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Chemical Compositions, Antiviral and Antioxidant Activities of Seven Essential Oils

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Abstract: The antiviral activity of hydro-distilled essential oils obtained from *Allium cepa L.* (bulbs), *Allium sativum* (bulbs), *Cuminum cyminum* (seeds), *Corriandrum sativum* (herb and seeds), *Petroselinum sativum* (herb) and *Ocimum basilicum* (herb) cultivated in Egypt against (HSV1) were tested by using cytopathicity (CPE) assay. African green monkey kidney (Vero) cell line (virus infected cells) were incubated with different levels of the seven essential oils[onion, garlic, cumin, coriander (herb and seeds), parsley and basil] 200, 500 and 1000µg/ml and the EC_{50} were 1060, 320, 400, 2045, 341, 386 and 615 µg/ml, respectively. On the other hand the antioxidant activity of essential oils against DPPH radical were determined *in vitro* by treated with different concentrations of 7 essential oils 25, 50, 75, 100, 200 µg/ml and the percentages of $DPPH^{\cdot}$ inhibition and EC_{50} were recorded. Chemical compositions of essential oils were examined by gas chromatography-mass spectrometry (GC/MS). Onion, garlic, cumin, coriander (herb and seeds), parsley and basil essential oils were found to contain 33, 21, 20, 19, 24, 17 and 33 compounds, respectively.

Key words: *Allium cepa L.*, *Allium sativum*, *Cuminum cyminum*, *Corriandrum sativum*, *Petroselinum sativum, Ocimum basilicum*, essential oils, antioxidant, antiviral.

INTRODUCTION

Essential oils are volatile, natural, complex compounds characterized by a strong odor and are formed by aromatic plants as secondary metabolites. They are usually obtained by steam or hydro-distillation first developed in the Middle Ages by Arabs. Known for their antiseptic, i.e. bactericidal, virucidal and fungicidal, and medicinal properties and their fragrance, they are used in embalmment, preservation of foods and as antimicrobial, analgesic, sedative, anti-inflammatory, spasmolytic and locally anesthesia remedies. Up to the present day, these characteristics have not changed much except that more is now known about some of their mechanisms of action, particularly at the antimicrobial level. In nature, essential oils play an important role in the protection of the plants as antibacterials, antivirals, antifungals, insecticides and also against herbivores by reducing their appetite for such plants[1].

Onion (*Allium cepa*) bulb from Liliaceae has hypotensive[2], antioxidant[3] but boiling reduces the later property[4]. The onion antioxidant effect was more potent than vitamin E[5] and its antioxidant activity is probably involves increased saving NO in L-nitro arginine methyl ester (L-NAME) induced-hypertensive rats[6]. Onion has a preventive activity against cancer[7,8] and flavonoids extracted from onion peel improve male sexual function[3,9]. The antispasmodic activity of saponins from bulbs of red onion has been also reported[10] but this effect has not been shown on onion peel. Furthermore, red onion peel contains abundant flavonoids such as quercetin[3, 11] which is a calcium-antagonist[12].

The widespread use of garlic (*Allium sativum L.*) as a flavoring agent in food is well known. Garlic is also known to have medicinal properties. Recent studies have shown that garlic contained active components known as diallyl disulfide and dipropyl disulfide lowering the blood glucose and lipid levels in humans[13,14] and in animals[15,16]. The essential oil of garlic prevented lipid accumulation in the aorta and showed protective effects against atherosclerosis in rabbits fed an atherogenic diet[17,16]. Oral administration of garlic to humans depressed platelet aggregation[18, 19]. The garlic oil supplements in human subjects lead to the increased resistance of low density lipoprotein to oxidation and may be one of the powerful mechanisms accounting for the antioxidative and anti-atherosclerotic properties of garlic[20,21,22].

Cumin is a strong aromatic of dried ripe fruit (seeds) of *Cuminum cyminum* L. Cumin seeds and distilled cumin are used as a stimulant, antispasmodic, carminative and antimicrobial agent. They are used as a carminative particularly in veterinary practice. Cumin is used widely in traditional medicine to treat flatulence, digestive disorders and diarrhea and in the treatment of wounds[23]. The oil of seeds of Cumin

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contained considerable amounts of oxygenated monoterpenes and sesquiterpene hydrocarbons[24]. Chemical studies have demonstrated the presence of cuminaldehyde (18.7%), alpha-pinene (1.2%), beta-pinene (19.9%), para-cymene (25.2%), gamaterpinene gamaterpinene (29.1%), perrialdehyde (2.4%) and myrcene (1.5%) as the major compounds of the fruit essential oil of *C. cyminum*[25]. Some of the constituents of the cumin essential oil such as alpha-pinene and beta-pinene have been reported to possess anti-inflammatory activity[26]. Moreover, myrcene has peripheral analgesic effect acting by the stimulation of nitric oxide pathway[27,28].

Coriandrum sativum L. has a long history of use. It is mentioned in Sanskrit literature as far back as 5000 B.C. and in the Greek Eber Papyrus as early as 1550 B.C.[29]. Coriander was used in traditional Greek medicine by Hippocrates (ca. 460–377 B.C.). The seeds of coriander were found in the ancient Egyptian tomb of Ramses the Second. The Egyptians called this herb the ''spice of happiness", probably because it was considered to be an aphrodisiac. It was used for cooking and for children's digestive upset and diarrhea. The Greeks and Romans also used coriander to flavor wine and as a medicine[30]. Also, Coriander seeds (fruits) are widely used as a seasoning agent in liqueurs, teas, meat products, and pickles, as well as pastry, cookies, buns, and tobacco products[31]. Moreover, the ground seeds is a major ingredient (10–50%) in curry powder used in cooking all over the world[32]. There is 0.3–1.2% essential oil in the seeds, and 60–70% of this essential oil is linalool, which gives the pleasant characteristic odor to the oil. Linalool, a terpene tertiary alcohol, is reported to have antioxidant potency at high concentrations[33,34]. The volatile oil of coriander is utilized in different branches of the food industry such as bakery, meat processing, and chewing gum production. This oil is also extensively used in perfumery and in the cosmetic industry for its powerful aroma[35,36] and in the pharmaceutical industry for its antibacterial, bacteriostatic, fungicidal, and insecticidal activities[37,38].

The use of parsley as a meaningful source of dietary antioxidants has been overlooked due to the more common practice of using this herb as a garnish for improving the organoleptic qualities of foods. Notwithstanding this however, is the fact that parsley is comprised of a unique makeup of bioactive flavonoids, which includes both flavones (e.g. apigenin) and essential oil components (e.g. myristicin and apiol). Information on the antioxidant activity of parsley has been evaluated using a variety of chemical and cell-based antioxidant assays, and on a variety of parsley samples derived from different solvent extracts and originating from different anatomic parts of the herb. Studies have shown parsley to contain both bioactive phytochemical constituents that possess antioxidant activity, while also containing other components that have a carryover effect that yields defined chemopreventative activity in cell systems that are exposed to oxidative stress. For example, apigenin, the primary flavone characteristic to parsley exhibits weak reducing and free-radical scavenging activity, albeit that it also has a strong affinity to sequester free metal ions that otherwise could be involved in Fenton-reaction-induced free-radical generation. Alternatively, this flavone can stimulate the induction of reactive oxygen species (ROS), while concomitantly inducing apoptosis in cultured cancer cell lines, thereby suggesting a strong chemoprevention activity rather than acting purely as an antioxidant. On the other hand, essential oil recovered from parsley leaves exhibits notable antioxidant capacity in assays designed to measure reducing power and free-radical scavenging activity. Apiol is a stronger antioxidant than myristicin, and a primary contributor to the antioxidant activity found in parsley essential oil[39].

The *Ocimum basilicum* L. (Lamiaceae), includes around 30 plant species from tropical and subtropical areas[40]. *Ocimum* are widely cultivated and extensively used for food, perfumery, cosmetics, pesticides, medicine, and traditional rituals because of their natural aroma and flavor and other properties[41,42]. Literature reports that *O. basilicum* leaf essential oils or leaf powder have effective insecticidal and pesticidal activities against *Vigna unguiculata* pests *Callosobruchus maculatus* (F) (Coleoptera: Bruchidae)[43, 44]. *O. basilicum* commonly grows semi-wild and is cultivated in Togo at small scale in vegetable gardens. Current domestic uses are only for food and folk medicine[45]. Nevertheless, a large scale production of the basil essential for well-known value-added applications[46,47] is quite viable under local circumstances. The chemical composition of *O. basilicum* essential oils has been intensively investigated throughout the world[48,49,50], indicating that the estragole chemotype and the linalool/estrgaole chemotype are the most widely distributed. Basil is an aromatic herb that has been used traditionally as a medicinal herb in the treatment of headaches, coughs, diarrhea, constipation, warts, worms and kidney malfunctions[51]. It has a long history as culinary herb, thanks to its foliage adding a distinctive flavor to many foods. It is also a source of aroma compounds and essential oils containing biologically active constituents that possess insecticidal[52], nematicidal[53], fungistatic[54] and antimicrobial properties[55].

The objectives of the present study were to determine antiviral and antioxidant activities of seven essential oils using cytopathicity (CPE) assay against herpes simplex virus 1 (HSV-1) and DPPH radical scavenging assay respectively.

MATERIALS AND METHODS

Plant Materials: The bulbs of *Allium cepa L.* (Onion) *family Liliaceae*, bulbs of *Allium sativum* (Garlic) *family Liliaceae*, seeds of Cuminum cyminum (Cumin) *family Apiaceae or Umbelliferae* and herb of *Petroselinum sativum* (Parsley) *family Apiaceae* were purchased from local market, while herb and seeds of *Corriandrum sativum* (Coriander) *family Apiaceae*, and herb of *Ocimum basilicum* (Basil) *Family Lamiaceae* were purchased from experimental station of medicinal plants, Faculty of Pharmacy, Cairo University, Egypt.

Essential Oils Extraction: Two hundred grams of each sample was hydro-distilled in a Clevenger type apparatus for 4h according to Council of Europe[56]. The essential oils were dried over anhydrous sodium sulphate, stored in a dark glass bottle, and kept at 4°C until analysis. The amount of oil obtained from each plant material was calculated as:
Oil (% v/w) = observed volume of oil (ml)/weight of sample (g) × 100

GC/MS Analysis of Essential Oils: The essential oils were analyzed by GC/MS[57]. GC/MS analysis was performed on a Thermoquest-Finnigan Trace GC-MS equipped with a DB-5 (5% phenyl) methylpolysiloxane column (60 m \ 0.25 mm i.d., film thickness 0.25 μm). The injection temperature was 220°C and the oven temperature was raised from 40°C (3 min hold) to 250°C at a rate of 5°C/min, then held at 250°C for 2 min; transfer line temperature was 250°C. 1 µl of sample was injected and helium was used as the carrier gas at a flow rate of 1.0 ml/min. The mass spectrometer was scanned over the 40 to 500 m/z with an ionizing voltage of 70 eV and identification was based on standard mass library that National Institute of Standards and Technology (NIST Version 2.0) to detect the possibilities of essential oil components.

Antiviral Assay: The antiviral activities of the essential oils were determined using cytopathicity (CPE) assay against herpes simplex virus 1 (HSV. Stock solutions of the essential oils were prepared in DMSO at a concentration of 10 mg/ml. Cells, grown to confluence in 96-well plates, were infected with 100 µl of stock virus. After an adsorption period of 2 h at 37°C, virus was removed and serial concentrations of the essential oils were added. The cultures were further incubated at 37°C for 3 days, until complete CPE was observed in the infected and untreated virus control. The determination of the anti-influenza activities of the essential oils was based on virus-induced cytopathicity (destruction) of African green monkey kidney (Vero) cell line (virus infected cells), measured at day 4 post virus infection by the MTT colorimetric method[58]. An absorbance of formazan was detected by UV spectrometer at 540 nm wavelength. The results were expressed as the percentages of antiviral activities and 50% effective concentration (EC_{50}). The 50% effective antiviral concentration (EC_{50}) was defined as the essential oil concentration required to protect 50% of the virus-infected cells against viral cytopathogenicity.

Antioxidant Activity of Essential Oils by DPPH Radical Scavenging Assay: Radical scavenging activity of plant essential oils against the stable DPPH radical was determined spectrophotometrically[59]. The colorimetric changes (from deep-violet to light-yellow), when $DPPH^{\bullet}$ is reduced, were measured at 517 nm on a UV/visible light spectrophotometer. The antioxidant activities of essential oils were measured in terms of hydrogen donating or radical scavenging ability, using the stable radical DPPH. Fifty microliters of various concentrations (25, 50, 75, 100 and 200 µg/ml) of the essential oils in dimethyl sulphoxide (DMSO) as well as vitamin C (as standard antioxidant compound) were put into appropriate tubes, and 5 ml of 0.004% methanolic solution of $DPPH^{\bullet}$ was added to each tube to give final concentrations (25, 50, 75, 100, 200 µg/ml). Tests were carried out in triplicate. Absorbance measurements commenced immediately. The decrease in absorbance at 517 nm was determined after 1 h for all samples. Methanol was used to zero the spectrophotometer. Absorbance of the DPPH radical without antioxidant, *i.e.* the control, was measured. Special care was taken to minimize the loss of free radical activity of the DPPH radical stock solution. The DPPH radical by the samples was calculated according to the following formula[13]:

$$\% \text{ inhibition} = ((A_{C(o)} - A_{A(t)}) / A_{C(o)}) \times 100$$

Where $A_{C(o)}$ is the absorbance of the control at t = 0 min and $A_{A(t)}$ is the absorbance of the antioxidant at t = 1 h.

The percentage of Scavenging activity was plotted against the essential oil concentration to obtain the effective concentration (EC_{50}), defined as the essential oil concentration necessary to cause 50% scavenging.

Statistical Analyses: Statistical analyses were done using S.P.S.S. (version 17, 2008)[60] program. Mean and standard error were descriptive measures of quantitative data using the analysis of variance test (ANOVA) for independent samples. P-values <0.05 were considered significant.

RESULTS AND DISCUSSION

The hydro distillation of *Allium cepa L.* (bulbs), *Allium sativum* (bulbs), *Cuminum cyminum* (seeds), *Corriandrum sativum* (herb and seeds), *Petroselinum sativum* (herb) and *Ocimum basilicum* (herb) gave essential oils of about 0.059, 0.073, 3.20, 0.31, 0.82, 0.45 and 0.63 % (v/w), respectively. The essential oils were analyzed by GC/MS for determination of their components and results are given in tables (1, 2, 3, 4, 5 and 6) as a relative peak area of each constituent.

Table 1: Chemical composition of *Allium cepa* (bulbs) essential oil:

No.	Compound name	Peak area (%)
1	Disulfide, 1-methylethyl propyl	0.98
2	2,4-dimethyl-thiophene	0.52
3	Methyl propyl disulfide	3.78
4	Dimethyl trisulfide	0.79
5	Isopropyldithioisopropane	18.10
6	Dipropyl disulfide	8.83
7	Methyl propyl trisulfide	8.10
8	Dimethyl tetrasulphide	0.19
9	3-Ethyl-5-methyl-1,2,4-trithiolane	1.60
10	Methyl-1-(methylthio) propyl disulfide	0.29
11	2-Undecanone	2.50
12	Diisopropyl trisulfide	20.69
13	*trans*-Propenyl propyl trisulfide	4.96
14	9-t-Butyl-9,10-dihydroanthracene	0.56
15	Ethyl-2-(formylamino)-4-methylthiazole-5-carboxylate	1.70
16	2-Methyl-2-methylthiopropanal	0.70
17	2-Hexyl-5-methyl-(2H)-furan-3-one	3.48
18	2-Tridecanone	10.45
19	4,4-Dimethoxy-2-butenoic acid	0.44
20	5-Methyl-2-octyl-(2H)-furan-3-one	2.21
21	Methyl 1,2,3,4-tetrahydro-1, 1-dimethyl-2-naphthoate	0.70
22	Propyl-1-(propylthio)-ethyl- disulfide	2.90
23	Methyl- 2,6-anhydro-3,4,7-tridesoxy -1-erythro-hept-2-enulonate	0.66
24	6,10,14-trimethyl-2-Pentadecanone	0.08
25	1,3-bis (propylthio) – Propane	0.88
26	3,5-diethyl-1,2,4-Trithiolane	0.50
27	Hexadecanoic acid	0.34
28	Tricosane	0.08
29	Methyl- 2,6-anhydro-3,4,7-tridesoxy -1-erythro-hept-2-enulonate	0.66
30	6,10,14-trimethyl-2-Pentadecanone	0.08
31	1,3-bis (propylthio) – Propane	0.88
32	3,5-diethyl-1,2,4-Trithiolane	0.50
33	Hexadecanoic acid	0.34
	Total identified compounds	99.47

GC/MS Analysis of Essential Oils: More than 90% of the studied essential oils constituents were identified. It seems that there were no similarities among chemical compositions of the seven essential oils. The onion, garlic, cumin, coriander (herb and seeds), parsley and basil essential oils were found to contain 33, 21, 20, 19, 24, 17 and 33 compounds, respectively. In some of the essential oils, the main constituents accounted for more than 55 % of total oil, *e.g.,* coriander herb and seeds (linalool 68.36 and 73.79 %, respectively), cumin

Table 2: Chemical composition of *Allium sativum* (bulbs) essential oil:

No.	Compound name	Peak area (%)
1	3,3'-thiobis-1-Propene	3.03
2	Disulfide	4.60
3	Methyl-trans-propenyl-disulfide	0.20
4	cis-Propenyl methyl disulfide	0.47
5	Propanedioic acid	3.23
6	Dimethyl trisulfide	2.63
7	Limonene	0.14
8	Di-2-propenyl disulfide	25.18
9	Methyl-2-propenyl trisulfide	23.80
10	3-vinyl-[4H]-1,2-dithiin	1.30
11	2,4,5,6-Tetramethylpyrimidine	1.12
12	2-vinyl-[4H]-1,3-dithiin	1.85
13	Di-2-propenyl trisulfide	21.05
14	Isobutyl isothiocyanate	0.18
15	3,3'-thiobis-1-propene	0.24
16	2,3-Dicarboxythiophene	1.45
17	Diallyl tetrasulphide	3.56
18	Diallyl pentasulfide	2.45
19	Diallyl hexasulfide	1.15
20	Methyl allyl pentasulfide	0.22
21	Methyl allyl hexasulfide	0.15
	Total identified compounds	98.00

Table 3: Chemical composition of *Cuminum cyminum* (seeds) essential oil:

No.	Compound name	Peak area (%)
1	α-pinene	2.14
2	Sabinene	1.01
3	β-pinene	4.89
4	β-myrcene	1.45
5	α-terpinene	0.84
6	p-cymene	1.77
7	Limonene	0.24
8	γ-terpinene	1.07
9	α-terpinolene	0.08
10	Camphor	0.12
11	Terpinen-4-ol	0.04
12	α-terpineol	2.47
13	Geraniol	0.07
14	geranyl acetate	4.11
15	β-caryophyllene	3.44
16	α-phellandrene	1.09
17	Cuminaldehyde	60.01
18	Thymol	2.04
19	β-Farnesene	3.01
20	Caryophyllene oxide	6.12
	Total identified compounds	96.01

(Cuminaldehyde 60.01 %) and basil oils (linalool 55.55 %). In onion essential oil, the content of diisopropyl trisulfide was 20.69 %; in garlic essential oil, the contents of di-2-propenyl disulfide, methyl-2-propenyl trisulfide and di-2-propenyl trisulfide were 25.18, 23.80 and 21.05 %, respectively and in parsley oil, the content of myristicin was 25.20 %. On the other hand essential oils, contained compounds accounted for less than 20 % of total oil. The main compounds of these last ones were the following: isopropyldithioisopropane (18.10 %), 2-tridecanone (10.45 %), dipropyl disulfide (8.83 %) and methyl propyl trisulfide (8.10 %) in onion oil; disulfide (4.60 %) and diallyl tetrasulphide (3.56 %) in garlic oil; caryophyllene oxide (6.12 %),

Table 4: Chemical composition of *Corriandrum sativum* (herb and seeds) essential oil:

No.	Compound name	Peak area (%)	
		Coriander herb oil	Coriander seeds oil
1	α-thujene	-	1.43
2	α-pinene	2.55	2.05
3	camphene	0.62	0.75
4	sabinene	0.27	0.86
5	β-pinene	0.07	0.48
6	β-myrcene	-	0.77
7	α-terpinene	0.27	0.68
8	p-cymene	1.52	2.79
9	limonene	2.47	3.59
10	cis-β-ocimene	-	0.08
11	trans beta ocimene	-	0.12
12	γ-terpinene	3.11	4.31
13	cis-linalool oxide	0.08	0.07
14	trans-linalool oxide	0.04	0.10
15	α-terpinolene	1.12	0.42
16	linalool	68.36	73.79
17	camphor	2.41	4.43
18	Terpinen-4-ol	2.7	0.01
19	α-terpineol	0.64	0.09
20	trans-Geraniol	1.84	0.21
21	geranyl acetate	1.87	1.27
22	β-caryophyllene	0.22	0.24
23	β-phellandrene	0.25	-
24	Linalyl propionate	-	0.20
25	cis-citral	-	0.02
	Total identified compounds	90.41	98.76

β-pinene (4.89 %), geranyl acetate (4.11 %) and β-caryophyllene (3.44 %) in cumin oil; limonene (3.59 %), camphor (4.43 %) and γ-terpinene (4.31 %) in coriander seeds oil; Apiol (18.23 %), α-pinene (16.16 %), β-pinene (11.16 %), 1-allyl-2,3,4,5- tetramethoxy benzene (7.54 %) and limonene (3.23 %) in parsley oil; 1,8-cineole (11.67 %), β-farnesene (7.10 %) and α-guaiene (6.14%) in basil oil. These results are in agreement with many authors like the following: the Cuminaldehyde was found as the main component in cumin oil[24]; the main compound of coriander seeds was linalool[61,38]; myristicin in parsley oil was found as a dominant compound (32.75%) and apiol was the second dominant compound (17.54%)[62]; the main compound of basil oil was linalool[63].

Antiviral Activity of Essential Oils: The antiviral activities of hydro-distilled essential oils of *Allium cepa L.* (bulbs), *Allium sativum* (bulbs), *Cuminum cyminum* (seeds), *Corriandrum sativum* (herb and seeds), *Petroselinum sativum* (herb) and *Ocimum basilicum* (herb) were determined using cytopathicity (CPE) assay

Table 5: Chemical composition of *Petroselinum sativum* (herb) essential oil:

No.	Compound name	Peak area (%)
1	Trans-Ocimene	1.99
2	l-Phellandrene	1.03
3	Limonene	3.23
4	Linalool oxide	0.24
5	α-pinene	16.16
6	γ-terpinene	0.43
7	Artemiseole	0.08
8	α-terpinolene	1.37
9	β-caryophyllene	2.68
10	L-Selinene	0.47
11	Caryophyllene oxide	0.14
12	β -pinene	11.16
13	Apiol	18.23
14	Elemicin	4.30
15	Myristicin	25.20
16	cis-Isomyristicin	2.69
17	1-allyl-2,3,4,5- tetramethoxy benzene	7.54
	Total identified compounds	96.94

Table 6: Chemical composition of *Ocimum basilicum* (herb) essential oil:

No.	Compound name	Peak area (%)
1	α-Pinene	0.55
2	Sabinene	0.11
3	β-Pinene	0.02
4	Myrcene	0.05
5	1,8-Cineole	11.67
6	*cis* Ocimene	0.20
7	β Ocimene	0.83
8	Linalool	55.55
9	Camphor	0.29
10	Borneol	0.14
11	1,4-Terpineol	0.14
12	α-Terpineol	0.47
13	Methylchavicol	0.12
14	Nerol	0.13
15	α-Cubebene	0.02
16	Eugenol	0.71
17	α-Copaene	0.01
18	β-Cubebene	0.04
19	β-Elemene	2.44
20	Methyleugenol	0.18
21	β-Caryophyllene	0.12
22	α-Guaiene	6.14
23	α-Humulene	0.47
24	β-Farnesene	7.10
25	Germacrene D	1.95
26	δ-Guaiene	0.97
27	α-Amorphene	2.16
28	δ-Cadinene	1.71
29	cis-Sabinene hydrate	0.05
30	Linalyl propionate	0.50
31	Bourbonene	0.17
32	cis-Calamenene	0.25
33	Bicyclogermacrene	0.38
	Total identified compounds	95.64

against herpes simplex virus 1 (HSV-1). The percentages of antiviral activities after virus-infected cells incubation with different concentrations of the essential oils were recorded in table (7). Data showed that the incubation of virus-infected cells with essential oils increased the viability of those cells when compared to untreated virus-infected cells (control). The antiviral activities were increased with increasing essential oils concentrations. The additions of 200, 500 and 1000 µg/ml of the onion, garlic, cumin, coriander, parsley and basil essential oils increased antiviral activity percentages to 30.53, 38.00 and 46.99%, respectively in onion oil; 37.66, 72.94 and 93.81%, respectively in garlic oil; 9.16, 10.06 and 91.60%, respectively in cumin oil; 21.36, 23.99 and 24.34%, respectively in coriander herb oil; 36.98, 68.19 and 88.89%, respectively in coriander seeds oil; 52.59, 59.54 and 64.46%, respectively in parsley oil; 37.66, 40.20 and 80.75%, respectively in basil oil. It was noticed that the concentration of 1000 µg/ml of onion, garlic, cumin, coriander seeds, basil and parsley essential oils significantly increased the antiviral activity percentages, while coriander herb oil was insignificant compared with the concentrations of 200 and 500 µg/ml. The highest EC_{50} was noticed in garlic oil (320 µg/ml) followed by coriander seeds oil, parsley oil, cumin oil, basil oil and onion oil (341, 386, 400, 615, and 1060 µg/ml, respectively), while the lowest EC_{50} was noticed in coriander herb oil (2045 µg/ml). The difference in antiviral activities between the seven essential oils is attributable to the chemical composition of each essential oil. Also, our oils used in the present study had chemical components such as linalool (coriander herb, seeds and basil oils), cuminaldehyde (cumin oil), diisopropyl trisulfide (onion oil), di-2-propenyl disulfide, methyl-2-propenyl trisulfid and di-2-propenyl trisulfide (garlic oil), myristicin and apiol (parsley) which have probably imparted antiviral properties to the essential oils.

Chiang *et al.*[64] reported that linalool showed strongest activity against adenoviruses[AVD-II (EC_{50} = 16.9 mg/L; SI = 10.5)]. Sekine *et al.*[65] studied antifungal activities of volatile compounds from 52 species of spices against four phytopathogenic fungi and reported that the main antifungal compound of the plants was cuminaldehyde. Onion and garlic have a wide spectrum of actions such as antibacterial, antiviral, antifungal and antiprotozoal. Alliums were revered to possess anti-bacterial and anti-fungal activities, sulfur and other numerous phenolic compounds which arouse significant interests[66,67,68,69,70,71,72,73,74,75]. Also, Nagai[76] reported that garlic extract has preventive effect against infection with influenza virus. Cumin seeds essential oil has reputation as an important economic drug because of their biological activities such as antiviral, antimicrobial, antifungal, antitumor and anti-inflammatory[77,78,79]. The essential oil from the coriander seeds has been found to possess antimicrobial[80] and antifungal activities[81]. In particular, recent work in the yeast *Saccharomyces cerevisiae*, has shown that the cytotoxicity of coriander

Table 7: Antiviral activity of plant essential oils against herpes simplex virus 1 (HSV-1):

Sources	Concentration (µg/ml)	% of Antiviral activity	EC_{50} (µg/ml)
Control	-	0	-
Allium cepa	200	30.53 ± 2.40[b]	1060
	500	38.00 ± 3.30[b]	
	1000	46.99 ± 1.32[a]	
$LSD_{0.05}$		8.58	
Allium sativum	200	37.66 ± 3.11[c]	320
	500	72.94 ± 1.19[b]	
	1000	93.81 ± 2.06[a]	
$LSD_{0.05}$		7.82	
Cuminum cyminum	200	9.16 ± 2.40[c]	400
	500	70.06 ± 4.28[b]	
	1000	91.60 ± 1.93[a]	
$LSD_{0.05}$		10.54	
Corriandrum sativum (herb)	200	21.36 ± 0.44[a]	2045
	500	23.99 ± 2.54[a]	
	1000	24.34 ± 3.74[a]	
$LSD_{0.05}$		9.08	
Corriandrum sativum (seeds)	200	36.98 ± 1.36[c]	341
	500	68.19 ± 3.56[b]	
	1000	88.89 ± 2.28[a]	
$LSD_{0.05}$		8.87	
Petroselinum sativum	200	17.30 ± 3.97[b]	386
	500	69.21 ± 3.95[a]	
	1000	71.59 ± 5.11[a]	
$LSD_{0.05}$		28.44	
Ocimum basilicum	200	37.66 ± 2.61[b]	615
	500	40.20 ± 4.17[b]	
	1000	80.75 ± 3.53[a]	
$LSD_{0.05}$		12.09	

Each value represents the mean ± SE.
The mean values with different small letters within a column indicate significant differences ($P < 0.05$).

essential oil, based on colony forming ability, differed considerably depending on its chemical composition; essential oil treated cells in stationary phase of growth showed 50% lethality at 1.6 µL/ml of *Coriandrum sativum* essential oil[82]. *Petroselinum sativum* has biological activities such as antimicrobial, antirheumatic, antiseptic, astringent, carminative, diuretic, depurative, emmenagogue, febrifuge, hypotensive, laxative, stimulant, stomachic[83]. *Ocimum basilicum* leaf essential oils or leaf powder have effective insecticidal and pesticidal activities against *Vigna unguiculata* pests *Callosobruchus maculatus* (F) (Coleoptera: Bruchidae)[43,44]. Antiviral and antimicrobial activities of *Ocimum basilicum* have also been reported by many authors[64,84].

Antioxidant Activity of Essential Oils: Antioxidant activities of essential oils from aromatic plants are mainly attributed to the active compounds present in them. This can be due to the high percentage of main constituents, but also to the presence of other constituents in small quantities or to synergy among them. In this study, the antioxidant activities of essential oils of seven plants belonging to different plant families compared with vitamin C as a reference anti-oxidant compound were determined by the method of DPPH radical scavenging assay and the results are summarized in table (8).

It was found that the essential oils of seven analyzed plant samples showed good antioxidant capacities compared with vitamin C (standard

Table 8: Scavenging effect (%) of different plant samples essential oils as well as vitamin C on DPPH˙ at different concentrations:

Sources	Concentration (µg/ml)	% Inhibition of DPPH•	EC50 (µg/ml)
Control	-	0	
Allium cepa	25	15.40 ± 0.35[e]	90.1
	50	25.43 ± 0.82[d]	
	75	42.07 ± 1.18[c]	
	100	56.61 ± 2.68[b]	
	200	77.17 ± 2.52[a]	
LSD $_{0.05}$		5.59	
Allium sativum	25	7.27 ± 0.64[e]	88.91
	50	26.47 ± 1.54[d]	
	75	32.53 ± 1.88[c]	
	100	67.87 ± 1.04[b]	
	200	87.00 ± 1.65[a]	
LSD $_{0.05}$		4.48	
Cuminum cyminum	25	9.33 ± 0.74[e]	72.3
	50	31.50 ± 2.63[d]	
	75	54.65 ± 2.68[c]	
	100	66.62 ± 3.00[b]	
	200	83.59 ± 2.06[a]	
LSD $_{0.05}$		7.44	
Corriandrum sativum (herb)	25	13.38 ± 1.11[e]	71.92
	50	23.43 ± 2.04[d]	
	75	55.25 ± 2.95[c]	
	100	76.46 ± 2.12[b]	
	200	93.35 ± 1.66[a]	
LSD $_{0.05}$		6.51	
Corriandrum sativum (seeds)	25	17.16 ± 2.61[e]	74.05
	50	27.56 ± 1.65[d]	
	75	52.39 ± 1.35[c]	
	100	67.48 ± 2.28[b]	
	200	74.72 ± 2.37[a]	
LSD $_{0.05}$		6.64	
Petroselinum sativum	25	17.17 ± 2.33[e]	83.92
	50	32.87 ± 1.80[d]	
	75	42.59 ± 1.85[c]	
	100	65.36 ± 1.78[b]	
	200	86.68 ± 2.22[a]	
LSD $_{0.05}$		6.33	

Table 8: Continue

Ocimum basilicum	25	19.32 ± 1.23^{d}	88.02
	50	22.57 ± 2.18^{d}	
	75	44.46 ± 1.39^{c}	
	100	59.80 ± 1.68^{b}	
	200	72.40 ± 1.24^{a}	
$LSD_{0.05}$		4.99	
Vitamin C	25	36.65 ± 0.36^{e}	38.49
	50	63.44 ± 1.45^{d}	
	75	80.99 ± 0.90^{c}	
	100	93.56 ± 1.91^{b}	
	200	98.58 ± 0.30^{a}	
$LSD_{0.05}$		3.01	

Each value represents the mean ± SE.
The mean values with different small letters within a column indicate significant differences ($P < 0.05$).

antioxidant compound). The results from table (8) indicate that the radical scavenging activity (% inhibition) of the essential oil from *Corriandrum sativum* (herb) was the highest (93.35%) at the concentration of 200 µg/ml, followed by *Allium sativum* and *Petroselinum sativum* (87.0 and 86.68%, respectively) while, % radical inhibition of *Cuminum cyminum, Allium cepa, Corriandrum sativum* (seeds) and *Ocimum basilicum* essential oils were 83.59, 77.17, 74.72 and 72.40%, respectively. It was noticed that the scavenging activities of the essential oils were increased with the increased of the essential oils concentrations. All the tested samples showed lower DPPH radical scavenging activity when compared with the standard. It is clear from the data that the concentration of 200 ppm of *Corriandrum sativum* (herb) essential oil gave a percentage inhibition of $DPPH^{\bullet}$ (93.35%) nearly of the same concentration of vitamin C which was 98.58%. The highest EC_{50} was noticed in vitamin C (38.49 µg/ml). All plants essential oils were able to reduce the stable, purple-colored radical DPPH into yellow-colored DPPH reaching 50% of reduction with EC_{50} values. The highest essential oil EC_{50} was *Corriandrum sativum* (herb) oil (71.91 µg/ml) followed by cumin oil, coriander seeds oil, parsley, basil and garlic oil (72.30, 74.05, 83.92, 88.02, and 88.91 µg/ml, respectively). On the other hand the lowest EC_{50} was noticed in onion oil (90.10 µg/ml). The difference in DPPH radical scavenging activity between the seven essential oils is attributable to the chemical composition of each essential oil. Also, our oils used in the present study had chemical components such as linalool (coriander herb, seeds and basil oils), cuminaldehyde (cumin oil), diisopropyl trisulfide (onion oil), di-2-propenyl disulfide, methyl-2-propenyl trisulfid and di-2-propenyl trisulfide (garlic oil), myristicin and apiol (parsley) which have probably imparted antioxidant properties to the essential oils.

Alliums were revered to possess powerful antioxidants, sulfur and other numerous phenolic compounds which arouse significant interests[66,67,68,69,70,71,72,73,74,75]. Also, the antioxidant properties by the oxidation of aliphatic aldehyde (trans-2-hexenal) into the corresponding carbonic acid, essential oil of garlic has the maximal efficiency of inhibiting hexenal oxidation (80%)[85]. Onion (*Allium cepa*) bulb from Liliaceae has antioxidant[3]. Cumin is a potent antioxidant capable of scavenging hydroxy, peroxy and DPPH free radicals and thus inhibits radical-mediated lipid peroxidation[86]. Essential oil from coriander seeds has previously been investigated for radical-scavenging activity and it was found that it possessed weak DPPH scavenging activity[87]. Essential oil recovered from parsley leaves exhibits notable antioxidant capacity in assays designed to measure reducing power and free-radical scavenging activity. Apiol is a stronger antioxidant than myristicin, and a primary contributor to the antioxidant activity found in parsley essential oil[39]. Free radical-scavenging capacities of the *O. basilicum* essential oils were measured by the DPPH assay. *O. basilicum* essential oils were able to reduce the stable, purple-colored radical DPPH into yellow-colored DPPH-H. *O. basilicum* essential oils obtained from winter and spring crops showed greater radical-scavenging activity than those collected during autumn and summer, exhibiting IC_{50} values for 4.8, 5.3 and 6.0 and 6.7 µg/ml, respectively. Linalool, the major component of *O. basilicum* essential oil, tested under the same conditions exhibited lower antioxidant activity (IC_{50} 16.4 µg/ml) than the entire oil[88].

In conclusion, the essential oils of *Allium cepa L. (bulbs), Allium sativum (bulbs), Cuminum cyminum (seeds), Corriandrum sativum (herb and seeds), Petroselinum sativum (herb) and Ocimum basilicum (herb)* showed antiviral activities against herpes simplex virus 1 (HSV-1). Considering the abundance of these volatile compounds in the oils, the total antioxidant activities of these oils were significant. Furthermore, the studied essential oils might help to prevent oxidative damage in the human body, such as lipid peroxidation which was associated with cancer, prematuring aging, atherosclerosis and diabetes. These results showed that the essential oils could be used as a potential natural antiviral and antioxidant agents. However, studies *in vivo* are needed to assess the true antioxidant and antiviral activities of these essential oils and to determine the metabolic pathways involved in their degradation.

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