Total Phenolic Content, Volatile Constituents and Antioxidative Effect of *Coriandrum sativum, Murraya koenigii* and *Mentha arvensis*

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Abstract: ***Background*:** Coriander, curry leaf and wild mint are among the most popular spices, and well known for their nutraceutical and essential oils (EOs) bearing properties.

***Objective*:** The present study aims to estimate total phenolic content, proline content, free radical scavenging activity, and volatile composition of the fresh leaves of coriander, curry leaf and wild mint.

***Method*:** A modified Folin-Ciocalteu method was used to estimate the total phenolic content and proline content, whereas 2,2-diphenyl-1-picrylhydrazyl (DPPH), and ferric ion reducing antioxidant power assay (FRAP) methods were used to determine the free radical scavenging activity. EOs were extracted through hydro-distillation method and subjected to GC-MS to identify their components.

***Results*:** Curry leaf was found to have highest total phenolic content (70.12 mg GAE/g), followed by wild mint (29.04 mg GAE/g) and coriander (24.02 mg GAE/g), whereas the uppermost proline content was obtained in curry leaf (453 mg/g), followed by mint (402 mg/g) and coriander (397 mg/g). All the extracts showed remarkable free-radical scavenging activity with EC_{50} values of 56.38 mg/100 g for curry leaf, 50.55 mg/100 g for wild mint and 49.89 mg/100 g for coriander. trans 2-Dodecenal (17%), 2-methylenecyclopentanol (9%), dodecanal (8%), cyclooctane (8%), 9-tetradecenal (8%) and decanal (8%) were found to be the major components in coriander oil. The wild mint EO contained menthol (52%), limonene (11%) and trans-dihydrocarvone (5%) as main components, whereas caryophyllene (19%), β -panasinsene (16%) and caryophyllene oxide (9%) were the principal constituents of curry leaf EO.

***Conclusion*:** The study concluded that coriander, curry leaf and wild mint are the rich source of antioxidants, and phenolics contents, and thus, could be used as potent nutraceutical agents in daily foods. Moreover, the EOs obtained from these spices contained various oxygenated compounds which might be useful for food and pharmaceutical industries.

Keywords: Antioxidant activity, caryophyllene, coriander, essential oils, menthol, total phenolic content.

INTRODUCTION

Dietary antioxidants play a vital role in human health mainly to minimize oxidative damage to living cells by deactivating Reactive Oxygen Species (ROS), the byproducts generated during normal cell aerobic respiration [1]. The reaction of ROS with lipid molecules forms peroxyl radicals and their interaction with proteins and nucleic acids promotes to certain alterations in the cells [2]. The oxidation in living cells caused through ROS or free radicals resulted to the skin aging, mutagenesis and even carcinogenesis [3]. Despite the health benefits, antioxidants also prevent oxidative deterioration of foods and drinks. The antioxidant efficacy of dietary herbs is mainly due to the presence of flavonoids, coumarins, anthocyanins, catechins and lignans [4]. Nowadays, researches on the potential benefits of natural antioxidants for human health have gained great attention due to their high efficacy and minimum or no adverse effects [5].

Coriandrum sativum L. (coriander), belongs to the Apiaceae family, is an annual herb, native to Italy, and now is cultivated in various Mediterranean, European and Asian countries [6]. The plant has been used as traditional remedy for cough, vomiting, diarrhea, dysentery, fever and various

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inflammatory conditions in India [7]. The fresh green leaves, commonly known as Dhania, Cilantro or Chinese parsley, are widely featured in the cuisines of various countries including India, China and Mexico [8]. The leaves possess a unique aroma due to the presence of EO, and are used as food flavoring agent [9]. Fruits and leaves of coriander are mainly used parts which contain EO. Dried seeds are added to dishes as an aromatic spice, and considered as digestive agent. The extracts and EO obtained from the plant showed various kinds of biological activities such as antimicrobial [10, 11], antioxidant, antidiabetic, anticancer, antihypertensive, diuretic [12] and anti-mutagenic [13]. Apart from the medicinal properties, the plant is also reported for its adverse effects such as antifertility, dyspeptic complaints, appetite suppression, convulsion, insomnia and anxiety [14]. Previous phytochemical analysis on various parts of the plant has led to the isolation of mainly EO [15] together with fatty acids [16], terpenoid glycosides [17], coumarins [18] and other polyphenols [19].

Murraya koenigii (L.) Spreng. (vern. Curry leaf) belongs to the Rutaceae family, is a native to India and now grown in tropical to sub-tropical regions. The plant leaves are extensively used for flavoring soups, curries, chutneys, sauces, pickles, fish and meat dishes in India [20]. Various parts of the plant are used in indigenous medicine as tonic, stomachic, anthelmintic, analgesic, stimulant and carminative agent [21]. The plant is also used to treat piles, influenza, asthma, fever, body aches, dysentery, diarrhoea, vomiting, itching and cuts [22]. The plant is cultivated mainly for its aromatic leaves which are fragrant, spicy, bitter, cooling and mild acidic in taste [23]. Many researches confirmed its use in diabetes, microbial infections and skin care, in the form of an antioxidant [24]. Moreover, the leaves have been found to possess pesticidal activity [25]. The aerial parts including fruits and seeds contain EO [26], whereas the fresh leaves are rich sources of β -carotene [27]. In addition to EOs, bioactive carbazole and indole alkaloids have also been reported from various parts of the plant [21].

Mentha arvensis L. (wild mint), a popular aromatic and flavoring herb Lamiaceae family, is well-known for its menthol-rich EO. The plant is widely grown in Europe, Asia and North America. The leaves of the plant are used as traditional remedy for indigestion, gastric troubles, cough, allergy and joint pain [28]. In addition to the menthol, menthone, neo-menthol, limonene and iso-menthone have also been detected as major constituents of the EO of wild mint grown in India [29]. Various extracts and EO obtained from the plant possess broad biological effects such as antiulcer, anti-inflammatory, sedative- hypnotic, hepatoprotective, antioxidants, antibacterial and anti-fertility activities [30]. Nowadays, mint extract and menthol- containing chemicals are extensively used in foods, drinks, cough medicines, creams and cigarettes worldwide [31].

The leaves of coriander, curry leaf and wild mint are preferably consumed by the people as fresh, rather than dried powder. Hence, it is important to determine the nutritional contents and biological efficacy of the fresh dietary herbs. A detailed literature analysis on these herbs revealed that all the earlier researches conducted, particularly in South Indian region, used dry leaves powder for the determination of Total Phenolic Content (TPC), proline and antioxidant activity by DPPH and FRAP assay. Herein, we used fresh leaves of the plants of this region to measure their TPC and antioxidant activity for the first time. In addition, the estimation of Total Oil Content (TOC) and the GC-MS analysis of volatile constituents of these herbs were also carried out to compare their concentration with previously published reports on similar species.

EXPERIMENTAL

Plant Materials

The fresh leaves of Coriander, Curry leaf and Wild mint were purchased from CMBT market, Chennai, Tamil Nadu. The plants were identified from the Department of Biology, Gandhigram Rural University, Dindigul (DT), Tamil Nadu, for their authenticity. The voucher specimen of *C. sativum* (No. GU489), *M. arvensis* (No. GU490) and *M. koenigii* (No. GU491) are available in the herbarium for future records.

Estimation of Total Phenol Content

A slightly modified Folin-Ciocalteu method [32] was used to determine the total phenolic content. Briefly, the fresh leaves (200 mg) were homogenized with 2 mL acetone-water (1:1, v/v) for 1 h at 25°C, and centrifuged at 6000 rpm for 10 min. After drying under vacuum, 9 µL of the extract (1 mg/mL) was mixed with 109 µL of Folin -Ciocalteu reagent. After about 3 min at 25ºC, 180 µL of Na_2CO_3 solution (7.5%, w/v) was added to this mixture. The mixture was allowed to stand for 5 min at 50°C, and after cooling to 25°C, the absorbance was measured by Zenyth 200rt Microplate Reader (UK-Biochrom Ltd.) at 760 nm. Finally, the total phenolic content was calculated using a standard curve of gallic acid and expressed as mg of Gallic Acid Equivalents (GAE) /g Fresh Weight (FW). All samples were analyzed in triplicate values.

Free-radical Scavenging Activity

The 2,2-diphenyl- 1-picrylhydrazyl (DPPH) method was used to evaluate the free-radical scavenging activity [33]. The fresh leaves were homogenized in methanol-water (3:2, v/v), centrifuged at 6000 rpm for 10 min, and the supernatant extract layer was separated and dried under vacuum. This extract was dissolve with methanol in order to obtain the desired concentrations of 40, 60, 80 and 100 mg/mL. Gallic acid solution (0.01 mg/mL), as a positive control, was prepared immediately before the analysis. Well-known DPPH radical scavenger ascorbic acid and rutin, prepared in methanol, were also used as standards to compare the activities of test samples. An aliquot (210 µL) of 0.04 nM DPPH, prepared in methanol, was mixed with 23 µL of the test samples in a 96 well microplate. The negative control contained all the reagents except the plant extract or positive control, gallic acid. The reaction mixture was allowed to leave for 60 min at 25°C, and the absorbance was then measured at 515 nm. The results were expressed as EC_{50} (sample required to reduce the absorbance of the radical by 50%) in mg of gallic acid equivalent per gram (mg GAE/g) of the samples. All samples were analyzed in triplicate values. The EC_{50} values were determined graphically by plotting the % absorbance of DPPH and then using following formula.

% Absorbance of DPPH = [(absorbance of control - absorbance of sample)/ absorbance of Control] × 100

Proline Estimation

Earlier described Proline estimation method [34] with some modifications was used. Briefly, the plants samples were homogenized with cold ethanol (40%; 2 mL) in mortar and pestle contained a little quantity of disinfected washed sand. After 10 min agitation, the extracts were filtered through Whatman filter paper, thereafter, 2 mL of aliquot was used for each extract. The absorbance was measured at 528 nm by spectrophotometer, whereas the values were compared with standard curve of proline. Results are expressed in proline µM/mg plant material.

Ferric Reducing Antioxidant Power Assay (FRAP)

A slightly modified method by Xu and Chang [35] was used to perform FRAP assay. FRAP solution was prepared with acetate buffer (pH 3.6, 300 mM), TPTZ (10 mM) in HCl (40 mM) and $FeCl_3.6H_2O$ (20 mM) (ratio mixed as 10:1:1). FRAP reagent (150 µL) and sample (20 µL) were added in to a 96-well plate, and incubated it under dark condition at room temperature for 8 min. After incubation, the plates were read at 600 nm by a spectrophotometer, and the results regression equation was calculated for the FRAP values (Units, mM FE(II)/g) and the sample ($R^2 = 0.962$).

Estimation of Total Oil Content

Fresh leaves of the plants (100 g in each case) were subjected to hydro -distillation for 2.5 h, using a Clevenger-type apparatus. The essential oils thus obtained were stored in dark vials at 4 ºC until further analysis. The total oil content was calculated by following formula.

Total oil content = (Total weight of oil / Total fresh weight of sample) × 100

EO Analysis by Gas Chromatography Mass Spectroscopy

The essential oils samples were diluted in *n*-hexane (10 µL/300 µL), and 10 µL of each solution was injected to a spit-mode Gas Chromatography which was performed on GC Agilent Technologies 7890 Apparatus, equipped with the split- splitless injector attached to HP-5 column (30 m×0.32 mm, film thickness 0.25 µm) and fitted to flame ionization detector. Helium (1 mL/min/210 ºC) was used as a carrier gas. The temperatures of injector and detector were set at 250 ºC and 280 ºC, respectively, whereas the column temperature was linearly programmed 40-260 ºC at 4 ºC/min. The percentage composition was computed from the peak areas, without correction factors. The GC-MS was performed on HPG 1800 C Series II GCD analytical system equipped with HP -5MS column. Mass spectra were recorded in EI mode (70 eV), in a range of m/z 40–450. The volatile constituents of the oils were identified by calculating their Kovats retention index (RI), and by comparing their mass spectra with reference compounds from Nirst and Willey libraries [36].

Statistical Analysis

The data were subjected to One-way Analysis of Variance (ANOVA) to evaluate the significant of difference of means of various treatment groups using SPSS statistical software package (Version: 10). The values are presented as mean ± S.D. and the values $p<0.05$ were considered as significant.

RESULTS AND DISCUSSION

Total Phenolic Content of Fresh Herbs

Total phenol contents from the fresh leaves of coriander, curry leaf and wild mint were found in ranging from 24.02 to 70.12 mg GAE/g FW. The results of TPC estimation are given in Fig. (**1**). Curry leaf was found to have the highest amount of TPC (70.12 ± 2.0 mg GAE/g) followed by wild mint (29.04 ± 1.6 mg GAE/g) and coriander (24.02 ± 2.4 mg GAE/g). Gallic acid was used as a standard for the estimation of TPC. All the previous studies on these herbs are based on the dried plant materials whereas we used fresh leaves of the plants for the first time. Previously, Al-Juhaimi and Ghafoor [37] found the TPC amounts of 1.24 and 1.12 mg GAE/100 mL for wild mint and coriander, respectively.

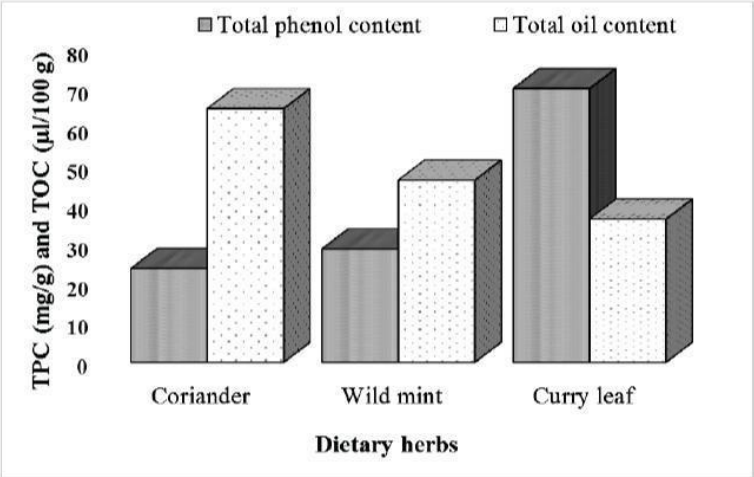

Fig. (1). Total phenol content and total oil content of the fresh leaves of coriander, wild mint and curry leaf.

However, Wangensteen *et al.* [38] reported TPC amounts of 5.45 and 1.89 g GAE/100 g from the ethyl acetate and acetone leaf extracts of coriander, respectively. Sasidharan and Menon [39] reported 0.501 g GAE/g TPC from the dried powder of curry leaf while a recent report by Ghasemzadeh *et al.* [40] found 14.371 mg GAE/g TPC in the dry powder. Our results showed a clear variation in the TPC of these herbs when compared to the earlier data. The major discrepancy was recorded for curry leaf which contained a highest amount of TPC (70.12 mg GAE/g FW).

Earlier researches confirmed the key role of phenolics for the antioxidant activities of wild mint, curry leaf and coriander, hence, the estimation of TPC of these herbs is an essential part of the present study. The phenolics or polyphenols are the important plant secondary metabolites, which constitute a wide and complex array of phytochemicals. These metabolites showed various physiological effects including antioxidant, antimicrobial, antiviral and anti-inflammatory activities in human beings [41]. Interestingly, the ability of phenolics to delay lipid oxidation in foods and biological membranes has provoked research into food science and biomedicine [42].

Proline Estimation

Proline an important parameter for stress tolerance capacity of the plants, acts as signaling molecules and defense pathway influences, legalizes complicated developmental and metabolic processes. It involved complementary opportunity for the plant development. With the sufficient information about the significance of proline, fresh plant materials tested for presence of proline. The results showed that a highest amount of proline content was observed in curry leaf (453 mg/g), followed by mint (402 mg/g) and coriander (397 mg/g) (Fig. **2**).

Ferric Ion Reducing Antioxidant Power Assay (FRAP)

Ferric ion reducing antioxidant power assay was measured tumbling possibility of an antioxidant to react with ferric tripyridyltriazine (Fe^{3+}-TPTZ) complex which produces a coloured ferrous tripyridyltriazine (Fe^{2+}-TPTZ) complex. In the present study, the highest content of FRAP was observed in mint. (126 mg/g), followed by curry leaf (110 mg/g) and coriander (95 mg/g) (Fig. **2**) whereas the R^2 value of standard Fe^{2+} showed ($y=0.0019x + 0.0114$, $R^2 = 0.955$).

Free Radical Scavenging Activity

The activities of all the fresh leaves samples (Fig. **3**) were expressed as EC_{50} values, the effective concentration at which the radicals were scavenged by 50%. A highest EC_{50} value was calculated for curry leaf (56.388 ± 2.0 mg/100 g), followed by wild mint (50.55 ± 1.2 mg/100 g) and coriander (49.891 ± 0.9 mg/100 g). However, ascorbic acid and rutin showed scavenging activity with EC_{50} values of 12.326 ± 3.0 and 30.192 ± 2.5 mg/100 g, respectively. All these values were found to be significant ($p<0.05$) when compared to that of negative control. Free radical scavenging activity by DPPH assay is considered as an important method to understand the potentiality of the plant materials toward its antioxidant ability. Among all the methods for antioxidant determination, DPPH method is most widely used due to its stability, ease and its simple reaction system which involves only the direct reaction between the radical and an antioxidant, which prevents further radical formation by donating hydrogen to highly reactive radical [43].

Antioxidant capacity of a crude extract mainly depends on the presence of polyphenols, which are known to inhibit the oxidation of lipids or other molecules by inhibiting the initiation or propagation of oxidizing chain reactions [44]. In the present study, we found a clear correlation between total phenolic content and antioxidant activity (Fig. **2**). The sample contained highest phenolic content i.e. curry leaf (70.12 mg GAE/g), showed highest scavenging activity while the lowest activity was recorded for coriander which contained least phenolic content (24.02 mg GAE/g). An earlier study on the antioxidant activity of curry leaf by Sasidharan and Menon [39] revealed that a hydro-alcoholic extract showed DPPH radical scavenging activity by 82% at a concentration of 10 µg/mL. An ethyl acetate extract obtained from the dried leaves of coriander showed antioxidant activity with an IC_{50} value of 147 µg/mL [38]. According to Al-Juhaimi and Ghafoor [37], the diethyl ether extract of the mint leaf extract showed DPPH radical scavenging activity by 34.21% whereas the diethyl ether extract of coriander leaf exhibited the activity by 26.82% at a concentration of 100 mg/mL for both cases.

Total Oil Content of Fresh Herbs

All the oils distilled from fresh leaves of coriander, curry leaf and wild mint were calculated for their total oil content as µg/100 g (Fig. **1**). Wild mint was found to contain the highest total oil content (65 µg/100 g), followed by coriander (46.666 µg/100 g) and curry leaf (36.666 µg/100 g).

GC-MS Analysis of Essential Oils

All the extracted essential volatile oils were subjected to GCMS analysis in order to identify and quantify their constituents. Various hydrocarbons, aldehydes, alcohols, diterpenes, sesquiterpene, and fatty acid esters have been identified from these oils. In coriander oil, a total of 96.81% contents have been characterized and are provided in Table **1**. Of 96.81% total identified constituents, *trans* 2-dodecenal (17%), 2-methylenecyclopentanol (9%), dodecanal (8%), cyclooctane (8%), 9- tetradecenal (8%), decanal (8%), 2-tridecenoic acid (4%), 2 -octenal (4%) and 2-cyclohexen-1-ol (3%) were found to be the major components in coriander oil. In case of wild mint oil, a total of 98.47% constituents has been identified (Table **1**) in which the highest amount of menthol (52%) has been recorded, whereas limonene (11%), dihydrocarvone (5%), β -myrcene (3%), germacrene D (2%), caryophyllene (2%), β -bourbonene (1%), carvyl acetate (1%), α-phellandrene (1%) and calamenene (1%) were found as other major constituents. Menthol, a key ingredient of wild mint, has numerous applications mainly as a flavoring agent for various food products.

A total of 96.7% volatiles were characterized from curry leaf oil, and are given in the Table **1**. Caryophyllene (19%), β-panasinsene (16%), caryophyllene oxide (9%), 7-epi-α-selinene (9%), β -selinene (7%), cyperene (7%), β - thujene (5%) and α –pinene (2%) were found to be the major

Table 1. Chemical constituents identified from coriander, wild mint and curry leaf essential oils.

Chemical Constituents	Coriander Essential Oil		Wild Mint Essential Oil		Curry Leaf Essential Oil	
	RI	Area %	RI	Area %	RI	Area %
α-Pinene	-	-	933	0.77	937	2.68
6,6-Dimethy l-2-methylene-bicyclo[3.1.1]heptane	-	-	985	1.71	981	1.46
1-Decene	988	0.27	-	-	-	-
β-Myrcene	-	-	989	3.14	992	0.52
γ-Terpinene	-	-	-	-	1053	0.23
β-Thujene	-	-	-	-	937	5.90
Limonene	-	-	1035	11.48		
(Z)-β-ocimene	-	-	1028	0.52	1023	1.54
1-Nonen-3-ol	-	-	1068	0.10	-	-
α-Terpinolene	-	-	1090	0.14	-	-
Linalool	-	-	1085	0.94	1087	0.27
Nonanal	1391	0.52	-	-	-	-
6-Methyl-3,5-heptadien-2-one	-	-	-	-	1096	0.28
2,6-Dimethyl-2,4,6-octatriene	-	-	1129	0.89	1129	0.18
Lavandulol	-	-	-	-	1166	0.66
Borneol	-	-	1169	0.44	-	-
1-Nonanol	1175	0.40	-	-	-	-
Terpinen-4-ol	-	-	1173	0.41	1176	0.22
3,5-Dimethyl-1H-pyrazole	-	-	-	-	1012	1.27
trans-Dihydrocarvone	-	-	1200	5.16	-	-
Hexadecane	1598	0.15	-	-	-	-
Decanal	1208	8.76	-	-	-	-
Dimethylhydrazone-formaldehyde	-	-	-	-	613	0.42
2-Methylcyclohexanone	-	-	-	-	953	0.26
2-Cyclohexen-1-ol	1427	3.83	-	-		
p-Mentha-1,4-dien-7-ol	-	-	-	-	2073	0.33
Cyclooctane	1023	8.32	-	-	-	-
Menthol	-	-	1173	52.34	-	-
Lavandulyl acetate	-	-	-	-	1584	0.80
Pentylcyclopentane	1088	0.20	-	-	-	-
trans Carvone oxide	-	-	1277	0.28	-	-
Benzothiazole	-	-	1409	0.19	-	-
δ-3-Carene	-	-	1012	0.22	1009	0.20
2-Acetylcyclopentanone	-	-	-	-	1942	0.60
10-Undecenal	1277	0.25	-	-	-	-
Cyclohexanol, 2-methyl-3-(1-methyletheny)	-	-	1441	0.95	-	-

(Table 1) contd….

Chemical Constituents	Coriander Essential Oil		Wild Mint Essential Oil		Curry Leaf Essential Oil	
	RI	Area %	RI	Area %	RI	Area %
2,6,6-Trimethyl-2-cyclohexenone	-	-	-	-	1057	0.17
Methyl-2,6,6-trimethyl-1-cyclohexenoate-1	-	-	1280	0.18	-	-
1-Methyl-1H-pyrrole-2-carboxaldehyde	-	-	1010	0.20	-	-
β-Cubebene	-	-	-	-	1390	0.38
2H-Pyran-3-ol, 6-ethenyltetrahydro-2,2,6	-	-	-	-	1771	0.56
2-Octenal	1056	4.54	-	-	-	-
Carvyl acetate	-	-	1759	1.32	-	-
2-Decenal	1265	1.92	-	-	-	-
α-Copaene	-	-	1377	0.16	-	-
Methylcyclohexane	726	0.76	-	-	-	-
β-Bourbonene	-	-	1381	1.55	-	-
β-Elemene	-	-	1384	0.30	1386	0.92
(Z)-Jasmone,	-	-	1368	0.20	-	-
Dodecanal	1388	8.56	-	-	-	-
Caryophyllene	-	-	1422	2.79	1424	19.78
1,2,3,4-Tetrahydronaphthalene	-	-	1164	0.66	-	-
β-Farnesene	-	-	1449	0.40	-	-
α-phellandrene	-	-	995	1.03	-	-
Longifolene	-	-	-	-	1404	0.45
β-Cedrene	-	-	-	-	1411	1.17
trans 2-Dodecenal	1485	17.81	-	-	-	-
2,7,10,14- Tetramethyl tridecane	1478	0.46	-	-	-	-
β-Selinene	-	-	-	-	1486	7.58
Germacrene D	-	-	1471	3.15	-	-
7-epi-α-Selinene	-	-	-	-	1507	9.29
Hexadecanal	1795	0.63	-	-	-	-
α-Panasinsen	-	-	-	-	1527	0.48
Calamenene	-	-	1509	1.08	-	-
α-Longipinene	-	-	-	-	1350	0.46
α-Fenchene	-	-	-	-	945	0.24
4,5-Epoxy-2-decenal	2000	0.89	-	-	-	-
2-Methylenecyclopentanol	1215	9.11	-	-	-	-
Camphene	-	-	27.34	0.82	-	-
Caryophyllene oxide	1562	1.20	1567	0.29	1557	9.07
Dodecanoic acid	1571	1.83	-	-	-	-
Tridecanal	1491	1.06	-	-	-	-

(Table 1) contd….

Chemical Constituents	Coriander Essential Oil		Wild Mint Essential Oil		Curry Leaf Essential Oil	
	RI	Area %	RI	Area %	RI	Area %
1,2,3,4-Tetrahydro-1,1,6-trimethylnaphthalene	-	-	1253	0.86	-	-
2,2,4,4,6,8,8-Heptamethylnonane	1319	0.48	-	-	-	-
Cyperene	-	-	-	-	1398	7.19
tau-Cadinol	-	-	1620	0.64	-	-
β-Humulene	-	-	-	-	1579	1.76
α-Cadinol	-	-	1633	0.84	-	-
2-Tridecenoic acid	2573	4.11	-	-	-	-
β-Panasinsene	-	-	-	-	1689	16.96
9-Tetradecenal	1946	7.97	-	-	-	-
5-Ethyl-5-methyldihydrofuran-2(3H)-one	-	-	1094	0.68	-	-
α-Bisabolol	-	-	-	-	1670	1.16
Z,E-2,13-Octadecadien-1-ol	2069	0.13	-	-	-	-
Octadecanal	2032	0.26	-	-	-	-
2-Methyl-5-isopropenylfuran	-	-	-	-	943	0.13
α-Campholenal	1106	0.33	-	-	-	-
Octopamine			1784	0.12	-	-
Nootkatone	-	-	-	-	1776	0.11
Alloaromadendrene	-	-	-	-	1464	0.11
cis-10-Heptadecenoic acid, methyl ester	2015	1.39	-	-	-	-
Hexahydrofarnesylacetone	1832	0.52	-	-	-	-
1-Hexadecene	1593	0.32	-	-	-	-
Tetradecanal	1613	0.18	-	-	-	-
Phytol	2622	0.26	2618	0.55	2625	0.19
Carbonic acid, tridecyl 2,2,2-trichloroethyl ester	2242	0.43	-	-	-	-
Tetratriacontyl pentafluoropropionate	3562	0.38	-	-	-	-
Octatriacontyl trifluoroacetate	3999	1.10				
Pentadecane	1504	0.24	-	-	-	-
1-Heneicosanol	2351	0.40	-	-	-	-
Tetradecane	1407	1.96	-	-	-	-
4-Tert.butyl-1-methyl-1-cyclohexanol	1430	0.46	-	-	-	-
Behenic alcohol	2451	0.79	-	-	-	-
1-Heptadecene	1693	0.63	-	-	-	-
4-Methylene-1-methyl-2-(2-methyl-1-propen-1-yl)-1-vinyl-cycloheptane	-	-	-	-	1475	0.22
n-Tetracosanol-1	2650	0.36	-	-	-	-
2-Dodecen-1-yl(-)succinic anhydride	2159	0.57	-	-	-	-

(Table 1) contd….

Chemical Constituents	Coriander Essential Oil		Wild Mint Essential Oil		Curry Leaf Essential Oil	
	RI	Area %	RI	Area %	RI	Area %
2,3-Bis[(3,7,11,15-tetramethylhexadecyl)oxy]-1-propanol	-	-	4113	0.11	-	-
Calarene-epoxide	-	-	-	-	1592	0.11
3-Heptadecene	1719	0.67		-	-	-
Octadecane	-		1801	0.24	-	-
Hexamethyl-cyclotrisiloxane	-	-	-	-	850	0.12
1-Heneicosyl formate	2472	1.22	-	-	-	-
Eicosane	-	-	2002	0.28	-	-
Heptacosane	-	-	-	-	2700	0.27
2,3-Dihydroindole	-	-	1039	0.34	-	-
Cyclooctacosane	3357	0.18	-	-	-	-
Total	**96.81%**		**98.47%**		**96.70%**	

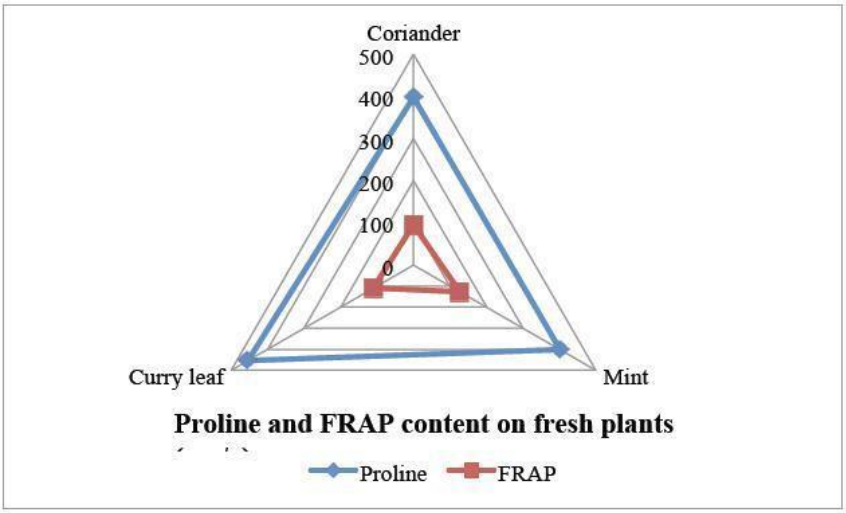

Fig. (2). Proline and FRAP contents in the fresh leaves of coriander, wild mint and curry leaf.

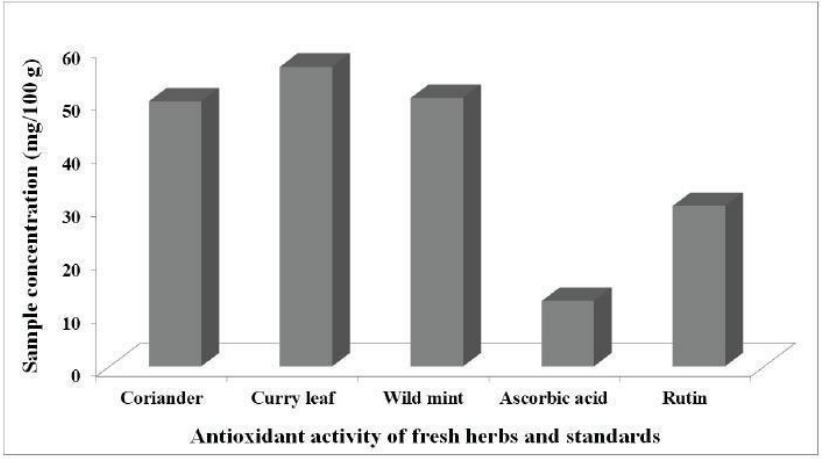

Fig. (3). Free radical scavenging activity of standards and fresh leaves of coriander, wild mint and curry leaf.

components of curry leaf oil. Previous reports revealed that curry leaf plants, harvested from north India, contained α -pinene (34%), sabinene (26%), β -pinene (10%), caryophyllene (2-3%), limonene (5%) and terpinen-4-ol (1%) as key ingredients. However, in present case, a highest concentration of caryophyllene (19%) followed by β -panasinsene (16%) and caryophyllene oxide (9%) has been recorded from the fresh curry leaf.

Essential oils, the volatile liquids derived from aromatic plants, are widely used in food and cosmetic industries due to their unique fragrance and various medicinal properties. These oils are mainly contained monoterpenes, sesquiterpenes, hydrocarbons and other oxygenated compounds including alcohols, aldehydes, esters, ethers and ketones [45]. Of about 3000 presently known essential oils, nearly 300 are of commercial importance and are key ingredients of various food and cosmetic products [46]. Besides seasoning the food, essential oils or their source herbs can also function as natural antioxidants. Hence, the graph of their use as natural antioxidant has grown up rapidly in recent years due to their effectiveness and the absence of any tendency to induce allergic or sensitive reactions in human beings.

CONCLUSION

The results from present study revealed that all three spice herbs, coriander, wild mint and curry leaf, contained high phenolic and oil contents, and showed significant scavenging activity against DPPH radical, FRAP assay. The study also confirmed that an herb with higher total phenolic content and proline content *i.e.* curry leaf, exhibited maximum antioxidant activity. Our results suggested that the use of fresh dietary plants, rather than a dry powder, could be more beneficial to the consumers in terms of physiological properties.

CONFLICT OF INTEREST

The authors confirm that this article content has no conflict of interest.

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