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Original Article

PHYTOCHEMICAL SCREENING, GAS CHROMATOGRAPHY-MASS SPECTROMETRY (GC-MS) ANALYSIS OF PHYTOCHEMICAL CONSTITUENTS AND ANTIBACTERIAL ACTIVITY OF *CORIANDRUM SATIVUM* (L) SEEDS

ARUN THANGAVEL*[1], SENTHILKUMAR BALAKRISHNAN[1, 2], VIJAYALAKSHMI[1], SENBAGAM DURAISAMY[3]

[1]Department of Biotechnology, Muthayammal College of Arts and Science, Rasipuram 637408, Tamil Nadu, India, [2]Department of Medical Microbiology, School of Medicine, Health and Medical Science College, Haramaya University, P. O. Box 235, Harar, Ethiopia, [3]Department of Microbiology, Vivekananda College of Arts and Science for Women, Tiruchengode 637205, Tamil Nadu, India
Email: arun1344@gmail.com

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ABSTRACT

Objective: The present study was carried out to evaluate the phytochemical screening, Gas Chromatography–Mass Spectrometry analysis of phyto-constituents and antibacterial activity of *Coriandrum sativum* (L.) seeds against the bacterial [Microbial Type Culture Collection (MTCC)] strains.

Methods: Methanol, ethanol, ethyl acetate, acetone and water extracts of *Coriandrum sativum* (L) seeds were prepared using the Soxhlet apparatus. The antibacterial activity of various extracts of *C. sativum* seeds were identified by disc diffusion method against bacterial strains. The bioactive components of methanol and acetone fraction of *C. sativum* seeds were evaluated by Gas Chromatography-Mass Spectrometry (GC-MS) analysis. The minimal inhibitory concentration (MIC) values were obtained by the well diffusion method between the ranges of 1000µg/ml to 7.8µg/ml.

Results: The preliminary phytochemical screening of various extracts of *C. sativum* revealed the presence of different Phyto-constituents. Methanol extract of *C. sativum* showed the maximum inhibition zone (20 mm) against *Staphylococcus aureus* and followed by *Klebsiella pneumoniae* (17 mm). The MIC values of methanol extract were found to be 62.5µg/ml against *Staphylococcus aureus*, *Proteus mirabilis* and *Bacillus subtilis*. In the GC-MS analysis of phyto-compounds, the methanol extracts showed fourteen bioactive fractions and eleven compounds from acetone extract.

Conclusion: The methanol and acetone extracts of *Coriandrum sativum* seeds showed maximum inhibitory activity against the tested bacterial strains.

Keywords: Phytochemical screening, Antibacterial activity, *Coriandrum sativum*, Gas chromatography-Mass spectrometry.

INTRODUCTION

Herbs and spices are the most important part of human diet. In addition to boosting flavor, these are also known for their preservative and medicinal value, which forms one of the oldest sciences. It is only in recent years that modern science has started paying attention to the properties of spices. Due to the side effects of conventional medicine, the use of natural products as an alternative way in healing of various diseases has been reported in the last few decades [1].

The World Health Organization (WHO) estimated that more than 4 billion inhabitants of the world rely mainly on traditional medicine for health care needs. A major part of traditional medicine involves the use of plant extracts and their derived active principles [2]. So, there is an urgent need for the isolation and identification of bioactive compounds from the medicinal plants [3].

India has rich in medicinal plants flora of more than 7500 species. Of these, 4635 species are used commercially on large scale. Over 50% of all modern clinical drugs are of natural product origin and plays an important role for the drug development in the pharmaceutical industry. Phytochemical compounds are found in plants that are not required for normal functioning of the body, but it has a beneficial effect on health and plays an active role in amelioration of diseases. This is due to increased awareness of the limited ability of synthetic pharmaceutical products to control major diseases and the need to discover new molecular structures from the plant kingdom [4].

Coriandrum sativum, (L.) is a hardy annual herb belongs to the natural order *Umbelliferae*. The popular name is derived from the generic, which comes from the ancient Greek Koris, a kind of bug, in allusion to the disagreeable odor of the foliage and other green parts. Coriander has been cultivated from ancient times in the native of Southern Europe and China. These leaves have a different taste from the seeds, with citrus overtones. In Indian and Central Asian recipes, coriander leaves are used in large quantities. The dry fruits are known as coriander seeds. The seeds have a lemony citrus flavor when crushed, due to terpenes linalool and pinene. The roasted coriander seeds are called as d hana dal used as snacks. It is the main ingredient of the two south Indian dishes includes *sambhar* and *rasam*. In Russia and Central Europe, coriander seed is an occasional ingredient in rye bread. The seeds are used in brewing of beer, particularly in Belgian wheat beers [5].

Phyto chemical constituents of this coriander seeds have been studied extensively and its analysis has revealed the presence of polyphenols (rutin, caffeic acid derivatives, ferulic acid, galic acid, and chlorogenic acid), flavonoids (quercetin and iso quercetin) and β-carotenoids [6]. The essential oil obtained from the seeds contains α and β-pinene, camphor, citronellol, coriandrol, *p*-cymene, geraniol, geranyl acetate, limonene, linalool, myrcene, α and β phellandrene and α and β-terpinene. A large number of water soluble compounds have been identified that includes monoterpenoid glycosides, monoterpenoid glucose sulfate and other glycosides [7].

The seeds are boiled with water and drunk as indigenous medicine for colds. The essential oil has been found to possess antimicrobial and antifungal properties. The seeds have an outstanding aphrodisiac effect by stimulating the sexual glands. Moreover, they stimulate fertility and help against dependency upon alcohol and against brain tumors. Coriander fruits are used as a stimulant for the gastrointestinal secretion, sedative and carminative. They ameliorate known as a bactericide, fungicide and anthelmintic effect [8].

Plants are an important source of potentially useful compounds for the development of new chemotherapeutic agents. *In vitro* evaluation of plants for antimicrobial property is the first step towards achieving the goal for developing eco-friendly management of infectious diseases of humans by search for new biomolecules of plant origin [9, 10]. Hence, the present research work was carried out to evaluate the phytochemical compounds of *Coriandrum sativum* seeds by Gas Chromatography-Mass Spectrometry analysis and its antibacterial activity against the selected bacterial strains.

MATERIALS AND METHODS

Collection of coriander seeds

The seeds of *Coriandrum sativum* Linn were collected from the surroundings of Rasipuram Taluk, Namakkal District, Tamil Nadu, India. The collected seeds were identified and confirmed by Dr. R. Selvaraj, Professor of Botany, Annamalai University, Tamil Nadu, where the voucher specimen was deposited.

Preparation of seed extracts

The collected seeds were washed thoroughly with running tap water and with distilled water to remove the dirt. Then the seeds were dried under shade for 7d. Then they were kept in the hot air oven for 4-6h at 50°C to remove excess moisture. The dried seeds were separately crushed gently to make powder form using mixer grinder. 30g of seed powder were extracted with 100 ml of each solvent (Methanol, Ethanol, Ethyl acetate, Acetone and Water) for 72h by Soxhlet extractor. Then, extracts with different solvents were evaporated using rotary evaporator. All the extracts were transferred into pre-weighed sample containers and stored for future purpose [11].

Preliminary phytochemical screening

The different solvents extracts of *Coriandrum sativum* (L) seeds were subjected to preliminary phytochemical screening using standard procedures for the detection of alkaloids, proteins, amino acids, anthraquinone glycosides, flavanoids, carbohydrates, saponins, coumarin, tannin and phenolic compounds [12, 13].

Gas chromatography-mass spectrometry (GC-MS) analysis

The GC-MS analysis of methanol and acetone extracts of *Coriandrum sativum* (L) seeds were performed using Thermo GC-Trace ultra version 5.0 gas chromatography interfaced to Thermo MS DSQ II mass spectrometer instrument employing the following conditions: DB5–MS Capillary standard non polar column (30 X 0.25 mm X 0.25 µm) and Helium gas was used as a carrier gas at a constant flow rate of 1 ml/min.

The oven temperature was kept at 70˚C and was programmed to reach 260 ˚C at a rate of 6˚C/min. Mass range was m/z 50–650. The total running time was completed in 43 minutes. The chromatogram obtained from Gas Chromatography was then analyzed in Mass Spectrometry to get the mass of all fractions. The identification of phyto components was achieved through retention time and mass spectrometry by comparing the mass spectra of unknown peaks with those stored in Wiley 9 GC-MS library.

Bacterial strains

The bacterial strains (*Staphylococcus aureus* MTCC-796, *Escherichia coli* MTCC-443, *Klebsiella pneumoniae* MTCC-109, *Salmonella typhi* MTCC-733, *Proteus mirabilis* MTCC-442 *Pseudomonas aeruginosa* MTCC-675 and *Bacillus subtilis* MTCC-441) were obtained from Microbial Type Culture Collection (MTCC), Chandigarh, India. The cells from lyophilized vials were transferred into the liquid nutrient broth medium, and then transferred into nutrient agar slants. Then, the slant cultures were preserved at 4 °C in the refrigerator.

Antibacterial activity of antibiotics

Antibacterial activity of the antibiotics was determined by Kirby-Bauer disc diffusion method using Muller-Hinton agar medium. The required quantity of Muller-Hinton agar medium (HIMEDIA, Mumbai, India) plates were prepared.

Then, ten hours old bacterial culture were swabbed uniformly on it and allowed to dry for about 5 min. The antibiotic discs [Amoxicillin (10µg/disc), Ampicillin (10µg/disc), Ciprofloxacin (30µg/disc), Erythromycin (15µg/disc), Gentamycin (30µg/disc), Polymixin B Sulphate (30µg/disc), Rifampicin (30µg/disc) and Tetracycline (30µg/disc)] were placed on the surface of the medium and the plates were incubated for 24h at 37 °C. After the incubation, the inhibition zones formed around the discs were measured with the transparent ruler in millimeter. All data on the antibacterial activity of antibiotics were the average of triplicate analyses.

Antibacterial activity of the seed extracts

Kirby-Bauer disc diffusion method was followed to determine the antibacterial activity against the bacterial strains [14]. The required quantity of Muller-Hinton agar medium (HIMEDIA, Mumbai, India) plates was prepared. Ten hours old bacterial culture were swabbed uniformly on it and allowed to dry for about 5 min.

The different concentrations of extracts (10 µl, 20 µl, 30 µl, 40 µl and 50 µl) were loaded on 5 mm sterile individual discs. The loaded discs were placed on the surface of the medium and the plates were incubated for 24h at 37°C. After the incubation, the inhibition zones formed around the discs were measured with the transparent ruler in millimeter. All data on antibacterial activity of seed extracts were the average of triplicate analyses.

Determination of minimal inhibitory concentration (MIC)

The MIC value of seed extracts were determined by the Micro tube dilution method. The different seed extracts ranges from a concentration of 1000µg/ml to 7.81µg/ml were diluted in the test tubes containing nutrient broth. Then, each tube was added with 0.1 ml of test organisms (inoculum containing 1-2 x 10^{-7} CFU/ml) and incubated for 18-24h at 37 °C. At the end of incubation, the tubes were examined for microbial growth by observing for turbidity. The tube containing the least concentration of extract showing no visible sign of growth was considered as the minimal inhibitory concentration value [15].

RESULTS AND DISCUSSION

The presence of antibacterial substances in higher plants is well established. Plants have provided a source of inspiration for novel drug compounds, as plant derived medicines have made the significant contribution towards human health. Successive isolation of chemical compounds from plant material is largely dependent on the type of solvent used in an extraction procedure. The present study was designed to evaluate the phytochemical screening, GC-MS analysis and antibacterial activity of various extracts of *Coriandrum sativum* (L) seeds.

In this assay, extracts were prepared using solvents like Methanol, Ethanol, Ethyl acetate, Acetone and Water. Out of five extracts, methanol and acetone extracts showed the better results for the presence of alkaloids, protein and amino acids, anthraquinone glycosides, flavonoids, tannins and phenolic compounds, saponins and coumarin (table 1). This is evidenced who supported the presence of phyto compounds from Coriander seeds [16].

The GC-MS analysis has been revealed the presence of fourteen bioactive compounds from the methanol extract (fig. 1) and eleven compounds in the acetone extracts (fig. 2). The bioactive compounds from the both extracts have been identified with their retention time, molecular formula, molecular weight and concentration (%). The most predominant compounds present in the methanol extract are Linalool (2.48%), Neryl acetate (2.62%), Anthracene-9,10-dicarbaldehyde-dioxime (0.61%), Methyl palmitate (0.77%), Palmitic acid (9.98%), 2,2,4,9,11,11-Hexamethyldodecane (0.56%), 6-Octadecenoic acid, methyl ester (12.2%), Ethyl 6-Chloro-5,8-dihydro-4-hydroxy-5,8-dioxo-2-naphthalenecarboxylate (36.29%), Nonacosane (0.97%), 6-Chloro-2-methyl-1,2-dihydroisoquinoline-3-carbaldehyde (0.6%), 5,7-Di-t-butyl-3-(4-Nitro benzylidene) benzo [b] furan-2(3H) (2.55%), n-Docosane (17.06%), 2-Methylpentanal (1.34%) and 2-(benzyloxy)-6,11-dimethoxy-4a-hydroxy-5-(phenyl sulfonyl)-1,2,3,4,4a,5,12,12a-octahydronaphthacene with 1.54% (table 2).

The bioactive compounds from acetone extract are Disulfide, methyl 2-methyl-1-(methyl thio) butyl (29.76%), (2, 3-13C_2) acetylene di-carboxylic acid (2.34%), Linalool (2.48%), Geranyl acetate (1.24%), 5-Bromo-1,4-dimethyl-1,4-epoxy-6-methoxy-1,4-dihydro naphthalene (0.43%), 2-Methyl-4-bromo acetophenone (6.3%), Methyl petroselinate (2.64%), Dinaphtho[2,1-b: 1',2'-d] pyran (47.93%), 11-acetoxy-9-chloro-8,9,10,11-tetrahydro noracronycin-acetate (1.65%), 9-Octadecenoic acid (0.48%) and 3-Ethyl-5-(2'-ethylbutyl) octadecane with 0.61% (table 3). The similar phytochemical study was obtained by Pathak Nimish L and Kasture Sanjay (2011) on the phyto constituents of *Coriandrum Sativum*

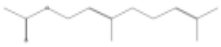
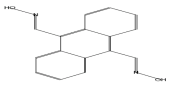
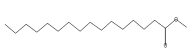
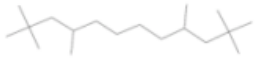
belongs to the family Umbelliferae. The different parts of this plant contain monoterpenes, a-pinene, limpnene, r-terpinene, p-cymene, borneal, citronellol, camphor, geraniol, coriandrin, dihydroco riandrin, coriandronsa-e, flavonoids and essential oils. Various parts of this plant such as seed, leaves, flower and fruit possess diuretic, antioxidant activity, anti-diabetic anti-convulsant activity, sedative hypnotic activity, anti-microbial activity, anti mutagenic, anthelmintic activity [17].

Table 1: Preliminary phytochemical screening of *Coriandrum sativum* (L) seeds

Constituents/Tests	Methanol	Ethanol	Ethyl acetate	Acetone	Water
Alkaloids					
Mayer's Test	++	+	+	++	+
Dragendorff's Test	++	+	+	++	+
Hager's Test	++	+	+	++	+
Wager's Test	++	+	+	++	+
Protein and Amino acid					
Millon's Test	++	+	+	++	+
Ninhydrin Test	++	+	+	++	+
Biuret Test	++	+	+	++	+
Anthraquinone glycosides					
Borntrager's Test	++	-	-	++	-
Flavonoids					
Shinoda's Test	++	+	+	++	+
Tannin & Phenolic Compounds					
Ferric Chloride Test	++	+	+	++	+
Lead Acetate Test	++	+	+	++	+
Gelatin Test	++	+	+	++	+
Carbohydrates					
Molisch's Test	-	-	-	-	+
Barfoed's Test	-	-	-	-	+
Fehling's Test	-	-	-	-	+
Saponins					
Frothing Test	++	+	+	++	+
Coumarin					
10% NaOH Solution	++	+	+	+	+

Note: (++) = Moderately present; (+) = Present; (-) = absent

Table 2: Gas chromatography-mass spectrometry (GC-MS) analyses of methanol extract of *Coriandrum sativum* (L) seeds

Retention time (min)	Name of the compound	Molecular formula	Molecular weight	Area (%)	Compound structure
12.76	Linalool	$C_{10}H_{18}O$	154	2.48	
18.65	Neryl acetate	$C_{12}H_{20}O_2$	196	2.62	
27.51	Anthracene-9,10-dicarbaldehyde-dioxime	$C_{16}H_{12}N_2O_2$	264	0.61	
31.28	Methyl palmitate	$C_{17}H_{34}O_2$	270	0.77	
32.18	Palmitic acid	$C_{16}H_{32}O_2$	256	9.98	
34.48	2,2,4,9,11,11-Hexamethyldodecane	$C_{18}H_{38}$	254	0.56	
35.17	6-Octadecenoic acid, methyl ester	$C_{19}H_{36}O_2$	296	12.20	
36.11	Ethyl 6-Chloro-5,8-dihydro-4-hydroxy-5,8-dioxo-2-naphthalenecarboxylate	$C_{13}H_9ClO_5$	280	36.29	
42.24	Nonacosane	$C_{29}H_{60}$	408	0.97	

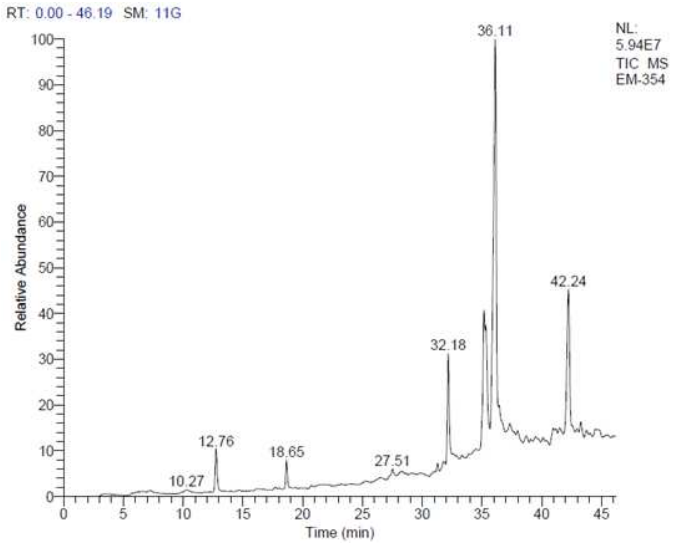
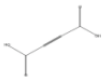
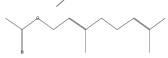
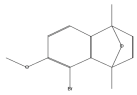
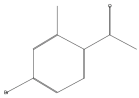
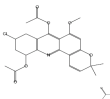
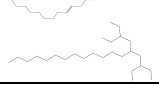


Fig. 1: GC-MS Chromatogram of methanol extract of *Coriandrum sativum* (L) seeds

Table 3: Gas chromatography-mass spectrometry (GC-MS) analyses of acetone extract of *Coriandrum sativum* (L) seeds

Retention time (min)	Name of the compound	Molecular formula	Molecular weight	Area (%)	Compound structure
5.22	Disulfide, methyl 2-methyl-1-(methyl thio) butyl	$C_7H_{16}S_3$	196	29.76	
9.99	(2,3-13C_2)acetylene-di carboxylic acid	$C_4H_2O_4$	112	2.34	
12.47	Linalool	$C_{10}H_{18}O$	154	2.48	
18.48	Geranyl acetate	$C_{12}H_{20}O_2$	196	1.24	
31.63	5-Bromo-1,4-dimethyl-1,4-epoxy-6-methoxy-1,4-dihydro naphthalene	$C_{13}H_{13}BrO_3$	280	0.43	
32.24	2-Methyl-4-bromoacetophenone	C_9H_9BrO	212	6.30	
35.03	Methyl petroselinate	$C_{19}H_{36}O_2$	296	2.64	
36.56	Dinaphtho [2,1-b: 1',2'-d] pyran	$C_{21}H_{14}O$	283	47.93	
41.18	11-acetoxy-9-chloro-8,9,10,11-tetrahydronoracronycin-acetate	$C_{23}H_{24}ClNO_6$	445	1.65	
42.43	9-Octadecenoic acid	$C_{18}H_{34}O_2$	282	0.48	
44.85	3-Ethyl-5-(2'-ethylbutyl) octadecane	$C_{26}H_{54}$	366	0.61	

The antibiotic sensitivity pattern was performed by disc diffusion method using standard antibiotic discs against the bacterial (*Staphylococcus aureus* MTCC-796, *Escherichia coli* MTCC-443, *Klebsiella pneumoniae* MTCC-109, *Salmonella typhi* MTCC-733, *Proteus mirabilis* MTCC-442 *Pseudomonas aeruginosa* MTCC-675 and *Bacillus subtilis* MTCC-441) strains on Muller Hinton agar medium. The zone of inhibition was measured and the results were recorded and tabulated (table 4). The results of antibacterial activity by antibiotics were used as control against the various solvent extracts of *Coriandrum sativum* seeds.

The tested antibiotics showed more activity against *Staphylococcus aureus* and followed by *Salmonella typhi, Proteus mirabilis, Bacillus subtilis, Pseudomonas aeruginosa, Klebsiella pneumoniae* and *Escherichia coli*.

Table 4: Antibacterial activity of antibiotics against bacterial (MTCC) strains

Name and concentration of the antibiotics	Zone of Inhibition (in mm)						
	Staphylococcus aureus	*Escherichia coli*	*Klebsiella pneumoniae*	*Salmonella typhi*	*Proteus mirabilis*	*Pseudomonas aeruginosa*	*Bacillus subtilis*
Amoxicillin (10µg/disc)	25 mm	-	-	11 mm	10 mm	-	10 mm
Ampicillin (10µg/disc)	21 mm	-	-	12 mm	24 mm	-	13 mm
Ciprofloxacin (30µg/disc)	30 mm	-	23 mm	28 mm	29 mm	26 mm	21 mm
Erythromycin (15µg/disc)	28 mm	-	12 mm	27 mm	23 mm	10 mm	25 mm
Gentamycin (30µg/disc)	23 mm	11 mm	16 mm	19 mm	17 mm	17 mm	18 mm
Polymixin B sulphate (30µg/disc)	13 mm	11 mm	10 mm	11 mm	12 mm	11 mm	10 mm
Rifampicin (30µg/disc)	31 mm	14 mm	11 mm	16 mm	14 mm	12 mm	14 mm
Tetracycline (30µg/disc)	29 mm	11 mm	18 mm	21 mm	20 mm	14 mm	17 mm

[Note: Zone of inhibition is mean of triplicate analyses; the inhibition zone includes the disc size of 5 mm]

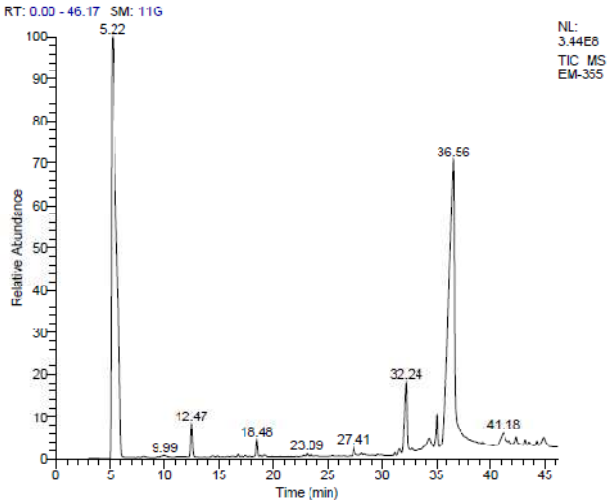


Fig. 2: GC-MS chromatogram of acetone extract of *Coriandrum sativum* (L). Seeds

The antibacterial activity of various solvent extracts of *Coriandrum sativum* (L) seeds against the bacterial (MTCC) strains (*Staphylococcus aureus* MTCC-796, *Escherichia coli* MTCC-443, *Klebsiella pneumoniae* MTCC-109, *Salmonella typhi* MTCC-733, *Proteus mirabilis* MTCC-442 *Pseudomonas aeruginosa* MTCC-675 and *Bacillus subtilis* MTCC-441) have been performed with different concentrations using agar disc diffusion method. Among the five extracts, the higher inhibitory activity was observed in methanol and acetone extracts and the moderate activity was observed in ethanol and water extracts, and the lesser inhibitory activity was observed in ethyl acetate (table 5).

The report of antibacterial activity of seed extract was compared to the activity of selected antibiotic activity. Here, methanol and acetone extracts showed high inhibitory zone against the *Staphylococcus aureus*. A similar study was obtained by Amel O. Bakhiet, and Sabna D. Mohammed concluded that the preliminary investigation of the antibacterial activity against four pathogenic organisms *Staphylococcus aureus, Escherichia coli, Pseudomonas aeruginosa* and *Salmonella typhi* from the extract of *Coriandrum sativum*. The detailed *in vitro* study utilizing the characterized active principles of this plant is necessary for assessing these antibacterial constituents [18].

Table 5: Antibacterial activity of *Coriandrum sativum* (L) seeds

Bacterial strains	Extract concentration (µg/disc)				
	100	200	300	400	500
Staphylococcus aureus	Methanol	10 mm	14 mm	15 mm	20 mm
Escherichia coli	-	-	7 mm	9 mm	12 mm
Klebsiella pneumoniae	-	9 mm	11 mm	14 mm	17 mm
Salmonella typhi	-	7 mm	10 mm	13 mm	14 mm
Proteus mirabilis	-	7 mm	8 mm	11 mm	12 mm
Pseudomonas aeruginosa	-	-	7 mm	9 mm	10 mm
Bacillus subtilis	-	-	8 mm	9 mm	12 mm
	Ethanol				
Staphylococcus aureus	-	-	7 mm	11 mm	12 mm
Escherichia coli	-	-	-	9 mm	11 mm
Klebsiella pneumoniae	-	-	-	8 mm	10 mm
Salmonella typhi	-	-	-	7 mm	9 mm
Proteus mirabilis	-	-	-	8 mm	11 mm
Pseudomonas aeruginosa	-	-	-	-	10 mm
Bacillus subtilis	-	-	-	7 mm	10 mm
	Ethyl acetate				
Staphylococcus aureus	-	-	-	8 mm	10 mm
Escherichia coli	-	-	-	-	9 mm
Klebsiella pneumoniae	-	-	-	8 mm	11 mm
Salmonella typhi	-	-	-	-	9 mm
Proteus mirabilis	-	-	-	7 mm	10 mm
Pseudomonas aeruginosa	-	-	-	7 mm	8 mm
Bacillus subtilis	-	-	-	-	9 mm
	Acetone				
Staphylococcus aureus	-	7 mm	10 mm	13 mm	16 mm
Escherichia coli	-	-	9 mm	11 mm	14 mm
Klebsiella pneumoniae	-	-	-	8 mm	10 mm
Salmonella typhi	-	-	7 mm	10 mm	13 mm

Proteus mirabilis	-	8 mm	10 mm	13 mm	15 mm
Pseudomonas aeruginosa	-	-	7 mm	10 mm	11 mm
Bacillus subtilis	-	-	8 mm	11 mm	14 mm
	Water				
Staphylococcus aureus	-	-	10 mm	12 mm	13 mm
Escherichia coli	-	-	-	10 mm	11 mm
Klebsiella pneumoniae	-	-	-	-	10 mm
Salmonella typhi	-	-	-	9 mm	12 mm
Proteus mirabilis	-	-	-	11 mm	13 mm
Pseudomonas aeruginosa	-	-	-	-	10 mm
Bacillus subtilis	-	-	-	9 mm	11 mm

[Note: Zone of inhibition is mean of triplicate analyses; the inhibition zone includes the disc size of 5 mm]

The minimal inhibitory concentration (MIC) values of various extracts of *Coriandrum sativum* (L) seeds have been observed (table 6). Methanol extract inhibited the growth of *S. aureus, P. mirabilis,* and *B. subtilis* at 62.5µg/ml and for *E. coli, K. pneumoniae, S. typhi* and *P. aeruginosa* at 125µg/ml. Acetone extract showed the inhibition against *S. aureus, E. coli* at 62.5µg/ml and for *K. pneumoniae, S. typhi, P. mirabilis, P. aeruginosa* and *B. subtilis* at 125µg/ml. Ethanol extract showed the inhibition for *E. coli, K. pneumoniae*, and *S. typhi* at 125µg/ml and for *S. aureus, P. mirabilis, P. aeruginosa* and *B. subtilis* at 250µg/ml. Water extract inhibited the growth of *E. coli, P. aeruginosa* and *B. subtilis* at 125µg/ml and for *S. aureus, K. pneumoniae*, *S. typhi* and *P. mirabilis* at 250µg/ml. Ethyl acetate inhibited the growth of all the tested bacterial strains at 250µg/ml. This is also evidenced by Arun T, *et al.*, reported that the same ranges of minimal inhibitory concentration (MIC) values from 1000µg/ml to 1.95µg/ml. The maximum MIC values of both the studies are similar in the range between 62.5µg/ml to 250µg/ml for all the tested bacterial strains [19].

Table 6: Minimal inhibitory concentration values of *Coriandrum sativum* (L) seeds

Experimental Flora	Name of the organisms	Name of the solvents	Extract Concentration (µg/ml)							
			7.8	15.6	31.2	62.5	125	250	500	1000
Coriandrum sativum (L).	*Staphylococcus aureus*	Methanol	-	-	-	β	+	+	+	+
		Ethanol	-	-	-	-	-	β	+	+
		Ethyl Acetate	-	-	-	-	-	β	+	+
		Acetone	-	-	-	β	+	+	+	+
		Water	-	-	-	-	-	β	+	+
	Escherichia coli	Methanol	-	-	-	-	β	+	+	+
		Ethanol	-	-	-	-	β	+	+	+
		Ethyl Acetate	-	-	-	-	-	β	+	+
		Acetone	-	-	-	β	+	+	+	+
		Water	-	-	-	-	β	+	+	+
	Klebsiella pneumoniae	Methanol	-	-	-	-	β	+	+	+
		Ethanol	-	-	-	-	β	+	+	+
		Ethyl Acetate	-	-	-	-	-	β	+	+
		Acetone	-	-	-	-	β	+	+	+
		Water	-	-	-	-	-	β	+	+
	Salmonella typhi	Methanol	-	-	-	-	β	+	+	+
		Ethanol	-	-	-	-	β	+	+	+
		Ethyl Acetate	-	-	-	-	-	β	+	+
		Acetone	-	-	-	-	β	+	+	+
		Water	-	-	-	-	-	β	+	+
	Proteus mirabilis	Methanol	-	-	-	β	+	+	+	+
		Ethanol	-	-	-	-	-	β	+	+
		Ethyl Acetate	-	-	-	-	-	β	+	+
		Acetone	-	-	-	-	β	+	+	+
		Water	-	-	-	-	-	β	+	+
	Pseudomonas aeruginosa	Methanol	-	-	-	-	β	+	+	+
		Ethanol	-	-	-	-	-	β	+	+
		Ethyl Acetate	-	-	-	-	-	β	+	+
		Acetone	-	-	-	-	β	+	+	+
		Water	-	-	-	-	β	+	+	+
	Bacillus subtilis	Methanol	-	-	-	β	+	+	+	+
		Ethanol	-	-	-	-	-	β	+	+
		Ethyl Acetate	-	-	-	-	-	β	+	+
		Acetone	-	-	-	-	β	+	+	+
		Water	-	-	-	-	β	+	+	+

Note: -= Resistance (Bacterial Growth or Turbidity), += Concentration showing no turbidity (Inhibition on bacterial growth), β = MIC Value

CONCLUSION

The present study suggested that the methanol and acetone extracts of *Coriandrum sativum* (L) seeds possesses the broad spectrum antibacterial activity against the tested bacterial strains. This study proposed that the plant drugs can be as effective as the modern medicine to inhibit the growth of pathogenic microorganisms and overwhelming the antibiotic resistance. Further studies should be needed with this seeds for the structural elucidation of bioactive compounds to formulate a new drug for regular use.

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CONFLICT OF INTERESTS

Declared None

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