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Interspecies variation of chemical constituents and antioxidant capacity of extracts from *Jasminum sambac* and *Jasminum multiflorum* grown in Malaysia

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ABSTRACT

The chemical constituents from various process of extraction of *Jasminum sambac* and *Jasminum multiflorum* were identified by gas chromatography–mass spectrometry to depict their interspecies differences. Major compounds identified from methanol extract of *J. sambac* were β-farnesene (52.52%), nerolidol (19.85%) and benzyl alcohol (17.56%) whereas, headspace solid phase microextraction (HS-SPME) showed linalool (35.92%), benzaldehyde (17.92%) and benzyl alcohol (10.87%) while hydrodistillation yielded β-farnesene (45.13%), α-cadinol (26.21%) and linalool (9.96%). The methanol extract of *J. multiflorum* yielded nerolidol (42.44%), benzyl benzoate (39.00%) and jasmolactone (12.02%) whereas, HS-SPME eluted nerolidol (76.56%), jasmone (15.31%) and hexyl benzoate (4.40%) while hydrodistillation yielded hexenyl benzoate (35.89%), β-farnesene (24.62%) and α-cadinol (14.30%). The methanol extracts of both *J. sambac* (0.48%) and *J. multiflorum* (1.38%) showed DPPH free radicals scavenging activities with an IC_{50} value of 208 μg/mL and 81 μ/mL respectively. The antioxidant properties of *Jasminum* provided a natural preservative ingredient for food and pharmaceutical products.

1. Introduction

The genus *Jasminum* is a genus of small trees and vines of the Family Oleaceae with 600 known species. *Jasminum sambac* (*J. sambac*) *and Jasminum multiflorum* (*J. multiflorum*) are small shrubs, which can grow up to roughly 1–1.5 m in height and are widely cultivated in Asia and some parts of Europe and Africa (Rao and Rout, 2003).

J. sambac and *J. multiflorum* are the two most widely cultivated jasmine species in Malaysia and both species bloom abundantly all year round reaching its peak in March–July. The flowers are commonly used for religious purpose and its fragrance has the characteristic jasmine aroma which has demand especially in the tea industries. The perfumery industries use the absolutes extensively for its fine, sweet, fruity, and elegant notes (Edris et al., 2008). Generally, jasmine scented tea is produced by allowing tea leaves to absorb the fragrance of fresh jasmine flowers. Among the scented teas, jasmine green tea, which is reprocessed from green tea scented of *J. sambac* flowers, is the most popular around the world. In some parts of Asia, a poultice of crushed *J. sambac* flowers are used as a lactifuge on women's breast while an infusion of the flowers are used in the treatment of pulmonary catarrh, bronchitis, and asthma (Samy et al., 2014).

Crude extracts of plants, fruits, herbs, and vegetables are becoming popular due to the presence of phytochemicals which contain considerable antioxidant capabilities and health benefits. Such benefits include prevention of heart diseases and cancer (Löliger, 1991). Antioxidants are compounds which are capable of slowing down or hindering the oxidation of lipids and other molecules by inhibiting the initiation or propagation of oxidative chain reactions (Velioglu et al., 1998). The usage of extracts from natural sources as functional ingredients in foods, drinks, toiletries and cosmetics has gained a wide interest in consumers due to the increasing concern of potentially harmful synthetic additives (Reische et al., 1998). Natural extracts which possess a combination of pleasant taste or smell and preservative action can prevent the oxidation of lipids and spoilage by microorganisms. These unwanted reactions usually occur when a lipid or perishable organic substrate is present. These reactions will promote undesirable off-flavors, produce toxicity, loss of color, flavor and aroma that affect the shelf-life of goods (Farag et al., 1989; Hirasa and Takemasa, 1998).

Few studies have been carried out on Malaysian grown *J. sambac* and *J. multiflorum*. The value of an isolate and composition of jasmine flowers is highly dependent on the techniques used for

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extraction. The objective of this study is to identify the extractable compounds from *J. sambac* and *J. multiflorum* by various extraction techniques: solvent extraction, hydrodistillation and headspace solid phase microextraction. In addition, we presented the genetic variation between the two species from different extraction techniques. The antioxidant activity of methanol extracts was also presented to show their different levels of free radical scavenging activities.

2. Materials and methods

2.1. Plant materials

Fresh blooms of *J. sambac* and *J. multiflorum* were obtained from a nursery in Sungai Buloh, Kuala Lumpur, Malaysia. The voucher specimen was deposited at the Chemistry Department Herbarium with voucher no: URL/JM/28 for *J. multiflorum* and voucher no: URL/JS/88 for *J. sambac*.

The flowers were washed with distilled water to remove dirt on the petals, and the cleaned flowers were aired at room temperature.

2.2. Chemicals and materials

All chemicals were of analytical grade, obtained from Merck (Darmstadt, Germany). Sodium sulfate was purchased from Systerm (Shah Alam, Malaysia). The chemical reagents, namely, 1,1-diphenyl-2-picrylhydrazyl (DPPH) and butylated hydroxy toluene (BHT) were purchased from Sigma Chem. Co. (St. Louis, USA). A SPME fibre holder with a 1 cm fibre assembly coated with a 100 μm polydimethylsiloxane (PDMS) was purchased from Supelco (Bellefonte, PA, USA).

2.3. Solvent extraction

An amount of 0.9 g of cleaned flowers were placed into a 20 mL scintillation vial (in triplicates) and extracted by maceration with 5 mL of methanol at room temperature for 24 h. After 24 h, each extract was filtered using filter paper and dried by passing through a 5 cm in length and 1 cm in width sodium sulfate column. A 1.5 mL of the extract was subjected to GC–MS analysis.

2.4. Hydrodistillation

An amount of 380 g of fresh flowers were placed in a 12 L round bottom flask which contained 6 L of distilled water and connected to a Clevenger apparatus. The mixture was heated to 100 °C for four hours. The distillate was extracted twice using 2 mL of dichloromethane. The organic layer was collected and drawn into a beaker containing anhydrous sodium sulfate for drying purposes. The concentrated extracts were analyzed using GC–MS.

2.5. Headspace solid phase microextraction (HS-SPME)

An amount of 0.7 g of fresh flowers were placed into a 20 mL vial (with triplicates) fitted with a pre-cut septum cap. The vial was then left for about 2 min at 80 °C to allow equilibration. A SPME fibre holder with a 1 cm fibre assembly coated with a 100 μm polydimethylsiloxane (PDMS) was used. The SPME needle was then injected through the cap into the headspace of the vial, and the fibre was exposed to carry out sampling for 15 min. The SPME fibre was immediately placed and left for 7 min in the injector port of the GC–MS system.

2.6. Gas-chromatography mass-spectroscopy (GC–MS)

A Hewlett Packard HP 6890 series mass selective detector linked to a GCMS-QP 2010 Plus Shimadzu gas chromatograph was used for the identification of chemical constituents. A sample volume of 2 μL was injected in a splitless mode into the gas chromatograph fitted with a DB-5 ms column coated with 5% phenyl 95% dimethyl arylene siloxane with film thickness of 0.25 μm, length of 30.0 m and a diameter of 0.25 mm. Helium was used as a carrier gas with a flow rate of 58.2 mL per minute. The injector temperature was set at 250 °C. Electron impact mass spectra with ionization energy of 70 eV was recorded at the 50–600 amu mass range. The initial oven temperature was set at 50 °C and held for 2 min. This temperature was then programmed to 120 °C at 3 °C per minute and held for 3 min. Then, the temperature was programmed to 180 °C at 3 °C per minute and held for 3 min. Finally, the temperature was programmed to 280 °C at a rate of 8 °C per minute.

2.7. Kovats indices

The compounds were identified by comparing its mass spectra with NIST library and they were further confirmed with Kovats retention index (Adams, 2001). The retention index of a component is calculated by interpolation (usually logarithmic) that relates the adjusted retention times of a component to the adjusted retention times of two standards which elutes before and after the peak of interest. In the gas chromatography seperation, *n*-alkanes are employed as standards where the retention index, *I* is expressed as:

$$\text{Retentionindex, } I = 100\left(\left(\frac{\log X_i - \log X_Z}{\log X_{(Z+1)} - \log X_Z}\right) + Z\right)$$

where *X* refers to the adjusted retention times, *z* is the number of carbon atoms of the *n*-alkane eluting before and (*z* + 1) is the number of carbon atoms of the *n*-alkane eluting after the peak of interest. The Kovats index uses the number of carbon atoms of a theoretical alkane which would have an adjusted retention time similar to that of the peak of interest which was evaluated under identical conditions (McNaught and Wilkinson, 1997). This enables Kovats indices to be used to confirm the peaks which were previously identified by GC–MS and by comparison of its relative retention indices with literature values (Adams, 2001).

2.8. Genetic distances

A measure of genetic differences between species or between populations within a specie is known as genetic distance and this can be determined by using Nei's (1987) standard genetic distance. This method explains that if the rate of genetic change is constant per year or generation then Nei's standard genetic distance (*D*) raises in proportion to divergence time. This method assumes that mutation and genetic drift contribute to the causes of genetic differences. The formula of genetic distances described by Nei is as follows:

$$D = -\frac{(\ln \Sigma X_i Y_i)}{(\sqrt{\Sigma X_i^2 \Sigma Y_i^2})}$$

where *X* and *Y* represent two different populations which have been studied and in this study *J. sambac* and *J. multiflorum*, respectively.

2.9. Methanolic extract for antioxidant assay

J. sambac and *J. multiflorum* flowers (11.08 g and 10.01 g, respectively) were extracted by maceration with 30 mL of 99.8% methanol at room temperature for 72 h. The mixture was then filtered

through filter paper and dried by passing through a 5 cm in length and 1 cm in width sodium sulfate column. The solvent was removed by using a rotatory evaporator (Buchi Rotavapor, R114, Switzerland). Dried *J. sambac* and *J. multiflorum* extract (0.05 g and 0.15 g, percentage yield of 0.48% and 1.38%, respectively) were subsequently stored at −21 °C in a 20 mL scintillation vial.

2.10. Determination of free radical-scavenging activity of methanol extract

The determination of scavenging activity of methanol extract was carried out by employing a UV–vis spectrophotometer (UV-1650 PC UV–vis Spectrophotometer, Shimadzu, Japan) to record spectral absorption values (Chen et al., 2000 and Frankel et al., 1998). In the presence of an antioxidant, the purple color of 1,1-diphenyl-2- picrylhydrazyl (DPPH) decays to pale yellow, and the change of absorbancy can be tracked spectrophotometrically at 517 nm (Brand-Williams et al., 1995). In this in-vitro method, methanolic DPPH solution (0.05 mM, 1 mL) was added to methanolic extracts of both jasmine species at various concentrations (3 mL, 50–1000 μg/mL). These solutions were carefully mixed and incubated in the dark for 30 min at room temperature. Butylated hydroxy toluene (BHT) was used as a positive control. Absorbance of the resulting solutions was measured at 517 nm. Scavenging capacity of the extract was calculated using the following equation:

$$\text{DPPH radical scavenging activity}(\%) = \left(\frac{(\lambda_o - \lambda_s)}{\lambda_o}\right) \times 100$$

where λ_o = absorbance of a control without a radical scavenger

λ_s = absorbance of the remaining DPPH in the presence of scavenger.

3. Results and discussion

3.1. GC–MS analysis of constituents in J. sambac and J. multiflorum

All chemical constituents of *J. sambac* and *J. multiflorum* identified by GC–MS were shown in Fig. 1 and were confirmed with the aid of Kovats indices (Table 1) by comparing its relative retention indices with literature values (Adams, 2001). The profile of methanolic *J. sambac* is characterized by the presence of β-farnesene (52.52%), nerolidol (19.85%) and benzyl alcohol (17.56%) which was also detected in Chinese *J. sambac* (Zhu et al., 1982). Hydrodistillation of *J. sambac* flowers yielded β-farnesene (45.13%), α-cadinol (26.21%), and linalool (9.96%) as the main components. HS-SPME analysis of the volatiles from *J. sambac* showed slight variation with linalool (35.92%), benzaldehyde (17.92%) and benzyl alcohol (10.87%) as the major compounds. These compounds were also present in Egyption *J. sambac* (Edris et al., 2008).

The methanol extract of flowers of *J. multiflorum* yielded nerolidol (42.44%), benzyl benzoate (39.00%) and jasmolactone (12.02%) while hydrodistillation yielded mostly hexenyl benzoate (35.89%), β-farnesene (24.62%) and α-cadinol (14.30%) and HS-SPME yield nerolidol (76.56%), jasmone (15.31%) and hexyl benzoate (4.40%). The percentage of most components detected in the HS-SPME was significantly different from that of the methanol extract and hydrodistillation. This may be due to the high proportion of the more volatile compounds in the headspace analysis and the differential adsorption of components on the SPME fibre coating used (Zhang et al., 1994). It is also worth mentioning that chemical changes to volatile compounds may arise due to the conditions used for hydrodistillation and even maceration especially during solvent removal. Although, high temperatures will yield extracts containing more of the less volatile components but thermal decomposition can degrade the fragrances (Guadayol et al., 1998). In general, SPME is a rapid, trouble free, inexpensive, and solvent-free technique suitable for analysis of volatile compounds.

Direct extraction of *J. sambac* was found to contain the least amount of constituents detected by GC–MS which are mostly oxygenated and non-oxygenated terpenes and aromatic alcohols. On the other hand, volatile compounds from the headspace of *J. sambac* fresh flowers were rich in alcohols, carbonyl groups and oxygenated monoterpenes. Product of hydrodistillation gave mostly oxygenated and non-oxygenated terpenes. It can be seen clearly that the methanol extract of *J. multiflorum* contains oxygenated sesquiterpenes, esters and carbonyl containing compounds. Oxygenated sesquiterpenes and carbonyl compounds were the main volatile compounds of the headspace of *J. multiflorum*. Esters, oxygenated and non-oxygenated sesquiterpenes are among the compounds which were quantitatively detected as main peaks from hydrodistillation.

3.2. Genetic distances

Genetic distance values which are close to zero, indicate populations with many similar genes, and therefore, depict close similarities. Even though, the task to identify genetic distance between species is straight forward, there are a few different statistical methods that have been proposed. Generally, genetic distance methods by Nei (1987), Cavalli-Sforza and Edwards (1967) and Reynolds et al. (1983) are among the few commonly used today. The genetic distance between *J. sambac* and *J. multiflorum* was calculated by Nei's method to show interspecies relationship based on compounds identified by GC–MS when solvent extraction, hydrodistillation and HS-SPME are carried out. It was found, that genetic distance between *J. sambac* and *J. multiflorum* was 0.49 by hydrodistillation. This value was the closest to zero as compared to solvent extraction (1.41) and HS-SPME (5.70) technique. Therefore, hydrodistillation is a suitable method to depict interspecies similarity between *J. sambac* and *J. multiflorum* as compared to other extraction methods.

3.3. Antioxidant activity of methanol extracts

The capability of methanol extracts of *J. sambac*, *J. multiflorum* and BHT to scavenge DPPH radicals were shown in Fig. 2(a). The half maximal inhibitory concentration (IC_{50}) value which is a quantitative measurement of concentration in inhibiting the DPPH free radicals by half. In a DPPH assay, a lower IC_{50} value indicates a better radical scavenger, particularly peroxy radicals, which are the propagators of the autoxidation of lipid molecules and thereby breaking the free radical chain reaction (Frankel, 1991).

A large variation was found in the antioxidant capacity of both jasmine types as shown in Fig. 2(b). *J. sambac* showed a significantly higher IC_{50} value of 208 μg/mL as compared to *J. multiflorum* of value of 81 μg/mL. BHT used as a positive control in this investigation showed an IC_{50} value of 12.5 μg/mL. Therefore, between the two jasmine species investigated, *J. multiflorum* extracts is considerably a better free radical scavenger compared to *J. sambac,* as it requires a much lower concentration to scavenge DPPH radicals. It is expected of BHT to have a very low IC_{50} value as it is an effective synthetic antioxidant. The lower radical scavenging activity of *J. sambac* compared to *J. multiflorum* may be due to reversible reaction of DPPH with certain phenols such as eugenol and its derivatives as reported by Bondet et al. (1997). Another possible reason could be due to the slow rate of the reaction between DPPH and the substrate molecules (Huang et al., 2005).

A lower antioxidant activity of Taiwan *J. sambac* was reported (Tsai et al., 2008) as compared to other herb teas. They also reported green tea and osmanthus had the highest radical scav-

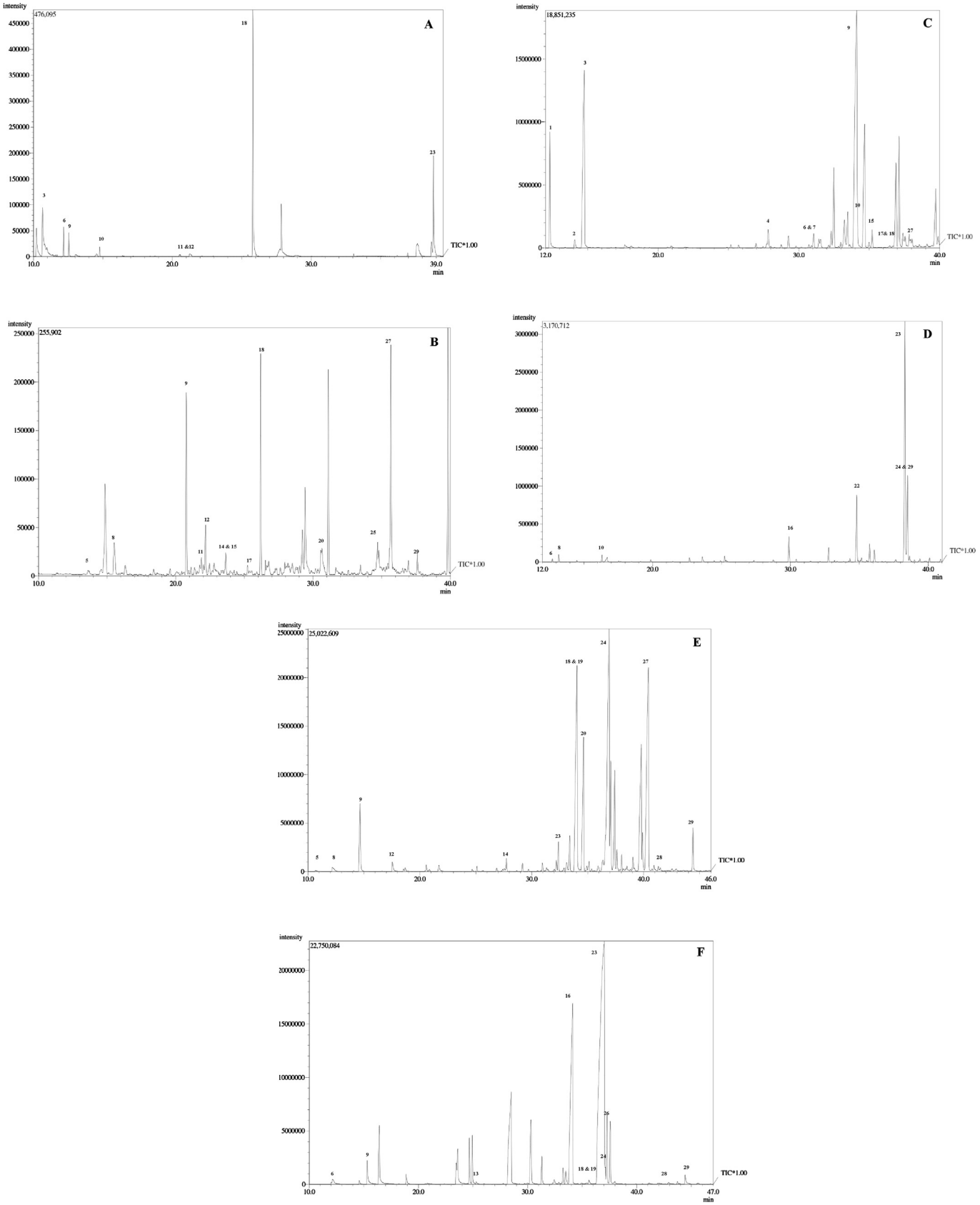

Fig. 1. GC–MS chromatograms profiles of *J. sambac* obtained from (A) solvent extraction; (B) hydrodistillation and (C) HS-SPME and *J. multiflorum* obtained from (D) solvent extraction; (E) hydrodistillation and (F) HS-SPME.

Table 1
Compounds identified from *J. sambac* and *J. multiflorum* were obtained by using three different extraction techniques: solvent extraction, hydrodistillation and headspace-solid phase microextraction (HS-SPME).

Compounds	#	I	Mean peak area % (from GC–MS data)					
			Jasminum sambac			*Jasminum multiflorum*		
			Solvent extraction	Hydrodistillation	HS-SPME	Solvent extraction	Hydrodistillation	HS-SPME
Trans-4-hexenal	1	844	ND	ND	9.36 ± 0.64	ND	ND	ND
2-Hexenol	2	856	ND	ND	5.30 ± 0.2	ND	ND	ND
Benzaldehyde	3	959	4.27 ± 1.88	ND	17.92 ± 1.01	ND	ND	ND
Mycrene	4	982	ND	ND	5.44 ± 0.18	ND	ND	ND
Hexenyl acetate	5	983	ND	0.25 ± 0.03	ND	ND	0.14 ± 0.02	ND
Benzyl alcohol	6	1033	17.56 ± 1.51	ND	10.87 ± 0.34	0.39 ± 0.20	ND	0.10 ± 0.02
2-Phenylacetaldehyde	7	1038	ND	3.40 ± 0.19	10.24 ± 0.30	ND	ND	ND
Tolualdehyde	8	1078	ND	1.30 ± 0.22	ND	0.90 ± 0.02	0.71 ± 0.06	ND
Linalool	9	1097	4.57 ± 0.69	9.96 ± 0.17	35.92 ± 1.09	ND	5.43 ± 0.88	0.26 ± 0.01
Phenyl ethyl alcohol	10	1106	1.23 ± 1.07	ND	2.367 ± 0.87	0.94 ± 0.03	ND	ND
α-Terpineol	11	1159	ND	0.58 ± 0.08	ND	ND	ND	ND
Benzyl acetate	12	1161	ND	1.64 ± 0.09	ND	ND	0.89 ± 0.12	ND
Indole	13	1287	ND	ND	ND	ND	ND	0.04 ± 0.02
δ-Elemene	14	1336	ND	0.49 ± 0.02	ND	ND	0.26 ± 0.03	ND
α-Copaene	15	1370	ND	0.46 ± 0.13	1.11 ± 0.39	ND	ND	ND
Jasmone	16	1381	ND	ND	ND	4.06 ± 0.04	ND	15.31 ± 1.06
α-Caryophyllene	17	1420	ND	0.50 ± 0.10	0.52 ± 0.09	ND	ND	ND
β-Farnesene	18	1448	52.52 ± 1.74	45.13 ± 1.48	0.82 ± 0.06	ND	24.62 ± 1.77	1.70 ± 0.08
α-Humulene	19	1469	ND	ND	ND	ND	0.54 ± 0.14	0.06 ± 0.02
γ-Cadinene	20	1473	ND	1.32 ± 0.58	ND	ND	12.30 ± 1.82	ND
Di-tertbutyl phenol	21	1476	ND	ND	ND	ND	ND	ND
Jasmolactone	22	1485	ND	ND	ND	12.02 ± 0.57	ND	ND
Nerolidol	23	1544	19.85 ± 3.04	ND	ND	42.44 ± 3.22	1.49 ± 0.04	76.56 ± 4.46
Hexenyl benzoate	24	1557	ND	ND	ND	0.25 ± 0.03	35.89 ± 1.03	0.58 ± 0.16
Viridiflorol	25	1583	ND	3.12 ± 0.98	ND	ND	ND	ND
Hexyl benzoate	26	1585	ND	ND	ND	ND	ND	4.40 ± 0.51
α-Cadinol	27	1650	ND	26.21 ± 0.87	0.14 ± 0.06	ND	14.30 ± 1.04	ND
Farnesol	28	1696	ND	ND	ND	ND	0.34 ± 0.14	0.25 ± 0.08
Benzyl benzoate	29	1773	ND	5.66 ± 0.3	ND	39.00 ± 0.85	3.09 ± 0.07	0.74 ± 0.11

I: Retention index.
ND: Not detected.
#: Compound number.

enging capacity compared to all other herbs used with decreasing order: rose > mate > rosemary > honeysuckle > juhua > duzhong > lemongrass > jasmine > jiaogulan > lavender. It was reported that 100 μg/mL of methanolic *J.sambac* extracted could only scavenge 13.0% of 200 μM DPPH as compared to the same concentration of green tea which could scavenge up to 94.5% of DPPH. Another study by Guo et al. (2014) investigated the antioxidant activity of compounds isolated from the stems of *J. nervosum*. Four caffeoyl phenylpropanoid glycosides of jasnervosides A–D, one monoterpenoid glycoside jasnervoside E, and three secoiridoid glycosides, jasnervosides F–H were tested by using the DPPH free radical scavenging system. It was found that three phenylpropanoid glycosides (A, B, and D) and one secoiridoid glucoside (G) exhibited strong antioxidant activity, with IC_{50} values ranging from 0.09 to 1.21 μg/mL. These results were consistent to earlier studies on phenylpropanoid glycosides and secoiridoid glucosides which also displayed antioxidant and free radical scavenging activities (Abdel-Mageed et al., 2012; He et al., 2001; Korkina, 2007). Other studies on the root extract of *J. sambac* to scientifically validate the traditional use in treatment of pain and inflammatory related ailments (Sengar et al., 2015). Results showed the roots of *J. sambac* displayed significant anti-inflammatory activity, anti-nociceptive and antipyretic activities.

It is also worth mentioning that high antioxidant activity property such as BHT and beta carotene has its adverse effects, too (Omenn et al., 1996; The Alpha-Tocopherol, Beta Carotene Cancer Prevention Study Group, 1994). The Beta-Carotene and Retinol Efficacy Trial (CARET) was conducted among 18,000 men and women who were at high-risk of lung cancer. This study was reported in 1996 in the New England Journal of Medicine (NEJM). The objective of this study was to investigate the ability of antioxidants in reducing the possibility of lung cancer in high-risk patients. Participants of this study included current smokers, ex-smokers, and workers who were exposed to asbestos. These participants were given synthetic antioxidant supplements such as beta carotene, vitamin A or placebo randomly. The results were unexpected when a higher (17%) death rate in the antioxidant group was observed. In another study in 1994, the *New England Journal of Medicine* (NEJM) published findings from a study on the prevention of lung cancer by using antioxidants in men who smoke. A total of 29,133 male smokers aged 50–69 were randomly given only one of the following: vitamin E only, vitamin E + beta carotene, beta carotene only or a placebo as a daily supplement. Results of this study were surprising when significantly more cases of lung cancer were reported in men who consumed beta carotene (either alone or in combination with vitamin E). This phenomenon was observed after 18 months of daily beta carotene use, and the number of lung cancer cases continued to increase disproportionately for the duration of the 8-year study (The Alpha-Tocopherol, Beta Carotene Cancer Prevention Study Group, 1994).

Governmental authorities and consumers are concerned about potential adverse effects of synthetic preservatives on health. According to the U.S. Food and Drug Administration (FDA), BHT was patented in 1947 and approved by FDA in 1954 for use in food products such as vegetable oils, lard, fat, margarine, carbonated drinks, cheese spreads, chewing gum, ice cream, and dry breakfast cereal. It is mostly added in combination with butylated hydroxyanisole (BHA) where it works as a preservative to prevent fats from becoming stale and to prolong the storage stability of food. Due to the side effects, Europe has restricted its use since 1987. There is evidence that BHT causes cell division. Some side effects of consuming BHT include allergic reaction which may trigger hyperactivity

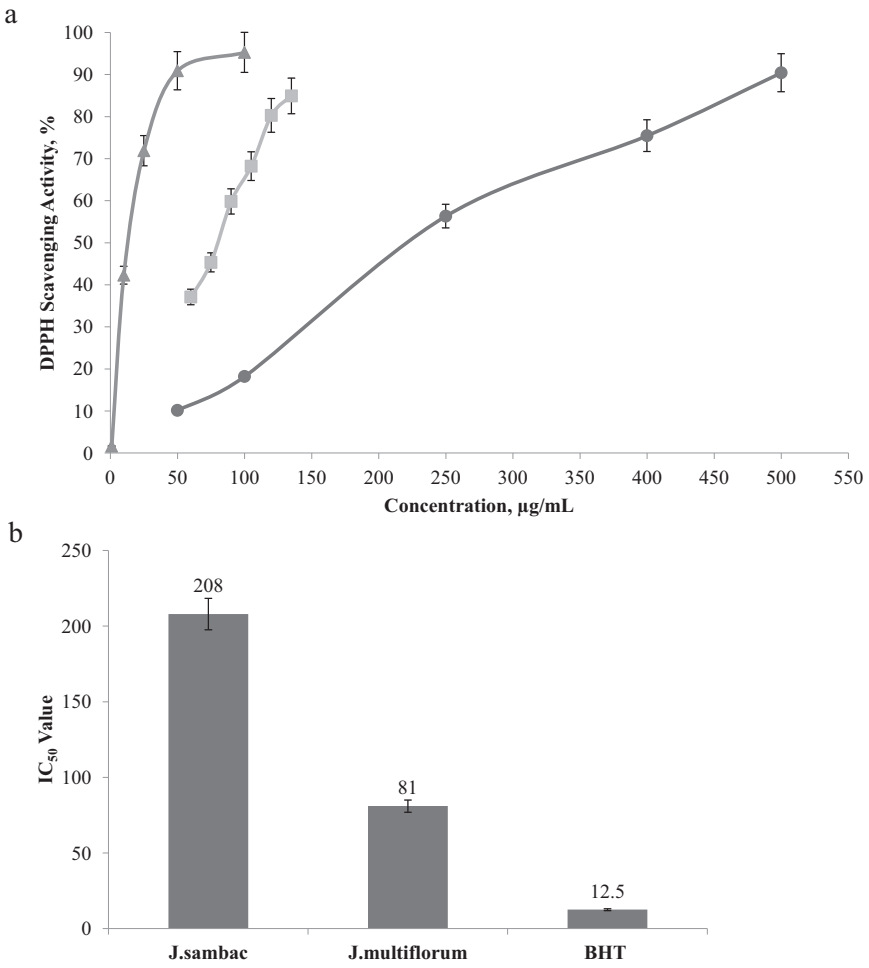

Fig. 2. (a) DPPH radical scavenging activity of extract from *J. sambac* (●), *J. multiflorum* (■) and BHT (▲). (b) IC_{50} value of methanol extract of *J. sambac*, *J. multiflorum* and BHT.

and asthma. There were serious concerns over carcinogenic and estrogenic effects when research found that in large doses, tumours developed in lab animals. Due to this, BHT was banned in Japan in 1958 while experts in UK suggested banning BHT but due to industry pressure it was not carried out (The UK Food Guide, 2014).

This only proves that synthetic antioxidants also have negative impacts.

4. Conclusion

β-farnesene, nerolidol, benzyl alcohol, linalool, and α-cadinol are among the major components present in *J. sambac* while *J. multiflorum* is rich in nerolidol, benzyl benzoate, jasmolactone, jasmone, hexenyl benzoate and β-farnesene. These compounds are all actively being utilized in the food and flavouring industries. HS-SPME technique has proven to be able to extract the most number of volatile compounds as compared to solvent extraction and hydrodistillation. This is due to its heat and solvent-free method which decreases the risk of chemical changes to volatile compounds and loss of compounds during the solvent removal step. *J. sambac* showed a much lower radical scavenging activity compared to *J. multiflorum* but it still contains a considerable amount of activity and can act as a reducing agent and free radical scavenger. Further, assays to confirm the presence of antioxidant activity from these species will be carried out in the near future. The presence of antioxidant activity in both *J. sambac* and *J. multiflorum* will have great potential to replace synthetic antioxidants such as BHT in the pharmaceutical and food industries especially in the process of food preservation.

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