Essential oil and antioxidant activity of the aerial parts of coriander (*Coriandrum sativum* L.) cultivated in Ethiopia

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ABSTRACT

Coriander (*Coriandrum sativum* L.) is an annual herbaceous plant which is used as spice. It is widely cultivated throughout the world for its essential oils. The percent composition of commercial essential oils is highly variable due to the effect of geographical origin. In the present investigation, the chemical constituents of the essential oils obtained from the aerial parts of the plant collected from three different areas of Ethiopia were determined by gas chromatography-mass spectrometry. The number of compounds identified in the essential oils of the plants from Jimma was 47, from Wolaita Sodo 21, and from Sululta 19. The major components of the essential oils were found to be decanal and (*E*)-2-decenal. The methanol extract of coriander aerial parts exhibited DPPH anti-oxidant activities in the range 91.1-92.3% at 500 µg/mL. Therefore, coriander aerial parts can safely be used for food flavoring and food preservation.

Keywords: Coriander (*Coriandrum sativum* L.); Aerial parts; Essential oils; Antioxidant activity
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INTRODUCTION

Coriander (*Coriandrum sativum* L.) is an annual herbaceous plant, which belongs to the family Apiaceae. It is cultivated all over the world for its seeds and leaves (Mandal *et al*., 2015). In Ethiopia, coriander grows at altitudes of 1500-2500 m (Jansen, 1981). Coriander can be cultivated in soils with sufficient organic matter and pH of 5.5 to 6.5 at temperatures of 10-28 ^{o}C. Higher amount of sunlight is one of the requirements for the synthesis of essential oils and plant growth (Nurzynska-Wierdak, 2013).

Coriander stems, leaves, and seeds are edible. Leaves are used for salad, flavoring soup, for food products and juice (Eyres *et al*., 2005). It can be combined with other spices to flavor them, for example, black peppers, bread and *injera*. Coriander stores a number of biologically active metabolites such as essential oils, fatty acids, minerals and antioxidants which are distributed in the whole plant with different type and amount. Variation in the level and chemical composition arises from differences in genotype, geographical location and stage of maturity. The essential oils composition in coriander

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fresh leaves was found dominated by aldehydes and alcohols (Matasyoh *et al*., 2009). However, the percent composition of some commercial essential oils is highly variable due to the effect of geographical origin, variation between and within species, processing parameters (either dry or wet plant material on distillation changes) and adulteration (use of either traditional or synthetic fertilizer) (Shu *et al*., 1997).

Coriander oil is stable and it can retain its characteristics for a longer time than the oil of its class (Purseglove *et al*., 1981). The presence of linoleic acids in the diet is well observable which plays important roles in human health and nutrition including cardiovascular disease prevention (Ertas *et al*., 2005). Various parts of this plant such as leaves, flower, and seeds possess phenolic compounds, β-carotene, vitamin C, E, and flavonoids. These bioactive compounds scavenge free radicals in our body and help prevent cancer and related diseases (Tang *et al*., 2013). Coriander essential oils also act as anti-bacterial agent (Silva *et al*., 2011). It contains high proportion of petroselenic acid that reduces the level of arachidonic acid in the heart and liver (Shahwar *et al*., 2012). Coriander also promotes digestion and treats gastro-intestinal disorders (Jabeen *et al*., 2009).

In the literature, we find several studies on the essential oils and antioxidant activity of coriander leaves and aerial parts from different countries (Satyal *et al*., 2020; Saxena *et al*., 2022; Al-Khayri *et al*., 2023; Jayakodi *et al*., 2024). However, there is no study on the chemical composition and radical scavenging activity of essential oils of the aerial parts (leaves, the twigs including flowers) of coriander plants cultivated in different regions of Ethiopia. The main objective of this study was to investigate the chemical constituents of essential oils and DPPH radicals that scavenge the activity of flowering aerial parts of coriander (*Coriandrum sativum* L.) cultivated in Ethiopia, specifically to (i) determine the percent yield of volatile compounds of the aerial parts of coriander cultivated at three different sites in Ethiopia and compare with that of the data reported in the literature, (ii) investigate the chemical composition of essential oils of the aerial parts of coriander by GC-MS, (iii) determine the percent scavenging ability of fresh coriander aerial parts at different concentrations, (iv) compare the % DPPH inhibition of solvent extract of coriander leaves with that of the data in the literature, and (v) compare the percent composition of dominant compounds of aerial parts of coriander essential oils with that of the data reported in the literature.

MATERIALS AND METHODS

Apparatus and equipment

Samples were ground and homogenized using ceramic crucibles (mortar and pestle). Digital analytical balance with a precision of (0.0001 g) was used for weighing. Round bottom flasks (Jlassco, Borosilicate), Erlenmeyer (Pyrex) flask and (INKALABORTECHINK) shaker, Clevenger apparatus, separatory funnel, rotavapor

(Heildolph instruments, Gmbh & Co: KG, Germany), and vials were used for sample preparation, distillation, extraction and storage of essential oils.

Chemicals and reagents

All the chemicals, reagents and solvents used in this study were analytical/HPLC grade and used as received without further purification. Methanol (> 99.7%, Sigma-Aldrich, USA), *n*-hexane (99%, Labachemic Pvt. Ltd, India), dichloromethane (Fisher Scientific, UK), chloroform (Carloerba reagent groups, France), DPPH (Alpha Chemika, India), KOH pellets, and NaCl were used for the study. Distilled water was used throughout the study.

Sample collection and description of the sampling area

The coriander herbs were collected from the production areas at three different localities of Southern Nations, Nationalities, and People's Region and Oromia Region of Ethiopia. Sululta is located at latitude of 9º11´0´´ N and longitude of 38º45´0 E´´ approximately 37 km north of Addis Ababa found at an altitude of 2750 above sea level. Wolaita Sodo is located at latitude of 6º54´ N and 37°45′ E and approximately 326 km far from Addis Ababa. Jimma is located at latitude of 7º40´26´´ and longitude of 36º50´8.8´´E with an elevation of 1400-2000 meters above sea level and approximately 348 km far from Addis Ababa. Selection of these areas was based on their high production and consumption of coriander plant. Coriander aerial parts were collected, washed with tap water without squeezing to remove dust particles and ground using mortar and pestle.

Extraction of volatile compounds

Essential oils from the samples (500 g) were extracted by hydro-distillation using a Clevenger apparatus (Clevenger, 1928). A 2 L distillation flask was filled with distilled water until it was half-filled and heated over an electro mantle for 5 hours. The essential oil was dried over anhydrous $NaSO_4$ and stored in a refrigerator until for GC-MS analysis (Mohamed *et al*., 2018). The percentage yield of essential oil was calculated using the formula:

$$\text{Percentage yields} = (\text{mass of essential oil/mass of plant sample}) \times 100 \quad (1)$$

An Agilent 7820A GC/5977E MSD was used for the analysis of the chemical components following the published procedure (Sisay et al., 2022a; Assefa *et al*., 2024). The constituents of essential oils were identified by matching their mass spectra with those of reference compounds recorded in the National Institute of Standards and Technology (NIST), USA, mass spectral library.

Chromatographic conditions for GC-MS analysis

The essential oils were analyzed using an Agilent Technology 7820A GC system coupled with an Agilent Technology 5977E MSD equipped with an autosampler. The chromatographic separation was done on a DB-1701 (14%-cyanopropyl-phenyl)-methylpolysiloxane, column (30 × 0.25 µm) at a pressure of 8 psi and a flow rate of 0.97989 mL/min. Ultra-high pure helium (99.999%) was used as carrier gas at constant flow mode. An Agilent G4567A autosampler was used to inject 1 µL of the sample with a splitless injection mode into the inlet heated to 275 ºC, with a total run time of 29.33 minutes. Oven temperature was programmed with the initial column temperature of 60 ºC and a hold time of 2 minutes. The column temperature was increased at a rate of 10 ºC/min until it reached 200 ºC and then heated again at the rate of 3 ºC/min until it reached 240 ºC. No mass spectra were collected during the first 4 minutes of the solvent delay. The transfer line and the ion source temperatures were at 280 ºC and 230 ºC, respectively. The detector voltage was 1600 V, and the electron energy was 70 eV. Mass spectral data were collected from 40 to 650 *m*/*z*. The names, structures, and qualities of peaks were determined through a NIST 2014 library search and retention index (I) calculation.

Sample preparation for free radical scavenging activity of coriander aerial parts

The absorbance of methanol extract from coriander aerial parts and DPPH solution were obtained by using 1 cm path length quartz cuvette and recorded on a Perkin Elmer Hitachi Spectrofluorometer (Flouromax-4, Spectrofluorometer, USA), as discussed by Bhuiyan *et al*. (2009).

A 5000 µg/mL stock solution of the sample was prepared from 0.5 g of methanol extract in 100 mL of methanol. 0.01 g of DPPH was dissolved in 250 mL of methanol to create a 0.004% solution, which was then kept in the refrigerator. Stock solutions of 2500, 1250, 500, 250, 125, and 62.5 µg/mL of the sample in 10 mL volumetric flasks were prepared and used to create 500, 250, 100, 50, 25, and 12.5 µg/mL solutions by adding 4 mL of the 0.004% DPPH solution to 1 mL of each sample concentration. The well-mixed solutions were incubated for 30 minutes in the dark at room temperature, and their absorbance was measured at 517 nm (El-Ghorab et al., 2008). The scavenging effect of DPPH free radicals was calculated using the equation:

% DPPH inhibition = [(Absorbance of sample-Absorbance of blank) ×100]/ (Absorbance of blank) (2)

Selection of optimal time for essential oil extraction

To determine the total amount of essential oils extracted from the aerial parts, the amount of essential oil produced was recorded for six hours at one hour interval. It was found that the amount of essential oils was continuously increased up to 5 hours; after that, it

remained constant. Hence, 5 hours was selected as an optimum time for the extraction of essential oils.

Antioxidant activity determination

The radical scavenging activity of methanolic extracts of coriander aerial parts was determined by DPPH method following the procedure described by Sisay *et al*. (2022b). When DPPH reacts with an antioxidant, it results changes in color (from deep-violet to light-yellow), which was measured at 517 nm by using UV-Visible spectrophotometer (El-Ghorab *et al*., 2008).

Determination of the amount of individual components in the essential oil

A 1000 µg/mL stock solution of essential oil was prepared, and from this, a 20 µg/mL solution was used for GC-MS analysis. The GC-MS chromatogram of the essential oil was recorded and the peak area obtained was used to determine the amount of individual component of the essential oil. Individual peaks were selected on the basis of relative quality information obtained from the NIST-14 library (47–99%).

Purity and identity of the peak was checked automatically using the software and also manually by selecting different regions of a peak and subtracting the background and comparing with data stored in the NIST-14 library. Number of individual components in the chromatogram of the sample was compared by considering peak area, retention time and index, following the procedure described by Sisay *et al*. (2022b).

RESULTS AND DISCUSSION

Percent yield of essential oils of coriander aerial parts

The essential oil content of coriander aerial parts was 0.17% for samples from Jimma, 0.31% for Sululta, and 0.18% for Wolaita Sodo. A comparison of the percent yield of essential oil from coriander aerial parts with other studies is shown in Table 1.

Chemical composition of essential oils coriander

Essential oils of coriander from Sululta are composed of 19 constituents with a total area of 88.1% (Table 2). The major compounds were (E)-2-decenal (42.9%), decanal (15.0%), 2-dodecenal (5.7%), 2-undecanal (5.3%), octacosane (3.7%) and tetracosane (3.4%). This sample is a rich source of (E)-2-decenal, 2-

undecenal, heptadecane, tetracosane and octacosane compared to other selected areas.

Table 1. Comparison of percent yield of essential oil from coriander aerial parts with other studies.

Sampling area	Yield of essential oil (%)	Reference
Jimma	0.17	This study
Sululta	0.31	This study
Wolaita Sodo	0.18	This study
Egypt	0.27	(Mohamed *et al*., 2018)
Bangladesh	0.10*	(Bhuiyan *et al*., 2009)
UK	0.10*	(Shahwar *et al*., 2012)

*leaves

Table 2. Chemical composition of essential oils coriander from Sululta.

Peak No.	Retention time (min)	Area (%)	Compound names	NIST matching quality (%)
1	8.8	1.69	Linalool	86
2	10.2	1.07	(*E*)-4-Decenal	81
3	10.27	15.01	Decanal	98
4	11.17	0.72	(*Z*)-2-Decenal	86
5	11.45	42.92	(*E*)-2-Decenal	53
6	11.67	2.86	Tetra decanal	92
7	12.81	5.32	2-Undecanal	83
8	13	1.28	Dodecenal	91
9	14.11	5.67	2-Dodecenal	95
10	16.38	0.4	2-Methyltricosane	87
11	17.57	0.34	Hexadecane	86
12	18.91	0.18	Octacosane	78
13	18.97	0.67	Hexadecanoic acid methyl ester	91
14	20.43	0.26	9-Methyl nonadecane	89
15	21.99	0.18	Allylcyclohexane	80
16	22.13	0.75	9-Octylheptadecane	93
17	23.99	1.7	Heptadecane	95
18	25.98	3.38	Tetracosane	97
19	28.07	3.71	Octacosane	90

The GC-MS data of essential oils from the coriander sample collected in Wolaita Sodo revealed 21 compounds with a total peak area of 98.0% (Table 3). Among these, (E)-2-decenal accounted for 29.1%, decanal for 24.8%, (E)-2-decen-1-ol for 8.2%, 2-dodecenal for 7.7%, and tetradecanal for 4.4%, representing the major constituents. A higher amount of linalool and decanal was found in this sample compared to the other samples. The essential oil constituents in the coriander sample from Wolaita Sodo are listed in Table 3. The coriander aerial parts from the Jimma region exhibited 47 compounds with a total percent area of 99.4%. The major components included (E)-2-

decenal (29.7%), decanal (20.2%), (E)-2-decen-1-ol (11.7%), and (E)-2-dodecenal (8.9%).

Table 3. Chemical composition of essential oils in the coriander sample from Wolaita Sodo.

Peak No.	Retention time (min)	Area (%)	Compound names	NIST matching quality (%)
1	8.26	1.26	(*E*)-Linalool oxide	83
2	8.55	1.78	Isopulegon	72
3	8.79	4.17	Linalool	87
4	9.84	0.73	(+)-2-Bornanone	95
5	9.99	0.71	1-Nonanol	52
6	10.19	0.41	(*E*)-4-Decenal	64
7	10.27	29.07	Decanal	99
8	11.36	8.16	(*E*)-2-Decen-1-ol	94
9	11.45	24.83	(*E*)-2-Decenal	91
10	11.67	4.44	Tetra decanal	87
11	12.82	2.06	2-Undecenal	91
12	13.00	1.98	Dodecenal	91
13	14.12	7.66	2-Dodecenal	86
14	14.40	0.93	7-(Propan-2-ylidene) bicyclo[4.1.0]heptane	74
15	15.58	1.25	*B*-Bisabolene	86
16	15.99	0.62	2-Isopropyl-5-methyl-9-methylene-bicyclo[4.4.0]dec-1-ene	90
17	16.50	2.28	(*E*)-Tetra dec-2-enal	93
18	23.99	0.59	Heptadecane	58
19	25.98	1.77	Tetracosane	91
20	27.41	2.38	N-(2-methylheptan-2-yl)-N-phenylbenzenamine	87
21	28.06	0.89	Octacosane	95

The coriander sample from Jimma showed the largest number of compounds in the essential oil compared to the other samples. However, the percent composition of each constituent, except for 2-dodecenal, was lower than that of Wolaita Sodo. The chemical compositions of essential oils in coriander from Jimma are shown in Table 4. The GC-MS data revealed that the percent composition of decanal determined in this study (15.0-29.1%) is higher than the reported values from Egypt (Mohamed et al., 2018), Fiji (Eyres et al., 2005), Poland (Nurzynska-Wierdak, 2013), and Pakistan (Shahwar et al., 2012), and is similar to the data for coriander leaves from Saudi Arabia (Foudah et al., 2021). The relative concentration of (E)-2-decenal determined in this study is higher than those

reported from Egypt (Mohamed et al., 2018) and Fiji (Eyres et al., 2005), and is closer to the reported data from Pakistan (Shahwar et al., 2012).

Table 4. Chemical composition of essential oils in coriander aerial parts from Jimma.

Peak No.	Retention time (min)	Area (%)	Compound names	NIST matching quality (%)
1	5.06	0.76	α-Pinene	97
2	6.70	0.34	D-Limonene	98
3	6.98	0.50	*p*-Cymene	97
4	7.23	0.79	γ-Terpinene	83
5	7.91	0.09	2-n-Octaylfuran	72
6	8.26	0.10	(E)-Linalool oxide	95
7	8.54	0.21	Isopulegon	78
8	8.79	10.56	Linalool	94
9	9.83	0.98	(+)-2-Bornanone	98
10	9.98	0.07	1-Nonanol	83
11	10.19	1.36	(*E*)-4-Decenal	83
12	10.27	20.22	Decanal	99
13	11.17	0.17	(Z)-2-Decenal	72
14	11.3	0.43	(*E*)-Geraniol	78
15	11.39	11.68	(*E*)-2-Decen-1-ol	95
16	11.45	29.66	(*E*)-2-Decenal	95
17	11.67	2.87	Tetradecanal	94
18	11.74	0.25	α-Copaene	99
19	11.96	0.06	β-Bourbonene	96
20	12.44	0.22	Decanoic acid, ethyl ester	98
21	12.51	0.49	3-Carene	95
22	12.61	0.11	α-Cadinene	91
23	12.70	0.63	(*Z*)-2-Undecen-1-ol	96
25	12.99	2.03	Hexadecanal	87
26	13.51	0.39	β-Bisabolene	98
27	13.8	0.05	(*E*)-2-Octenal	80
28	13.94	0.65	(*Z*)-2-dodecen-1-ol	96
29	14.08	8.88	(*E*)-2-Dodecenal	91
31	14.24	0.11	2-Heptadecyl oxirane	93
32	15.29	0.08	2-Dodecenal	89
33	15.37	0.06	(*E*)-3-Tetradecen	55
34	15.42	0.26	Tetradecanal	99
35	15.56	0.07	Heptane,1,7-dibromo	47
36	16.26	0.07	2-Tridecyne	91
37	16.36	0.05	Octadecane	91
38	16.45	3.20	(*E*)-Hexadec-2-enal	91
39	17.55	0.04	Hexadecene	94
40	17.72	0.05	(*E*)-4-Tetradecene	76
41	18.94	0.10	Methyl palmitate	97
42	20.42	0.04	Heneicosane	97
43	22.12	0.08	Hexadecane	96

44	23.41	0.14	*n*-Tridecan-1-ol	68
45	23.98	0.12	Heptadecane	91
46	25.97	0.19	Tetracosane	97
47	28.06	0.20	Octacosane	93

A comparatively lower amount of 2-n-octylfuran was found than in the aerial parts from Poland (Nurzynska-Wierdak, 2013). (E)-4-tetradecenal was identified in the present study, which has not been reported in other studies (Table 5). The relative concentrations of (Z)-2-undecen-1-ol and (Z)-2-dodecen-1-ol are higher in the coriander leaves from Saudi Arabia (Foudah et al., 2021) compared to the samples in the present study. The essential oils analyzed in this study consist of 28 different constituents that were not determined in previously reported works (Mohamed et al., 2018). Table 5 shows the relative concentrations of the essential oil constituents from this study and from five different countries.

Radical scavenging activities of essential oils and methanol extract of coriander aerial parts

The antioxidant activity was determined using the 2,2-diphenyl-1-picrylhydrazyl (DPPH) method by measuring absorbance at 517 nm. This assay is based on the transfer of hydrogen ions from the sample to the DPPH free radical. The DPPH assay is an easy, economical, and rapid method for evaluating radical scavenging activity.

As shown in Table 6, the sample from Sululta exhibited a maximum absorbance value of 0.075 ± 0.00 A.U., compared to 0.071 ± 0.00 A.U. for Jimma and 0.049 ± 0.00 A.U. for Wolaita Sodo at 500 µg/mL. This result indicates a lower amount of antioxidants in the sample from Sululta than in those from Jimma and Wolaita Sodo. The DPPH inhibition values were 44.8% for the methanol extracts of coriander samples from Sululta, 40.9% from Jimma, and 38.3% from Wolaita Sodo, all at 100 µg/mL. However, the radical scavenging activity of standard ascorbic acid (96.1%) was higher than that of all the other samples. Samples from Wolaita Sodo exhibited higher radical scavenging activity than those from Jimma and Sululta, with inhibition values ranging between 91.1% and 92.3%. These inhibition values were attributed to the total phenolic compounds extracted in methanol from the samples. The radical scavenging activities of the coriander samples are shown in Table 7.

The values for all three samples at 500 µg/mL are very close to each other. However, the level of inhibition is much lower than that of the standard compound used during the analysis. A comparison of the DPPH scavenging activity of coriander samples from the present study with values reported in the literature is provided in Table 8. There is only one study from Pakistan on DPPH scavenging activity at three different concentrations.

The percent DPPH inhibition in the present study was relatively much higher than that reported from Pakistan at all three concentration levels.

Table 5. Comparison of essential oils of coriander with the reported values.

Compounds name	**Egypt (Mohamed *et al*., 2018)**	**Fiji (Eyres *et al*., 2005)**	**Poland (Nurzynska-Wierdak, 2013)**	**Pakistan (Shahwar *et al*., 2012)**	**Saudi Arabia (Foudah *et al*., 2021)**	**Ethiopia (This study)**
α-Pinene	3.23	0.07	-	1.90	-	0.78
D-Limonene	3.30	0.10	-	-	-	0.35
p-Cymene	4.08	0.70	-	-	-	0.51
γ-Terpinene	2.21	0.32	0.10	-	0.28	0.81
2-n-Octaylfuran	-	-	0.30	-	-	0.09
(E)-Linalool oxide	0.36	0.04	-	-	-	0.11-1.26
Linalool	18.34	0.17	1.00	13.97	0.23	1.7-20.6
(+)-2-Bornanone	2.70	0.02	0.10	-	-	0.73-1.01
1-Nonanol	0.53	0.12	0.20	-	-	0.07-0.53
(*E*)-4-Decenal	-	-	0.80	-	-	0.41-1.39
Decanal	2.85	6.56	17.20	1.73	11.04	15.0-29.1
(*Z*)-2-Decenal	-	0.16	-	-	1.42	0.17-0.72
(*E*)-Geraniol	1.90	-	-	-	-	0.44-1.90
(*E*)-2-Decen-1-ol	-	26.00	-	5.45	-	8.2-12.0
(*E*)-2-Decenal	5.10	9.12	-	32.23	-	24.8-42.9
Tetradecanal	0.52	0.96	-	1.09	1.08	0.42-2.94
3-Carene	-	0.02	-	-	-	0.50
(*Z*)-2-Undecen-1-ol	-	-	-	-	0.78	0.15
2-Undecenal	-	1.20	-	-	-	5.32
(*E*)-2-Dodecenal	-	5.37	-	-	-	1.98-9.11
(*Z*)-2-Dodecen-1-ol	-	-	-	-	7.87	0.67
(*E*)-Hexadec-2-enal	-	0.39	-	2.94	-	3.28
(*E*)-4-Tetra decenal	-	-	-	-	-	0.10
2-Dodecenal	-	-	-	7.51	-	0.16-7.66
Method	GC-MS	GC-GC TOFMS	GC-MS/MS	GC-MS	GC-MS	GC-MS

Table 6. Average absorbance of coriander aerial parts extracts.

Concentration µg/mL	**Mean absorbance of sample at 517 nm collected from***		
	Wolaita Sodo	**Jimma**	**Sululta**
12.5	0.699±0.00	0.732±0.02	0.660±0.00
25	0.654±0.00	0.689±0.00	0.635±0.00
50	0.613±0.00	0.657±0.00	0.581±0.01
100	0.525±0.00	0.541±0.01	0.469±0.01
250	0.252±0.02	0.195±0.00	0.158±0.00
500	0.049±0.00	0.071±0.00	0.075±0.00

*means were calculated from three replications.

Table 7. Radical scavenging activity of the coriander samples.

Concentration µg/mL	Percent DPPH inhibition (mean±SD)*			
	Wolaita Sodo	**Jimma**	**Sululta**	**Standard ascorbic acid**
12.5	18.18±0.41	21.88±0.36	22.37±0.33	-
25	23.80±0.00	24.55±0.06	24.44±1.81	-
50	28.32±0.50	28.10±0.51	31.64±1.63	96.09±0.16
100	38.32±0.50	40.85±0.01	44.83±0.01	96.29±0.06
250	70.63±0.275	79.73 ±0.39	82.42±0.84	96.26±0.06
500	92.30±0.33	92.27±0.06	91.09±0.42	96.06±0.12

*means were calculated from three replications.

Table 8. Comparison of DPPH scavenging activity of the methanol extract with that reported from Pakistan.

Concentration (µg/mL)	Percent DPPH inhibition, Pakistan (Shahwar *et al.*, 2012)	Percent DPPH inhibition, Ethiopia (This study)		
	MLE	**MEAW**	**MEAJ**	**MEAS**
100	29.7±0.73	38.6±0.00	40.9±0.01	44.8±0.01
250	44.3±1.19	70.1±0.00	78.7±0.00	82.8±0.07
500	72.0±0.64	92.3±0.00	92.3±0.00	91.1±0.00

MLE = methanol leave extract, MEAW = methanol extract of aerial part from Wolaita Sodo, MEAS = methanol extract of aerial part from Sululta and MEAJ = methanol extract of aerial part from Jimma.

CONCLUSION

Essential oils from the aerial parts of coriander were extracted by hydro-distillation at an optimum time of 5 hours. The essential oils of coriander plants from Jimma contained 47 different compounds, while those from Wolaita Sodo had 21 and from Sululta had 19. The major components of the essential oils were decanal (8.2-20.2%) and (E)-2-decenal (24.8-42.9%). The antioxidant activity of the crude extracts of coriander aerial parts was determined using the DPPH method. The sample from Wolaita Sodo exhibited higher radical scavenging activity at 500 µg/mL than those from other sampling areas. Therefore, the use of coriander aerial parts for food flavoring and preservation is supported by chemical analysis and DPPH radical scavenging activity tests. Additionally, it can be used to deactivate free radicals in the body, which helps prevent many diseases.

Data Availability

The experimental data used to support this study are provided within the article.

Disclosure

This manuscript is extracted from MSc thesis of Mekides Assefa submitted to Addis Ababa University. All the materials taken from the thesis are duly acknowledged. The thesis from which this article is extracted has been reposited at Addis Ababa University repository as part of the partial requirement for MSc degree of Mekides Assefa.

Conflicts of Interest

The authors declare no conflict of interest. There is no conflict of interest with the Department of Chemistry, Addis Ababa University for publishing the MSc thesis work in any international journals.

Authors' Contributions

MA, EEY, BSC, and MAS designed the study. MA and MAS carried out the experimental work. EEY, BSC and MA wrote the paper. EEY and MA did the data entry. All authors participated in the data analysis and interpretation and read and approved the final manuscript.

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REFERENCES

Al-Khayri, J.M., Banadka, A., Nandhini, M., Nagella, P., Al-Mssallem, M.Q and Alessa, F.M. (2023). Essential oil from *Coriandrum sativum*: A review on its phytochemistry and biological activity. *Molecules* **28**(2): 696–740.

Assefa, M., Yaya, E.E., Chandravanshi, B.S and Assefa, M. (2024). Fatty acid and essential oil compositions of seeds of coriander (*Coriandrum sativum* L.) cultivated in different regions of Ethiopia. *Bulletin of the Chemical Society of Ethiopia* **38**(4): 863–876.

Bhuiyan, M.N.I., Begum, J and Sultana, M. (2009). Chemical composition of leaf and seed essential oil of *Coriandrum sativum* L. from Bangladesh. *Bangladesh Journal of Pharmacology* **4**(2): 150–153.

Clevenger, J.F. (1928). Apparatus for the determination of volatile oil. *The Journal of the American Pharmaceutical Association* **17**(4): 345–349. doi: https://doi.org/10.1002/jps.3080170407

El-Ghorab, A., Shaaban, H.A., El-Massry, K.F and Shibamoto, T. (2008). Chemical composition of volatile extract and biological activities of volatile and less-volatile extracts of juniper berry (*Juniperus drupacea* L.) fruit. *Journal of Agricultural and Food Chemistry* **56**(13): 5021–5025. doi:10.1021/jf8001747

Ertas, O.N., Guler, T., Ciftci, M., Dalkilic, B and Yilmaz, O. (2005). The effect of a dietary supplement coriander seeds on the fatty acid composition of breast muscle in Japanese quail. *Revue de Medecine Veterinaire* **156**(10): 514–518.

Eyres, G., Dufour, J.-P., Hallifax, G., Sotheeswaran, S and Marriott, P.J. (2005). Identification of character-impact odorants in coriander and wild coriander leaves using gas chromatography-olfactometry (GCO) and comprehensive two-dimensional gas chromatography–time-of-flight mass spectrometry (GC×GC–TOFMS). *Journal of Separation Science* **28**(9-10): 1061–1074. doi:https://doi.org/10.1002/jssc.200500012

Foudah, A.I., Alqarni, M.H., Alam, A., Ayman Salkini, M., Ibnouf Ahmed, E.O and Yusufoglu, H.S. (2021). Evaluation of the composition and in vitro antimicrobial, antioxidant, and anti-inflammatory activities of Cilantro (*Coriandrum sativum* L.) leaves cultivated in Saudi Arabia (Al-Kharj). *Saudi Journal of Biological Sciences* **28**(6): 3461–3468. doi:https://doi.org/10.1016/j.sjbs.2021.03.011

Jabeen, Q., Bashir, S., Lyoussi, B and Gilani, A.H. (2009). Coriander fruit exhibits gut modulatory, blood pressure lowering and diuretic activities. *Journal of Ethnopharmacology* **122**(1): 123–130. doi: https://doi.org/10.1016/j.jep.2008.12.016

Jansen, P.C.M. (1981). *S*pices, condiments and medicinal plants in Ethiopia, their taxonomy and agricultural significance: Wageningen University and Research.

Jayakodi, Y., Thiviya, P., Gamage, A., Evon, P., Madhujith, T., and Merah, O. (2024). Antioxidant activity of essential oils extracted from apiaceae family plants. *Agrochemicals* **3**(1): 57–69.

Mandal, S., and Mandal, M. (2015). Coriander (*Coriandrum sativum* L.) essential oil: chemistry and biological activity. *Asian Pacific Journal of Tropical Biomedicine* **5**(6): 421–428. doi:https://doi.org/10.1016/j.apjtb.2015.04.001

Matasyoh, J.C., Maiyo, Z.C., Ngure, R.M and Chepkorir, R. (2009). Chemical composition and antimicrobial activity of the essential oil of *Coriandrum sativum*. *Food Chemistry* **113**(2): 526–529. doi:https://doi.org/10.1016/j.foodchem.2008.07.097

Mohamed, M.A., Ibrahim, M.E and Wahba, H.E. (2018). Flavoring compounds of essential oil isolated from agriculture waste of coriander (*Coriandrum sativum*) plant. *Journal of Materials Environmental Science and Technology* **9**(1): 77–82.

Nurzynska-Wierdak, R. (2013). Essential oil composition of the coriander (*Coriandrum sativum* L.) herb depending on the development stage. *Acta Agrobotanica* **66**(1): 53–60.

Purseglove, J.W., Brown, E.G., Green, C.L and Robbins, S.R.J. (1981). In: *Spices* (**2**: 736–788). New York: Longman Scientific and Tecnial Co. and John Wiley and Sons, Inc.

Satyal, P and Setzer, W.N. (2020). Chemical compositions of commercial essential oils from *Coriandrum sativum* fruits and aerial parts. *Natural Product Communications* **15**(7): 1–12. doi:10.1177/1934578x20933067

Saxena, S.N., Swarup Meena, R., Vishal, M.K., John, S., Kumar Sharma, L., Mishra, B.K and Agarwal, D. (2022). Variation in essential oil constituents of coriander (*Coriandrum sativum* L.) germplasm across coriander growing regions in India. *Journal of Essential Oil Research* **34**(2): 173–180. doi:10.1080/10412905.2022.2036644

Shahwar, M.K., El-Ghorab, A.H., Anjum, F.M., Butt, M.S., Hussain, S and Nadeem, M. (2012). Characterization of coriander (*Coriandrum sativum* L.) seeds and leaves: Volatile and non volatile extracts. *International Journal of Food Properties* **15**(4): 736–747. doi:10.1080/10942912.2010.500068

Shu, C.-K and Lawrence, B.M. (1997). Reasons for the variation in composition of some commercial essential oils. In: *Spices* (**660**: 138–159): American Chemical Society.

Silva, F., Ferreira, S., Queiroz, J.A and Domingues, F.C. (2011). Coriander (*Coriandrum sativum* L.) essential oil: its antibacterial activity and mode of action evaluated by flow cytometry. *Journal of Medical Microbiology* **60**(10): 1479–1486. doi:https://doi.org/10.1099/jmm.0.034157-0

Sisay, M.A., Yaya, E.E and Mammo, W. (2022a). Essential oil and smoke components of *Carissa spinarum*. *Bulletin of the Chemical Society of Ethiopia* **36**(3): 641–649.

Sisay, M.A., Yaya, E.E and Mammo, W. (2022b). Essential oil and smoke components of *Carissa spinarum*. *Bulletin of the Chemical Society of Ethiopia* **36**(3): 641–649.

Tang, E.L.H., Rajarajeswaran, J., Fung, S.Y and Kanthimathi, M.S. (2013). Antioxidant activity of *Coriandrum sativum* and protection against DNA damage and cancer cell migration. *BMC Complementary and Alternative Medicine* **13**(1): 347–359. doi:10.1186/1472-6882-13-347