <i>S. aureus* microorganisms by using a micro-dilution assay. Flower oil inhibited the growth of *Bacillus cereus* with the MIC 62.5 µg/mL which was 2 fold less concentration than the positive control chloramphenicol. Both flower and stem oils showed relative toxicity to *Vibrio fischeri* in the TLC-bioluminescence assay.

Keywords: Asteraceae; *Tanacetum chiliophyllum* var. *monocephalum*; essential oil; *Vibrio fischeri* TLC-bioluminescence cytotoxicity assay; antimicrobial activity; camphor; 1,8-cineole; hexadecanoic acid; alismol.

## 1. Plant Source

*Tanacetum chiliophyllum* (Fisch. & Mey.) Schultz Bip. var. *monocephalum* Grierson (Asteraceae) grows naturally in NorthWestern Iran, Azerbaijan, Armenia and East Turkey. Flowering time for this species is between May and June on volcanic, limestone slopes between 1200-3200 m altitude. *Tanacetum chiliophyllum* is represented in Turkey with four varieties which are var. *monocephalum*, var. *chiliophyllum*, var. *oligocephalum* and var. *heimerlei* [1]. Plant materials were collected in June 2006 from South East province of Van Turkey at 2954 m altitude. Plant material was identified by Dr. Kerim Alpınar and herbarium specimens have been deposited at the Herbarium of the Faculty of Pharmacy, Istanbul University with Voucher No: ISTE 83478

### 2. Previous Studies

Previous investigations reported essential oil composition of *T. chiliophyllum* var. *chiliophyllum* from different locations with different main components. According to these reports it seems there are three different chemotypes of this plant with camphor (28.5%), 1,8-cineole (17.1%), camphene (7.1%), isobornyl propionate (5.4%) [2]; camphor (17.9%), 1,8-cineole (16.6%), borneol (15.4%), dihydro- $\alpha$ -cyclogeranyl hexanoate (10.1%)

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[3] and camphor (16.8%), *cis*-chrysanthenyl acetate (16.3%),  $\alpha$ -thujone (12.5%) as main constituents [4]. Chemovariation is a well known fact in *Tanacetum* species which is encountered on species level [5-7], and on subspecies level [8,9]. In our previous investigations on Tanacetum genus we have identified essential oil compositions of T. cadmeum ssp. orientale [8], T. densum ssp. sivasicum, T. densum ssp. amani [10,11], T. macrophyllum [12], T. armenum, T. balsamita, T. haradjani, T. argyrophyllum var. argyrophyllum, T. argenteum ssp. argenteum var. canum, T. argenteum ssp. argenteum, T. praeteritum ssp. praeteritum, and T. praeteritum ssp. massicyticum, T. parthenium, T. zahlbruckneri, T. tabrisianum [4,13-16]. Various biological activities and rich sesquiterpene content of Tanacetum extracts are well known [17]. Previous reports indicate isolation of sesquiterpene lactones from this species which include isolation of tamirin from T. chiliophyllum var. chiliophyllum [18]; new chiliophyllin, heimerlein and known spiciformin, deacetyllauerenbiolide,  $1\alpha$ -hydroperoxy-1-desoxo chrysanolide, tabulin, tanachin, tamirin, dentatin from T. chiliophyllum var. heimerlei [19,20]. To the best of our knowledge, except a report on the (+)-linalool content of its oil [21] there is no previous report on the phytochemistry, essential oil composition, antibacterial activity or cytotoxicity of T. chiliophyllum var. monocephalum. In the course of our biological activity screening project of *Tanacetum* species growing in Turkey, here we report on the essential oil compositions, antibacterial and cytotoxic activities of T. chiliophyllum var. *monocephalum* oils.

#### 3. Present Study

*Isolation of the Essential Oils:* Flower, stem and roots (100g each) of the air dried plant samples were separately subjected to hydrodistillation for 4h using a Clevenger-type apparatus to obtain the oils. Yellow colored oil was obtained from each part of the plant with 0.06%, 0.05% (v/w) yields for flower and stem oils respectively. Root oil (<0.01%) was retrieved from the apparatus with n-hexane.

Gas Chromatography-Mass Spectrometry Analysis: Results of the analysis were given in Table 1. Method employed in the analysis was given in supporting information S1.

Antibacterial Activity test: Method employed in the tests was given in supporting information S2. Results of the antibacterial tests were given in Table 2 which was given in supporting information S4.

*Vibrio Fischeri Toxicity:* Method employed in the tests was given in supporting information S3. Results of the *Vibrion fischeri* toxicity tests were in Table 2 which was given in supporting information S4.

Composition of the oils were given in Table 1 with their relative percentages. The essential oils obtained from various parts of *T. chiliophyllum* var. *monocephalum* yielded oils with yellow color. A total of 93, 85 and 29 compounds were identified in flower, stem and root oils which represent 57.5%, 44.5% and 63.6% of the oils, respectively. Flower and stem oils were rich in camphor (17.3%, 10.4%) and 1,8-cineole (8.3%, 2.5%). Root oils were rich in hexadecanoic acid (37.5%), alismol (6.3%) and geranyl isovalerate (5.3%). All of the oils contained a couple of unidentified compounds with high percentages. The structure of these compounds could not be identified because of the low yield of the oils and inadequate amount of the plant material. Essential oils from *Tanacetum* species are commonly rich in 1,8-cineole, camphor, borneol, thujone, chrysanthenyl esters and alcohols [4,13]. In some species essential oils were found to be rich in carvone, pinenes and irregular monoterpenes such as lavandulyl esters and alcohol, artemisia ketone [22-24].

RI	Compound	Pe	Percent Composition		
		Α	В	С	
1014	Tricyclene	0.2	-	-	
1032	α-Pinene	0.3	-	tr	
1043	Santolinatriene	1.6	0.1	-	
1076	Camphene	3.4	0.2	-	
1093	Hexanal	0.1	-	-	
1118	β-Pinene	0.1	-	-	
1132	Sabinene	tr	tr	tr	
1135	Thuja-2,4(10)-diene	0.1	-	-	
1159	$\delta$ -3-Carene	-	-	tr	
1194	Heptanal	tr	-	-	
1195	Dehydro 1,8-cineole	tr	-	-	
1213	1,8-Cineole	8.3	2.5	-	
1255	γ-Terpinene	0.1	0.1	-	

Table 1. Composition (%) of flower stem and root oils of T. chiliophyllum var. monocephalum. (Continued overleaf)

Essential oil composition and antimicrobial activities of <i>T. chiliophyllum</i> var. <i>monocephalum</i>						
1280	<i>p</i> -Cymene	0.9	0.1	tr		
1296	Octanal	0.1	-	-		
1299	2-Methyl butyl isovalerate	0.1	0.1	-		
1348	6-Methyl-5-heptene-2-one	-	tr	-		
1400	Nonanal	0.1	0.1	-		
1400	Tetradecane	tr	-	-		
1403	Yomogi alcohol	0.1	-	-		
1405	Santolina alcohol	0.6	-	-		
1445	<i>a</i> , <i>p</i> -Dimethyl styrene Filifolene	tr 0.2	-	-		
1465	Eucarvone	tr	-	-		
1474	Camphenilone	0.1	-	-		
1474	<i>trans</i> -Sabinene hydrate	-	0.7	-		
1482	Longipinene*	0.4	0.4	-		
1492	α-Copaene	0.2	tr	-		
1499	$\alpha$ -Campholene aldehyde	tr	-	-		
1506	Decanal	-	tr	-		
1532	Camphor	17.3	10.4	-		
1535	β-Bourdonene trans-Chrysanthenyl acetate	- 0.9	tr 0.9	-		
1550	Benzaldehyde	-	tr	_		
1547	Dihydro achillene	0.1	tr	-		
1553	Linalool	0.2	0.2	-		
1556	cis-Sabinene hydrate	-	0.1	-		
1502	trans-p-Menth-2-ene-1-ol	- tr	0.2	-		
1582	cis-Chrysanthenyl acetate	-	0.2	-		
1583	Junipene (longifolene)	0.1	0.1	-		
1586	Pinocarvone	1.4	1.3	-		
1590	Bornyl acetate	0.3	0.2	-		
1611	Terpinene-4-ol	1.3	0.9	-		
1638	cis-p-Menth-2-ene-1-ol	tr	0.1	-		
1643	Dehydrosabinaketone	tr	-	-		
1648	Myrtenal Domulia shutumete	0.3	0.3	-		
1656	Bornyl isobutyrate Chrysanthenyl isobutyrate	- 0.1	0.2	-		
1657	Umbellulone	0.2	0.1	-		
1668	(Z)-β-Farnesene	0.1	-	0.4		
1669	Sesquisabinene	-	0.1	-		
1670	trans-Pinocarveol	1.1	0.8	-		
1683	trans-Verbenol	0.1 -	0.1	-		
1684	<i>trans</i> -chrysanthemol	0.2	-	-		
1685	Isovaleric acid	tr	-	-		
1688	Selina-4,11-diene	-	tr	-		
1689	trans-Piperitol (=trans-p-Menth-1-en-3-ol)	-	0.1	-		
1700	1-Heptadecane	_	0.1	_		
1704	Myrtenyl acetate	-	0.1	-		
1704	y-Muurolene	-	0.1	-		
1706	a-Terpineol	0.3	-	-		
1719	Borneol Verbenone	2.9	1.2	-		
1726	Germacrene D	tr	tr	-		
1740	cis-α-Bisabolene	-	0.2	-		
1741	β-Bisabolene	-	-	1.7		
1743	Chrysanthenyl isovalerate I	0.1	0.4	-		
1751	cis-Piperitol	0.2	0.2	-		
1760	Chrysanthenyl isovalerate II	0.3	0.3	-		
1763	Naphthalene	0.1	0.1	0.5		
1766	1-Decanol	-	tr	-		
1782	o-Cadinene	-	0.6	tr		
1802	Cumin aldehyde	0.1	0.2	-		
1804	Myrtenol	-	0.3	-		
1808	Nerol	-	-	0.3		
1819	(E)-2-Decen-1-ol	-	tr	-		
1827	(E, E)-2,4-Decadenal $(E)$ - $\beta$ -Damascenone	tr 0 1	U.1 -	tr -		
1849	Calamenene	0.1	0.2	-		
1857	Geraniol	0.1	0.1	-		

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1868 $(L)$ -Geranyl acetone       0.1       -       0.4         1882 $ar$ -himachalene       0.1       -       -         1889       Geranyl isovalente       0.1       -       -         1893       Geranyl isovalente       0.3       0.6       tr         1900 $rpt$ -Cubebol       0.3       0.6       tr         1900 $rpt$ -Cubebol       0.1       -       -         1941 $a$ -Galacorene       r       0.1       -         1945       I.S-spoxyabvial-4(14)-ene       0.1       -       -         1957       Cubebol       0.1       -       -       0.1       -         1957       Cubebol       0.1       -       -       0.1       -       -         1958       (L)-forone       0.1       0.1       0.3       0.4       0.6         2061       Isoamyl phylacetate       -       0.1       -       -       -         2050       (L)-Nerolidol       tr       r       -       -       -         2050       (L)-Nerolidol       tr       r       -       -       -         10       hexahydrofarnesyl acetone       <	1864	<i>p</i> -Cymen-8-ol	0.1	tr	-
1882       ar-thinachalene       -       0.1       -         1889       Geranyl isovalerate       -       0.3       5.3         1900       Pri-Cubebol       0.3       0.6       tr         1900       Nonadecane       -       0.1       tr         1941       ar-Calacorene       r       0.1       -         1945       1.5-epoxysalvial-4(14)-ene       -       0.1       -         1957       Cubebol       0.1       -       -         1958       ( <i>B</i> )-f-lonone       0.1       -       -         1958       ( <i>B</i> )-f-lonone       0.1       0.1       -         2060       Caryophylleno oxide       0.6       0.4       0.6         2016       Isoamyl phenylacetale       -       0.1       -         2037       Salvial-4(14)-lone-1-one       0.1       0.1       0.3         2040       Urbenol       tr       -       -         2050       Cubenol       tr       r       -       -         2060       Cubenol       tr       -       -       -       -         2073 <i>P</i> -Mentha-1,4-diene-7-ol       tr       r       -       - </td <td>1868</td> <td>(E)-Geranyl acetone</td> <td>0.1</td> <td>-</td> <td>0.4</td>	1868	(E)-Geranyl acetone	0.1	-	0.4
1889 $ar-himachalene       0.1       -       -       0.3       5.3         1900       epl-Cubebol       0.3       0.6       tr         1900       Nonadecane       -       0.1       tr         1941       a-Calacorene       tr       0.1       -         1945       1.5-proysalvial-(14)-ene       -       0.1       -         1957       Cubebol       -       1       tr         1958       (E)-benne       0.1       -       -         1957       Cubebol       -       0.1       -         1958       (E)-benne       0.1       0.1       -         1958       (E)-benne       0.1       0.1       -         1950       Cubenol       tr       -       0.1       -         2037       Salvial-(14)-ene-lone       0.1       0.1       0.3       -       -         2050       (E)-benoided       tr       -       -       -       2.0         014       Denoid       tr       -       9.2       2.2       2.2         Unknown II       -       9.2       2.2       2.2       2.0       1.4       1.4       1 $	1882	<i>α-ar</i> -himachalene	-	0.1	-
1893       Geranyl isovalerate       -       0.3       0.6       tr         1900       Nondecane       -       0.1       tr         1941       a-Calacorene       tr       0.1       -         1945       1.5 epoxysalvial-4(14)-ene       -       0.1       -         1957       Cubebol       -       1       tr         1958       (C)-pl-lonone       0.1       -       -         Unknown I       6.6       0.4       0.6         2008       Caroyophyllene oxide       0.6       0.4       0.6         2016       Issumyl phenylacetate       -       0.1       0.1       0.3         2037       Salvial-4(14)-ene-1-one       0.1       0.1       0.3       2.4         2041       Pentadecanal       tr       3.2       3.3         2073       p-Mentha-1.4-diene-7-ol       tr       r       -         2080       Cubenol       tr       -       9.2       2.2         Unknown II       -       9.2       2.1       3       0.5         2144       Spathulenol       0.6       0.3       -       -         2131       Hexalydrofnaresyl acetone <td< td=""><td>1889</td><td>ar-himachalene</td><td>0.1</td><td>-</td><td>-</td></td<>	1889	ar-himachalene	0.1	-	-
1900 $epi$ -Cubebol       0.3       0.6       tr         1900       Nonadecame       -       0.1       tr         1941 $a$ -Calacorene       tr       0.1       -         1945       1.5-cpoxysalvial-4(14)-ene       -       0.1       -         1957       Cubebol       -       1       tr         1958       (E)-f-lenone       0.1       -       -         Unknown I       6.6       0.6       0.4       0.6         2008       Caryophyllene oxide       0.6       0.4       0.6         2016       Iscamyl phenylacetate       -       0.1       -         2037       Salvial-4(14)-ene-1-one       0.1       0.1       0.3       -         2050       (D-Nerolidol       tr       tr       -       -         2080       Cubenol       tr       tr       -       -         2080       Cubonol       tr       tr       -       -         2080       Globulol       tr       tr       -       -         2080       Globulol       tr       tr       -       -       -         2013       Hexanydrofarnesyl acetone       0.2	1893	Geranyl isovalerate	-	0.3	5.3
1900       Nonadecane       -       0.1       r         1944       a-Calacorene       tr       0.1       -         1945       1.5-poxysalvial-4(14)-ene       -       0.1       -         1957       Cubebol       0.1       -       -         1958       (B)-fl-lonone       0.1       0.1       -         Unknown I       6.6       0.4       0.6         2008       Caroophyllene oxide       0.1       0.1       0.3         2037       Salvial-4(14)-ene-l-one       0.1       0.1       0.3         2041       Pentadecanal       tr       -       -         2050       (C)-Nerolidol       tr       3.2       3.3         2073       p-Mentha-1.4-diene-7-ol       tr       r       -         Unknown II       -       9.2       2.2       2.0         Unknown II       5.2       -       8.7         2131       Hexahydrofarnesyl acetone       0.2       1.3       0.5         2144       Spathulenol       0.6       0.3       -       -         2186       Eagenol       -       1       0.4       2.2         2209       T-murefol	1900	epi-Cubebol	0.3	0.6	tr
$\begin{array}{cccccccccccccccccccccccccccccccccccc$	1900	Nonadecane	-	0.1	tr
$\begin{array}{c c c c c c c c c c c c c c c c c c c $	1941	a-Calacorene	tr	0.1	-
1957       Cubéhol       -       1       tr         1958 $(E)\rho_f$ Bronce       0.1       -       -         Unknown I       6.6       10.4       2.6         2008       Caryophyllene oxide       0.6       0.4       0.6         2016       Isoamyl Phenplacetate       -       0.1       -         2037       Salvial-4(14)-ene1-lone       0.1       0.1       0.3         2030       Cubenol       tr       -       -         2050 $(E)$ -Nerolidol       tr       -       -         2080       Cubenol       tr       -       -         Unknown II       -       9.2       2.2       -       8.7         2098       Globulol       tr       -       -       -         2113       Curin alcohol       0.3       -       -         2144       Spathulenol       0.6       0.3       1.4         2183       y-Decalactone       0.9       -       -       0.6         2184       Marsupellol       .4       1       -       -       0.6         2184       Marsupellol       .4       1       -       -       -	1945	1,5-epoxysalvial-4(14)-ene	-	0.1	-
1958 $(E)$ -β-lonone       0.1       -       -         Unknown I       6.6       10.4       2.6         2008       Caryophyllene oxide       0.6       0.4       0.6         2016       Isoamyl phenylacetate       -       0.1       -         2037       Salvial 4(14)-ene1-one       0.1       0.1       0.3         2050 $(E)$ -Nerolidol       tr       -       -         2050 $(E)$ -Nerolidol       tr       -       -         Unknown II       -       -       9.2       2.2         Unknown II       5.2       -       8.7         2098       Globulol       tr       r       -         Unknown II       5.2       -       8.7         2098       Globulol       tr       r       -         2131       Hexalydrofarnesyl actome       0.2       1.3       0.5         2144       Spathulenol       0.6       0.3       1.4         2183       y-Decalactome       0.9       -       -         2184       Marsupellol       1.4       1       -         2184       Tymmol       -       0.3       -	1957	Cubebol	-	1	tr
Unknown I6.610.42.62008Caryophyllen oxide0.60.40.62016Isoamyl phenylacetate-0.10.10.32041Pentadecanaltr2050 $(E)$ -Nerolidoltr3.23.32073p-Mentha-1.4-diene-7-oltr2080Cubenoltrr2080CubenoltrtrUnknown II-9.22.22.2-8.72098Globuloltrr2113Cumin alcohol0.32131Hexahydrofarnesyl acetone0.21.30.521442144Marsupellol1.41Unknown IV37.43.121852186Eugenol-0.32186Eugenol0.62198Thymol-0.32257//>//>// Fludesmol0.60.32360Carophyllaldienol 10.22300Tricosane0.52300Tricosane0.1-with-0.3244Alismol0.22300Petracosane0.1-with <t< td=""><td>1958</td><td><math>(E)</math>-<math>\beta</math>-Ionone</td><td>0.1</td><td>-</td><td>-</td></t<>	1958	$(E)$ - $\beta$ -Ionone	0.1	-	-
2008         Caryophyllene oxide         0.6         0.4         0.6           2016         Isoamyl phenylacetate         -         0.1         -           2037         Salvial+(14)-ene-1-one         0.1         0.1         0.3           2041         Pentadecanal         tr         -         -           2050         (E)-Nerolidol         tr         3.2         3.3           2073         p-Mentha-1,4-diene-7-ol         tr         r         -         -           2080         Cubenol         tr         tr         r         -         -           Unknown II         -         -         9.2         2.2         2         -         8.7           2098         Globulol         tr         r         -         -         -         2013         0.5           2114         Spathylenovil I         5.2         -         8.7         -         -         2014         Spathylenovil I         -         -         -         2014         Spathylenovil I         1.4         1         -         -         -         2014         Spathylenovil I         -         -         -         -         -         2014         Spathylenovil I <t< td=""><td></td><td>Unknown I</td><td>6.6</td><td>10.4</td><td>2.6</td></t<>		Unknown I	6.6	10.4	2.6
2016       Isamyl phenylacetate       -       0.1          2037       Salvial-4(14)-ene-1-one       0.1       0.1       0.3         2041       Pentadecand       tr       -       -         2050 $(E)$ -Nerolidol       tr       -       -         2073       p-Menthal-14-diene-7-ol       tr       -       -         2080       Cubenol       tr       r       -       -         2080       Cubenol       tr       tr       -       -       2.2         Unknown II       -       9.2       2.2       -       8.7         2098       Globulol       tr       -       -       -       -         2113       Cumin alcohol       0.3       -       -       -       2.13       0.5         2144       Spathuenol       0.6       0.3       1.4       1       -       -       -       0.6       0.3       -       -       2.13       0.5       2.144       Spathuenol       0.6       0.3       -       -       2.13       0.5       -       -       2.14       1.4       1       -       -       2.16       Miknown NW       3       7.4	2008	Caryophyllene oxide	0.6	0.4	0.6
2037       Salvial-4(14)-ene-1-one       0.1       0.1       0.3         2041       Pentadecanal       tr       -       -         2050       (E)-Nerolidol       tr       3.2       3.3         2073       p-Mentha-1,4-diene-7-ol       tr       -       -         2080       Cubenol       tr       tr       -       -         2080       Cubenol       tr       tr       -       -         2080       Cubenol       tr       tr       -       -         2080       Globulol       tr       -       9.2       2.2         Unknown III       -       9.2       -       -       8.7         2131       Hexatydrofamesyl actone       0.2       1.3       0.5         2144       Spathulenol       0.6       0.3       1.4         2183       y-Decalactone       0.9       -       -         2184       Marsupellol       -       0.6       0.3       -         2209       Trunurolol       0.2       -       -       -         2214       ar-Bisabolol       -       1       0.4       6.3         22232       ar-Bisabolol <td< td=""><td>2016</td><td>Isoamyl phenylacetate</td><td>-</td><td>0.1</td><td>-</td></td<>	2016	Isoamyl phenylacetate	-	0.1	-
2041       Pentadecand       tr       -       -         2050       (E)-Nerolidol       tr       3.2       3.3         2073 $p$ -Mentha.1.4-diene-7-ol       tr       -       -         2080       Cubenol       tr       tr       -       -         2080       Cubenol       tr       tr       r       -       -         2080       Cubenol       tr       tr       -       9.2       2.2         Unknown III       5.2       -       8.7         2098       Globulo       tr       -       -       -         2113       Cumin alcohol       0.3       -       -       -         2131       Hexabydrofarnesyl acetone       0.2       1.3       0.5       2144         Yaptatolenol       1.4       1       -       -       0.6         2186       Eugenol       -       0.3       -       -         2187       Thymol       -       0.3       -       -         2209       T-murrolol       0.2       -       -       -         2214       ar-Turmerol       0.2       -       -       -       -	2037	Salvial-4(14)-ene-1-one	0.1	0.1	0.3
2050       (E)-Nerolidol       tr       3.2       3.3         2073 $p$ -Mentha-1,4-diene-7-ol       tr       -       -         2080       Cubenol       tr       tr       -       -         Unknown II       5.2       -       8.7         2098       Globulol       tr       -       -         2113       Cumin alcohol       0.3       -       -         2113       Hexatylorfarmesyl acetone       0.2       1.3       0.5         2144       Spathulenol       0.6       0.3       1.4         1       -       -       -       0.6         2183       p-Decalactone       0.9       -       -         2209       T-muurolol       0.2       -       -         2209       T-muurolol       0.2       -       -         2209       T-muurolol       0.2       -       -         2316       Caryophylladienol I       0.3       -       -         2326       Alismol       -       0.4       6.3         2298       Decanoic acid       0.1       -       -         2300       Tertacesane       0.1       -       -	2041	Pentadecanal	tr	-	-
2073 $p$ -Mentha-1,4-diene-7-ol         tr         tr         tr         tr         tr           2080         Cubenol         tr         tr         tr         -<	2050	(E)-Nerolidol	tr	3.2	3.3
2080       Cubenol       tr       tr       tr       tr       tr       tr       tr       -       9,2       2,2         Unknown III       5,2       -       8,7         2098       Globulol       tr       -       -       -         2113       Cumin alcohol       0,3       -       -         2131       Hexalydrofarnesyl acetone       0,2       1,3       0,5         2144       Spathulenol       0,6       0,3       1,4       1         1       Hexalydrofarnesyl acetone       0,9       -       -       0,6         2183 $\gamma$ -Decalactone       0,9       -       -       0,6         2198       Thymol       -       0,3       -       -         2209       T-muurolol       0,2       -       -       -         2214       ar-Turmerol       0,2       -       -       -         22209       T-muurolol       0,2       -       -       -         2232       a-Bisabolol       -       0,4       6,3       -         2244       Arismol       -       -       -       -       -         2300       Tricos	2073	<i>p</i> -Mentha-1.4-diene-7-ol	tr	-	-
Unknown II       -       9.2       2.2         Unknown III       5.2       -       8.7         2098 Globulol       tr       -       -         2113       Cumin alcohol       0.3       -       -         2131       Hexahydrofarnesyl acetone       0.2       1.3       0.5         2144       Spathulenol       0.6       0.3       1.4         Unknown IV       3       7.4       3.1         2185       Eugenol       -       -       0.6         2198       Thymol       -       -       0.6         2198       Thymol       -       0.3       -         2209       T-muurolol       0.2       -       -         2209       T-muurolol       0.2       -       -         2209       T-muurolol       0.2       -       -         2214       ar-Turmerol       0.2       -       -         2209       T-muurolol       0.6       0.3       -         2200       T-muurolol       0.6       0.3       -         2300       Tricosane       0.5       -       -         2300       Tricosane       0.1	2080	Cubenol	tr	tr	-
Unknown III5.2-8.72098Globuloltr2113Cumin alcohol0.32131Hexahydrofarnesyl acetone0.21.30.52144Spathulenol0.60.31.42148Marsupellol1.41-Unknown IV37.43.12186Eugenol0.62198Thymol-0.92198Thymol-0.322097-muurolol0.22232a-Bisabolol-10.4-2257β-Eudesmol0.60.32264Alismol-0.46.3-2298Decanoic acid0.42300Tricosane0.12369Eudesm-4(15),7-dien-1 $\beta$ -ol0.3-0.82400Tetracosane0.12500Pentacosane1-0.9260711-Octadecanol0.20.70.3-2670Tetradecanoic acid0.1-tr-2931Hexadecanoic acid2.53.537.5Monoterpene Hydrocarbons0.71.82.1-0xygenated Sesquiterpenes37.823.46.6Sesquiterpene Hydrocarbons0.71.82.1- <t< td=""><td></td><td>Unknown II</td><td>-</td><td>9.2</td><td>2.2</td></t<>		Unknown II	-	9.2	2.2
2098Globuloltr2113Cumin alcohol0.32131Hexahydrofarnesyl acetone0.21.30.52144Spathulenol0.60.31.42148Marsupellol1.41-Unknown IV37.43.12183 $\gamma$ -Decalactone0.92186Eugenol-0.3-2209 $T$ -muurolol0.22209 $T$ -muurolol0.22214 $ar$ -Turmerol0.22215 $d$ -Eudesmol0.60.3-2204Alismol-10.42257 $\beta$ -Eudesmol0.60.3-2264Alismol-0.46.32298Decanoic acid0.42316Caryophylladienol I0.22300Tricosane0.12300Pentacosane0.12500Pentacosane1-0.926071-Octadecanol0.20.70.32622Phytol-2.8-2670Tetradecanoic acid0.1-tr2931Hexadecanoic acid2.53.537.5Monoterpene37.823.46.6Sesquiterpene Hydrocarbons0.71.82.1Oxygenated Sesquiterpenes4.79.713.6 <td></td> <td>Unknown III</td> <td>5.2</td> <td>-</td> <td>8.7</td>		Unknown III	5.2	-	8.7
2113       Cumin alcohol       0.3       -       -         2131       Hexahydrofarnesyl acetone       0.2       1.3       0.5         2144       Spathulenol       0.6       0.3       1.4         2148       Marsupellol       1.4       1       -         Unknown IV       3       7.4       3.1         2183       y-Decalactone       0.9       -       -         2186       Eugenol       -       0.6       0.3       -         2198       Thymol       -       0.3       -       -         2209 <i>T</i> -muurolol       0.2       -       -       -         2216 <i>a</i> -Tumerol       0.2       -       -       -         2232 <i>a</i> -Bisabolol       -       1       0.4       6.3         2257 <i>β</i> -Eudesmol       0.6       0.3       -       -         2300       Tricosane       0.5       -       -       -         2316       Caryophylladienol I       0.2       -       -       2       -       2         2670       Floradecanol       0.2       0.7       0.3       -       1       -       0.9	2098	Globulol	tr	-	-
2131Hexahydrofarnesyl acetone0.21.30.52144Spathulenol0.60.31.42148Marsupellol1.41-Unknown IV37.43.12183 $\gamma$ -Decalactone0.92186Eugenol-0.3-2198Thymol-0.3-2209T-muurolol0.22214 $ar$ -Turmerol0.22232 $a$ -Bisabolol-10.42257 $\beta$ -Eudesmol0.60.3-2300Tricosane0.52300Tricosane0.52316Caryophylladienol I0.22309Penacosane1-0.92607I-deceanol0.20.70.32622Phytol-2.8-2500Pentacosane1-0.92607I-deceanol0.20.70.32622Phytol-2.8-2670Tetradecanoic acid0.1-tr200Nonacosane1-0.32.12931Hexadecanoic acid2.53.537.5Monoterpene Hydrocarbons7.40.90Oxygenated Monoterpenes37.823.46.6Sequiterpenes6.98.741.3Others6.98.741.3 <td>2113</td> <td>Cumin alcohol</td> <td>0.3</td> <td>-</td> <td>-</td>	2113	Cumin alcohol	0.3	-	-
2144       Spathulenol       0.6       0.3       1.4         2148       Marsupellol       1.4       1       -         Unknown IV       3       7.4       3.1         2183       y-Decalactone       0.9       -       -         2186       Eugenol       -       0.3       -         2198       Thymol       -       0.3       -         2209       7-muurolol       0.2       -       -         2214       ar-Turmerol       0.2       -       -         2232       a-Bisabolol       -       1       0.4         2257 $\beta$ -Eudesmol       0.6       0.3       -         2264       Alismol       -       0.4       6.3         2298       Decanoic acid       0.4       -       -         2300       Tricosane       0.5       -       -         2316       Caryophylladienol I       0.2       0.7       0.3         2400       Tetracosane       0.1       -       -         2500       Pentacosane       0.1       -       tr         2607       1-Octadecanol       0.2       0.7       0.3	2131	Hexahydrofarnesyl acetone	0.2	1.3	0.5
2148       Marsupellol Unknown IV       1.4       1       -         2183 $\gamma$ -Decalactone       0.9       -       -         2186       Eugenol       -       -       0.6         2198       Thymol       -       0.3       -         2209       T-muurolol       0.2       -       -         2214 $ar$ -Turmerol       0.2       -       -         2232 $a$ -Bisabolol       -       1       0.4         2257 $\beta$ -Eudesmol       0.6       0.3       -         2264       Alismol       -       0.4       6.3         2298       Decanoic acid       0.4       -       -         2300       Triccosane       0.5       -       -         2369       Eudesm-4(15), 7-dien-1 $\beta$ -ol       0.3       -       0.8         2400       Tetracosane       0.1       -       -         2500       Pentacosane       1       -       0.9         2607       1-Octadecanol       0.2       0.7       0.3         2600       Tetradecanoic acid       0.1       -       r         2700       Heptacosane       0.7       0	2144	Spathulenol	0.6	0.3	1.4
Unknown IV37.43.12183 $y$ -Decalactone0.92186Eugenol-0.03-2187 $hymol$ 0.22209 $T$ -muurolol0.22214 $ar$ -Turmerol0.22232 $ar-Bisabolol$ -10.42257 $\beta$ -Eudesmol0.60.3-2264Alismol-0.46.32298Decanoic acid0.42300Tricosane0.52316Caryophylladienol I0.22309Tetracosane0.12309Tetracosane0.12500Pentacosane0.12000Nonacosane1-0.926071-Octadecanol0.20.70.32622Phytol-2.8-2700Heptacosane0.1-tr2700Heptacosane0.70.5-2900Nonacosanetr0.32.12931Hexadecanoic acid2.53.537.5Monoterpene Hydrocarbons0.71.82.1Oxygenated Monoterpenes37.823.46.6Sesquiterpenes0.71.82.1Oxygenated Sequiterpenes6.98.741.3Others6.98.741.3Others6.9 </td <td>2148</td> <td>Marsupellol</td> <td>1.4</td> <td>1</td> <td>-</td>	2148	Marsupellol	1.4	1	-
$2183$ y-Decalactone $0.9$ $  2186$ Eugenol $  0.3$ $ 2198$ Thymol $ 0.3$ $ 2209$ T-muurolol $0.2$ $  2214$ $ar$ -Turmerol $0.2$ $  2232$ $a$ -Bisabolol $ 1$ $0.4$ $2257$ $\beta$ -Eudesmol $0.6$ $0.3$ $ 2264$ Alismol $ 0.4$ $6.3$ $2298$ Decanoic acid $0.4$ $  2300$ Tricosane $0.5$ $  2369$ Eudesm-4(15),7-dien-1 $\beta$ -ol $0.3$ $ 0.8$ $2400$ Tetracosane $0.1$ $  2500$ Pentacosane $1$ $ 0.9$ $2607$ $1$ -Octadecanol $0.2$ $0.7$ $0.3$ $2622$ Phytol $ 2.8$ $ 2700$ Heptacosane $0.7$ $0.5$ $ 2900$ Nonacosane $tr$ $0.3$ $2.1$ $2931$ Hexadecanoic acid $2.5$ $3.5$ $37.5$ Monoterpene $37.8$ $23.4$ $6.6$ Sequiterpenes $0.7$ $1.8$ $2.1$ $0xgenated$ Monoterpenes $6.9$ $8.7$ $41.3$ Total Identified $57.5$ $44.5$ $63.6$		Unknown IV	3	7.4	3.1
2186Eugenol0.62198Thymol-0.3-2209T-murolol0.22214 $ar$ -Turmerol0.22232 $a$ -Bisabolol-10.42257 $\beta$ -Eudesmol0.60.3-2264Alismol-0.46.32298Decanoic acid0.42300Tricosane0.52316Caryophylladienol I0.22369Eudesm-4(15),7-dien-1 $\beta$ -ol0.3-0.82400Tetracosane0.12500Pentacosane1-0.926071-Octadecanol0.20.70.32622Phytol-2.8-2700Heptacosane0.1-tr2700Heptacosane0.70.5-2900Nonacosanetr0.32.12931Hexadecanoic acid2.53.537.5Monoterpene Hydrocarbons7.40.900Oxygenated Monoterpenes37.823.46.6Sesquiterpene Hydrocarbons0.71.82.1Oxygenated Sesquiterpenes4.79.713.6Others6.98.741.3Total Identified57.544.563.6	2183	v-Decalactone	0.9	_	_
2198Thymol-0.3-2209T-muurolol0.22214 $ar$ -Turmerol0.22232 $a$ -Bisabolol-10.42257 $\beta$ -Eudesmol0.60.3-2264Alismol-0.46.32298Decanoic acid0.42300Tricosane0.52316Caryophylladienol I0.22369Eudesm-4(15),7-dien-1 $\beta$ -ol0.3-0.82400Tetracosane0.12500Pentacosane1-0.92607I-Octadecanol0.20.70.32622Phytol-2.8-2700Heptacosane0.70.5-2900Nonacosanetr0.32.12931Hexadecanoic acid2.53.537.5Monoterpene37.823.46.6Sequiterpene Hydrocarbons7.40.90Oxygenated Monoterpenes37.823.46.6Sequiterpene Hydrocarbons0.71.82.1Oxygenated Sesquiterpenes4.79.713.6Others6.98.741.3Total Identified57.544.563.6	2186	Eugenol	-	-	0.6
2209T-murolol0.22214ar-Turmerol0.22232 $\alpha$ -Bisabolol-10.42257 $\beta$ -Eudesmol0.60.3-2264Alismol-0.46.32298Decanoic acid0.42300Tricosane0.52316Caryophylladienol I0.22369Eudesm-4(15),7-dien-1 $\beta$ -ol0.3-0.82400Tetracosane0.12500Pentacosane1-0.926071-Octadecanol0.20.70.32622Phytol-2.8-2700Heptacosane0.1-tr2700Heptacosane0.70.5-2900Nonacosanetr0.32.12931Hexadecanoic acid2.53.537.5Monoterpenes37.823.46.6Sequiterpene Hydrocarbons0.71.82.1Oxygenated Sesquiterpenes4.79.713.6Others6.98.741.36.9Others6.98.741.363.6	2198	Thymol	-	0.3	_
2214ar-Turmerol0.22232 $\alpha$ -Bisabolol-10.42257 $\beta$ -Eudesmol0.60.3-2264Alismol-0.46.32298Decanoic acid0.42300Tricosane0.52316Caryophylladienol I0.22369Eudesm-4(15),7-dien-1 $\beta$ -ol0.3-0.82400Tetracosane0.12500Pentacosane1-0.926071-Octadecanol0.20.70.32622Phytol-2.8-2700Heptacosane0.1-tr2700Heptacosane0.70.5-2900Nonacosanetr0.32.12931Hexadecanoic acid2.53.537.5Monoterpene Hydrocarbons7.40.90Oxygenated Monoterpenes6.71.82.1Oxygenated Sesquiterpenes4.79.713.6Others6.98.741.3Total Identified <b>57.544.563.6</b>	2209	<i>T</i> -muurolol	0.2	-	-
2232 $\alpha$ -Bisabolol-10.42257 $\beta$ -Eudesmol0.60.3-2264Alismol-0.46.32298Decanoic acid0.42300Tricosane0.52316Caryophylladienol I0.22369Eudesm-4(15),7-dien-1 $\beta$ -ol0.3-0.82400Tetracosane0.12500Pentacosane1-0.926071-Octadecanol0.20.70.32622Phytol-2.8-2670Tetradecanoic acid0.1-tr2700Heptacosane0.70.5-2900Nonacosanetr0.32.12931Hexadecanoic acid2.53.537.5Monoterpene Hydrocarbons0.71.82.1Oxygenated Monoterpenes37.823.46.6Sesquiterpene Hydrocarbons0.71.82.1Oxygenated Sesquiterpenes4.79.713.6Others6.98.741.3Total Identified57.544.563.6	2214	ar-Turmerol	0.2	-	-
2257 $\beta$ -Eudesmol0.60.3-2264Alismol-0.46.32298Decanoic acid0.42300Tricosane0.52316Caryophylladienol I0.22369Eudesm-4(15),7-dien-1 $\beta$ -ol0.3-0.82400Tetracosane0.12500Pentacosane0.126071-Octadecanol0.20.70.32622Phytol-2.8-2670Tetradecanoic acid0.1-tr2700Heptacosane0.70.5-2900Nonacosanetr0.32.12931Hexadecanoic acid2.53.537.5Monoterpene Hydrocarbons0.71.82.1Oxygenated Monoterpenes4.79.713.6Oxygenated Sesquiterpenes4.79.713.6Others6.98.741.3Total Identified <b>57.544.563.6</b>	2232	a-Bisabolol	-	1	0.4
2264Alismol-0.46.32298Decanoic acid0.42300Tricosane0.52316Caryophylladienol I0.22369Eudesm-4(15),7-dien-1 $\beta$ -ol0.3-0.82400Tetracosane0.12500Pentacosane1-0.926071-Octadecanol0.20.70.32622Phytol-2.8-2700Heptacosane0.1-tr2700Heptacosane0.70.5-2900Nonacosanetr0.32.12931Hexadecanoic acid2.53.537.5Monoterpene Hydrocarbons7.40.90Oxygenated Monoterpenes37.823.46.6Sesquiterpene Hydrocarbons0.71.82.1Oxygenated Sesquiterpenes4.79.713.6Others6.98.741.3Total Identified <b>57.544.563.6</b>	2257	β-Eudesmol	0.6	0.3	_
2298Decanoic acid $0.4$ $ -$ 2300Tricosane $0.5$ $ -$ 2316Caryophylladienol I $0.2$ $ -$ 2369Eudesm-4(15),7-dien-1 $\beta$ -ol $0.3$ $ 0.8$ 2400Tetracosane $0.1$ $ -$ 2500Pentacosane $1$ $ 0.9$ 26071-Octadecanol $0.2$ $0.7$ $0.3$ 2622Phytol $ 2.8$ $-$ 2670Tetradecanoic acid $0.1$ $-$ tr2700Heptacosane $0.7$ $0.5$ $-$ 2900Nonacosanetr $0.3$ $2.1$ 2931Hexadecanoic acid $2.5$ $3.5$ $37.5$ Monoterpene Hydrocarbons $7.4$ $0.9$ $0$ Oxygenated Monoterpenes $4.7$ $9.7$ $13.6$ Others $6.9$ $8.7$ $41.3$ Total Identified <b>57.544.563.6</b>	2264	Alismol	-	0.4	6.3
2300Tricosane0.52316Caryophylladienol I0.22369Eudesm-4(15),7-dien-1 $\beta$ -ol0.3-0.82400Tetracosane0.12500Pentacosane1-0.926071-Octadecanol0.20.70.32622Phytol-2.8-2670Tetradecanoic acid0.1-tr2700Heptacosane0.70.5-2900Nonacosanetr0.32.12931Hexadecanoic acid2.53.537.5Monoterpene Hydrocarbons7.40.90Oxygenated Monoterpenes37.823.46.6Sesquiterpenes4.79.713.6Others6.98.741.3Total Identified57.544.563.6	2298	Decanoic acid	0.4	_	_
$\begin{array}{c ccccccccccccccccccccccccccccccccccc$	2300	Tricosane	0.5	-	-
2369Eudesm-4(15),7-dien-1 $\beta$ -ol0.3-0.82400Tetracosane0.12500Pentacosane1-0.926071-Octadecanol0.20.70.32622Phytol-2.8-2670Tetradecanoic acid0.1-tr2700Heptacosane0.70.5-2900Nonacosanetr0.32.12931Hexadecanoic acid2.53.537.5Monoterpene Hydrocarbons7.40.90Oxygenated Monoterpenes37.823.46.6Sesquiterpene Hydrocarbons0.71.82.1Oxygenated Sesquiterpenes4.79.713.6Others6.98.741.3Total Identified57.544.563.6	2316	Caryophylladienol I	0.2	-	-
2400       Tetracosane       0.1       -       -         2500       Pentacosane       1       -       0.9         2607       1-Octadecanol       0.2       0.7       0.3         2622       Phytol       -       2.8       -         2670       Tetradecanoic acid       0.1       -       tr         2700       Heptacosane       0.7       0.5       -         2900       Nonacosane       tr       0.3       2.1         2931       Hexadecanoic acid       2.5       3.5       37.5         Monoterpene Hydrocarbons       7.4       0.9       0         Oxygenated Monoterpenes       37.8       23.4       6.6         Sesquiterpene Hydrocarbons       0.7       1.8       2.1         Oxygenated Sesquiterpenes       4.7       9.7       13.6         Oxygenated Sesquiterpenes       4.7       9.7       13.6         Others       6.9       8.7       41.3         Total Identified       57.5       44.5       63.6	2369	Eudesm-4(15),7-dien-1 $\beta$ -ol	0.3	-	0.8
$\begin{array}{c ccccccccccccccccccccccccccccccccccc$	2400	Tetracosane	0.1	-	-
$\begin{array}{c ccccccccccccccccccccccccccccccccccc$	2500	Pentacosane	1	-	0.9
2622       Phytol       -       2.8       -         2670       Tetradecanoic acid       0.1       -       tr         2700       Heptacosane       0.7       0.5       -         2900       Nonacosane       tr       0.3       2.1         2931       Hexadecanoic acid       2.5       3.5       37.5         Monoterpene Hydrocarbons       7.4       0.9       0         Oxygenated Monoterpenes       37.8       23.4       6.6         Sesquiterpene Hydrocarbons       0.7       1.8       2.1         Oxygenated Sesquiterpenes       4.7       9.7       13.6         Others       6.9       8.7       41.3         Total Identified       57.5       44.5       63.6	2607	1-Octadecanol	0.2	0.7	0.3
2670       Tetradecanoic acid       0.1       -       tr         2700       Heptacosane       0.7       0.5       -         2900       Nonacosane       tr       0.3       2.1         2931       Hexadecanoic acid       2.5       3.5       37.5         Monoterpene Hydrocarbons       7.4       0.9       0         Oxygenated Monoterpenes       37.8       23.4       6.6         Sesquiterpene Hydrocarbons       0.7       1.8       2.1         Oxygenated Sesquiterpenes       4.7       9.7       13.6         Others       6.9       8.7       41.3         Total Identified       57.5       44.5       63.6	2622	Phytol	-	2.8	_
2700       Heptacosane       0.7       0.5       -         2900       Nonacosane       tr       0.3       2.1         2931       Hexadecanoic acid       2.5       3.5       37.5         Monoterpene Hydrocarbons       7.4       0.9       0         Oxygenated Monoterpenes       37.8       23.4       6.6         Sesquiterpene Hydrocarbons       0.7       1.8       2.1         Oxygenated Sesquiterpenes       4.7       9.7       13.6         Others       6.9       8.7       41.3         Total Identified       57.5       44.5       63.6	2670	Tetradecanoic acid	0.1	_	tr
2900       Nonacosane       tr       0.3       2.1         2931       Hexadecanoic acid       2.5       3.5       37.5         Monoterpene Hydrocarbons       7.4       0.9       0         Oxygenated Monoterpenes       37.8       23.4       6.6         Sesquiterpene Hydrocarbons       0.7       1.8       2.1         Oxygenated Sesquiterpenes       4.7       9.7       13.6         Others       6.9       8.7       41.3         Total Identified       57.5       44.5       63.6	2700	Heptacosane	0.7	0.5	_
2931         Hexadecanoic acid         2.5         3.5         37.5           Monoterpene Hydrocarbons         7.4         0.9         0           Oxygenated Monoterpenes         37.8         23.4         6.6           Sesquiterpene Hydrocarbons         0.7         1.8         2.1           Oxygenated Sesquiterpenes         4.7         9.7         13.6           Others         6.9         8.7         41.3           Total Identified         57.5         44.5         63.6	2900	Nonacosane	tr	0.3	2.1
Monoterpene Hydrocarbons         7.4         0.9         0           Oxygenated Monoterpenes         37.8         23.4         6.6           Sesquiterpene Hydrocarbons         0.7         1.8         2.1           Oxygenated Sesquiterpenes         4.7         9.7         13.6           Others         6.9         8.7         41.3           Total Identified         57.5         44.5         63.6	2931	Hexadecanoic acid	2.5	3.5	37.5
Oxygenated Monoterpenes         37.8         23.4         6.6           Sesquiterpene Hydrocarbons         0.7         1.8         2.1           Oxygenated Sesquiterpenes         4.7         9.7         13.6           Others         6.9         8.7         41.3           Total Identified         57.5         44.5         63.6	Monoterpene Hydrocarbons		7.4	0.9	0
Sesquiterpene Hydrocarbons         0.7         1.8         2.1           Oxygenated Sesquiterpenes         4.7         9.7         13.6           Others         6.9         8.7         41.3           Total Identified         57.5         44.5         63.6	Oxygenated Monoterpenes		37.8	23.4	6.6
Oxygenated Sesquiterpenes         4.7         9.7         13.6           Others         6.9         8.7         41.3           Total Identified         57.5         44.5         63.6	Sesquiterpene Hydrocarbons		0.7	1.8	2.1
Others         6.9         8.7         41.3           Total Identified         57.5         44.5         63.6	Oxygenated Sesquiterpenes		4.7	9.7	13.6
Total Identified         57.5         44.5         63.6	Others		6.9	8.7	41.3
	Total Identified		57.5	44.5	63.6

 Total Identified
 57.5
 44.5
 65.6

 t: trace; A: T. chiliophyllum var. monocephalum – Flower Oil; B: T. chiliophyllum var. monocephalum – Stem Oil; C: T. chiliophyllum var. monocephalum – Root Oil.
 Unknown I EL/MS 70 ev m/z (rel. abun.) M\* 218 (12), 203 (4), 190 (4), 175 (9), 161 (8), 147 (11), 132 (53), 125 (27), 119 (28), 107 (100), 91 (34), 77 (19), 67 (9), 55 (14), 41 (17)

 Unknown II EL/MS 70 ev m/z (rel. abun.) M\* 220 (14), 205 (5), 191 (4), 177 (30), 163 (17), 149 (28), 135 (24), 124 (95) 109 (100), 95 (80), 81 (97), 67 (55), 55 (43) 41 (48)
 Unknown III EL/MS 70 ev m/z (rel. abun.) M\* 222 (15), 204 (11), 189 (5), 178 (35), 159 (84), 147 (9), 134 (33), 119 (100), 108 (52), 93 (30), 81 (31), 71 (22), 56 (18), 43 (42)

 Unknown IV EL/MS 70 ev m/z (rel. abun.) M\* 220 (5), 206 (6), 187 (15), 177 (7), 159 (29), 145 (38), 132 (95), 119 (100), 107 (100), 91 (74), 79 (41), 67 (25), 55 (29), 41 (38)

The essential oils obtained from flowers and stems of *T. chiliophyllum* var. *monocephalum* inhibited all microorganisms at various MIC. Most significant inhibition was observed against *Bacilius cereus* with 62.5  $\mu$ g/mL, which is found to be 2 fold less diluted than the positive control chloramphenicol (125  $\mu$ g/mL) under the same test conditions. *B. cereus* is responsible for some of the food poisoning cases. It causes severe nausea, vomiting and diarrhea. Growth of this bacteria on food results in the production of enterotoxin causing the food poisoning [25,26]. Toxicity tests, activity guided isolation and structure elucidation studies are still required to understand the active principle in the oil and to find potential use for this oil with beneficial activity. For all other microorganisms MIC of positive control were lower than the oils. Both flower and stem oils showed toxicity to *Vibrio fischeri* which was observed as black spots on the TLC. This procedure was used to evaluate general toxicity of the oils as an initial indicator. The toxicity results observed at low concentrations when compared to Vitamin C which confirm that the oil inhibits the growth of *V. fischeri*. Results of antibacterial and cytotoxicity tests were given in Table 2 in supporting information **S4**.

Essential oil composition and antimicrobial activities of *T. chiliophyllum* var. *monocephalum* 

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