PHYTOCHEMICAL AND BIOLOGICAL INVESTIGATIONS OF CORIANDRUM SATIVUM (CILANTRO) LEAVES

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Abstract

The present study was carried out Coriandrum sativum has Antioxidant potential; Cytotoxicity and Antimicrobial potential were also assessed. In DPPH (1,1-diphenyl-2-picrylhydrazyl) radical scavenging methods, a dose dependent scavenging of DPPH radical was observed with all three extractions; ethanolic extraction (ETCS), water extraction (AQCS) and petroleum ether extraction (PECS) of the plant with IC50 values of 380.56 μg/ml, 591.81 μg/ml and 751.05 μg/ml respectively. However, in reducing power and CUPRAC assays, the extractions were found to have weak to moderate Cu2+ ion reducing capacity compared to ascorbic acid. Moreover, total phenolic content of ethanolic extraction (ETCS), water extraction (AQCS) and petroleum ether extraction (PECS) equivalent to gallic acid were found 63.22 ± 3.59 mg/g, 62.86 ± 12.81 mg/g and 54.17 ± 6.15 mg/g respectively indicating presence of phenolic content. The total flavonoid contents equivalent to quercetin were found highest in PECS extract 42.76 ± 3.25 mg/g, then 31.84 ± 1.44 mg/g and 22.09 ± 0.43 mg/g ethanolic extraction (ETCS) and water extraction (AQCS) respectively. Cytotoxicity test through Brine shrimp method showed moderate to less toxicity compared to standard (Vincristine sulphate).

Key words: Coriandrum sativum, Antioxidant, Cytotoxicity, Antimicrobial, Cilantro

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INTRODUCTION

The plant Coriandrum sativum, belonging to the family Apiaceae, locally known as ‘Dhania’, is a medicinal herb and worldwide has a reputation for its various medicinal properties such as antioxidant, anti-inflammatory, chelating agent (thus acting on metal detoxification) and so on. Thus the present study was designed to investigate Phytochemical and Biological properties of fresh Coriander leaf (Cilantro). The three different solvent extractions by ethanol, petroleum ether and water of fresh Coriandrum sativum leaf were used as sample extract.

Experiments were antioxidant activity including DPPH radical scavenging assay and Fe^{3+} reducing power of the plant extracts (Oyaizu., 1986)[1], nitric oxide scavenging assay (Govindarajan et al., 2003)[2], (Oyaizu., 1986)[1], total phenolic contents (Yu et al., 2002)[3], total flavonoid contents (Kumaran and Karunakaran (2007)[4], brine shrimp lethality bioassay (Meyer et al., 1982)[5] and in vitro antimicrobial activity of crude extracts by well diffusion method.

MATERIALS AND METHOD

PLANT COLLECTION AND IDENTIFICATION

The whole Plant samples of Coriandrum sativum was collected from Amin Bazar, Dhaka in September, 2010. The whole plant with leaves, stems and roots was collected and identified by experts in Bangladesh National Herbarium, Mirpur, Dhaka, where a Voucher specimen has been deposited for future reference. In the local area this plant is known as ‘Dhaniapata’.

The accession number is: Coriandrum sativum (L.)- 35626. The specimen samples are kept in the Bangladesh National Herbarium and Laboratory of Natural Products Research in the department of Pharmacy, Jahangirnagar University, Bangladesh.

EXTRACT PREPARATION

The plant was thoroughly washed with water. Roots were discarded and spread in thin layers in trays and finally placed into a dryer having a good air circulating system and a temperature-controlling thermostat (Ghani, 2003)[6]. Then the aerial parts (whole part without root) were dried in hot air oven at 60°C for 3 days. The dried aerial parts were ground to coarse powder.
with a mechanical grinder (Grinding Mill). Then the powdered sample was kept in clean closed glass containers till extraction. The weight of the total dry powder was 800 gm. Total amount of dried powder of sample was 800 gm. Extraction was performed with three different solvents- Ethanol, Petroleum ether and Water. From this total amount of powder, 300 gm was used for Ethanolic extraction; 300 gm was used for Petroleum Ether extraction and remaining 200 gm for water extraction. The dried powder of sample (C. sativum leaves) were coarsely powdered by a milling machine and extracted exhaustively with a 1200ml of Ethanol in a Soxhlet apparatus for 24 hours for each attempt of extraction of the total 300 gm powder. When the powder became exhausted of its chemical constituents as evident from cycles of colorless liquid siphoning in the Soxhlet apparatus, extraction was considered to be complete. After the completion of extraction process, the liquid was filtered using a sterilized cotton filter. Then solvent was completely removed by heating in a water bath (using steam through water bath) and obtained 10 gm dried crude extract. Remaining dried sample powder was divided into 300 gm and 200 gm and extracted by petroleum ether and water respectively. And yield was 9 gm and 7 gm. Extraction was performed at room temperature and preserved in a Petridish in refrigerator.

PHYTOCHEMICAL SCREENING TEST

Preliminary phytochemical screening of the three different crude extracts of the plant of Coriandrum sativum was done by various reagents such as Molishch’s reagents (10% naphthol in alcohol) for carbohydrate test, Dilute sulphuric acid and NaOH solution for glycoside test, Aqueous sodium hydroxide solution for glycoside test, Fehling’s solution for glycoside test, 10% Ammonia solution for anthraquinone glycoside test, Mayer’s reagent (potassiomercuric iodide solution), Wagner’s reagent (solution of I in KI), Hager’s reagent (Saturated solution of picric acid), Dragendroff’s reagent (Bismuth sub nitrate and acetic acid solution) for alkaloid tests, Conc. Hydrocloric acid for flavanoid test, Conc. Sulphuric acid for steroid test, FeCl₃ (5%) for tannin test. Alcohol, chloroform and distilled water are used as solvent.

ANTIOXIDANT ACTIVITY TEST BY DPPH RADICAL SCAVENGING ASSAY

DPPH (1, 1-diphenyl, 2-picrylhydrazyl, Sigma USA) free radical scavenging activity of different solvent extracts of plant parts were determined following the method described by Oyaizu,
In brief, 3 mL of a 0.004% methanolic solution of DPPH was added in tube containing 100µL of either extract or standard (ascorbic acid, SD Fine chem. Ltd., Biosar, India), kept in dark for 30min for the to take place, then absorbance taken at 517 nm using a spectrophotometer (Shimadzu UV PC-1600) against a blank (methanol). Percent of activity was calculated by –

% Scavenging = \{(A_0 – A_1)/ A_0\} X 100

Where, A_0 is the absorbance of the control, and

A_1 is the absorbance of the samples/standard

ANTIOXIDANT ACTIVITY TEST BY NITRIC OXIDE (NO) RADICAL SCAVENGING ASSAY

Nitric oxide scavenging assay of the plant extracts was determined following the method of Govindarajan et al. 2003 with slight modification. Briefly, 1.0 mL of Sodium nitroprusside (5 mM) solution was added into the test tube containing 4.0 mL of either extract or standard (ascorbic acid) and kept in incubation at 30 0C for 2 hours, followed by withdrawing 2.0 mL solution from the mixture and mixed with 1.2 mL of Griess reagent ((1% Sulfanilamide, 0.1% naphthylethlenediamine-dihydrochloride in 2% H₃PO₄, Roch-light Ltd., Suffolk, England) and absorbance reading at 550 nm.

ANTIOXIDANT ACTIVITY TEST BY FE³⁺ REDUCING POWER

The reducing capacity can also be termed as an antioxidant activity of any compound. Reduction of Ferric Chloride (FeCl₃, Fine Chemicals, India) to Fe²⁺ can be monitored by measuring the color formation of Perl’s Prussian blue at 700 nm (Oyaizu., 1986). Briefly, 2.0 mL each of extract or standard (ascorbic acid) in different concentrations were taken in test tubes, then 2.5 mL of potassium ferricyanide [K₃Fe(CN)₆] 1% solution was added. 2.5 mL of trichloro acetic acid (10%) were added, preceded by 10min incubation at 50 0C. After centrifuging the mixture at 3000 rpm for 10 minutes, 2.5ml aliquot was withdrawn and mixed with 2.5mL sterile water and 0.5 mL of ferric chloride (0.1%) solution and finally the absorbance taken at 700nm.
TOTAL PHENOL CONTENT DETERMINATION

Total phenolic contents of the plant fractions were determined according to the method described by Yu et al., (2002) [3]. Test tube containing 1.0 mL each of extracts (200 µg/mL) or standard (gallic acid, Sigma Chemicals, USA) were mixed with 5 ml of Folin–ciocalteu (Diluted 10 fold, Merck, Germany) reagent and 4mL sodium carbonates solution and the mixture was incubated at 20 °C for 1 hr followed by absorbance taking at 765 nm.

DETERMINATION OF TOTAL FLAVONOID CONTENT

Total flavonoid contents of the plant fractions were determined according to the method described by Kumaran et al., (2007) [4]. Briefly, 1.0 mL of extracts (200 µg/mL) or standard (quercetin, Sigma Chemicals, USA) were mixed with 3 mL of methanol, 200 µL of 10% aluminum chloride, 200 µL of 1 M potassium acetate and 5.6 mL of distilled water. Then 30min incubated at room temperature and absorbance taken at415 nm. Total flavonoid contents of the fractions were expressed as quercetin equivalents (QE) after calculation using the following equation:

\[ C = \left( \frac{c \times V}{m} \right) \]

Where: \( C \) = total flavonoid contents, mg/g plant extract in QE, \( c \) = concentration of quercetin obtained from calibration curve (mg/ml), \( V \) = the volume of the sample solution (ml), \( m \) = weight of the sample (g).

BRINE SHRIMP LETHALITY BIOASSAY

Cytotoxicity of the plant extractives was determined by Brine Shrimp lethality bioassay described by Meyer et al., (1982) [5]. Nauplii were collected from brine shrimp eggs after hatching in simulated seawater (38g/L). Ten nauplii are taken in vials containing 5 mL of simulated seawater treated with extracts dissolved in DMSO. The median lethal concentration, \( LC_{50} \) values of the test samples were calculated after 24 hours, and obtained by a plot of percentage of dead Shrimps against the logarithm of the sample concentration using Microsoft Excel. Vincristine sulphate was utilized as a reference cytotoxic molecule (Meyer et al., 1982) [6].
ANTIMICROBIAL ACTIVITY TEST BY WELL DIFFUSION METHOD

Solutions of known concentration (μg/ml) of the test samples are made by dissolving measured amount of the samples in calculated volume of solvents. The plates are prepared by incubation organism and then make wells where the sample solution can be poured. These plates are then kept at low temperature (4 °C) for 24 hours to allow maximum diffusion. During this time the diffusion occurs according to the physical law that controls the diffusion of molecules through agar gel. As a result there is a gradual change of test materials concentration in the media surrounding the discs. The plates are then incubated at 37 °C for 24 hours to allow maximum growth of the organisms. If the test materials have any antimicrobial activity, it will inhibit the growth of the microorganisms and a clear, distinct zone of inhibition will be visualized surrounding the medium. The antimicrobial activity of the test agent is determined by measuring the diameter of zone of inhibition expressed in millimeter. The experiment is carried out more than once and the mean of the readings is required. In the present study the crude ethanolic, petrol ether and water extracts of *Coriandrum sativum* were tested for antimicrobial activity by well diffusion method.

RESULTS

Preliminary Phytochemical Group Tests

Preliminary phytochemical screening of the 3 different crude extracts of the plant of *Coriandrum sativum* revealed the presence of alkaloid, carbohydrate, glycoside, flavonoid, steroid and tannins (Table 1).

Table 1: Result of chemical group test of the crude ethanolic, Petroleum ether and water extract of the *Coriandrum sativum* leaves (Cilantro)

<table>
<thead>
<tr>
<th>Test for</th>
<th>Experimental extraction of <em>C. sativum</em> (L.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alkaloids</td>
<td>+</td>
</tr>
<tr>
<td>Carbohydrate</td>
<td>+</td>
</tr>
<tr>
<td>Glycosides</td>
<td>+</td>
</tr>
<tr>
<td>Saponin</td>
<td>-</td>
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</table>
BIOLOGICAL INVESTIGATION OF CORIANDRUM SATIVUM

Tests For Antioxidant Activity

In DPPH radical scavenging methods, a dose dependent scavenging of DPPH radical was observed with all three extractions; scavenging of DPPH radical was displayed by ethanolic extraction (ETCS), water extraction (AQCS) and petroleum ether extraction (PECS) of the plant with IC50 values of 380.56 μg/ml, 591.81 μg/ml and 751.05 μg/ml respectively (Figure:1). However, in reducing power and CUPRAC assays, the extractions were found to have weak to moderate Cu²⁺ ion reducing capacity compared to ascorbic acid (Fig: 2; Fig: 3). Moreover, total phenolic content of ethanolic extraction (ETCS), water extraction (AQCS) and petroleum ether extraction (PECS) equivalent to gallic acid were found 63.22 ± 3.59 mg/g, 62.86 ± 12.81 mg/g and 54.17 ± 6.15 mg/g respectively indicating presence of phenolic content (Table: 2). The total flavonoid contents equivalent to quercetin were found highest in PECS extract 42.76 ± 3.25 mg/g, then 31.84 ± 1.44 mg/g and 22.09 ± 0.43 mg/g ethanolic extraction (ETCS) and water extraction (AQCS) respectively (Table: 3).

Figure 1: DPPH radical scavenging activity of the different extraction of C. Sativum Leaves
Figure 2: Reducing power of the different extracts of *Coriandrum Sativum* Leaf (Cilantro)

Figure 3: Cupric Reducing Antioxidant Capacity (CUPRAC)

Values are the mean of duplicate experiments and represented as mean ±SD. ETCS= Ethanolic extraction, PECS= Pet. ether extraction, AQCS= Aqueous extraction of the different extraction of *Coriandrum Sativum* Leaf (Cilantro)

Table 2: Total phenol content within three extracts of Coriandrum Sativum Leaf (Cilantro)

<table>
<thead>
<tr>
<th>Sample</th>
<th>Total Phenol content (mg/g, gallic acid equivalents)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ethanolic extract. (ETCS)</td>
<td>63.22 ± 3.59</td>
</tr>
<tr>
<td>Aqueous extract. (AQCS)</td>
<td>62.86 ± 12.81</td>
</tr>
<tr>
<td>Petroleum ether extract (PECS)</td>
<td>54.17 ± 6.15</td>
</tr>
</tbody>
</table>

* Values are the mean of duplicate experiments and represented as mean ± SD
Table 3: Total flavonoid contents of the different extracts of Coriandrum Sativum Leaf (Cilantro)

<table>
<thead>
<tr>
<th>Sample</th>
<th>Total Flavonoid content (mg/g, Gallic acid equivalents)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Petroleum ether Extract (PECS)</td>
<td>42.76 ± 3.25</td>
</tr>
<tr>
<td>Ethanol extract (ETCS)</td>
<td>31.84 ± 1.44</td>
</tr>
<tr>
<td>Aqueous extract (AQCS)</td>
<td>22.09 ± 0.43</td>
</tr>
</tbody>
</table>

* Values are the mean of duplicate experiments and represented as mean ± SD

BRINE SHRIMP LETHALITY BIOASSAY FOR CYTOTOXICITY ACTIVITY

In this study, three extractions; ethanolic extract, pet. Ether extract and aqueous extract were found to be less toxic to Brine Shrimp nauplii, with LC$_{50}$ of 133.0047 µg/ml, 77.007 µg/ml and 163.6114 µg/ml respectively while the LC50 of the reference anticancer drug vincristine sulphate was 0.66µg/ ml. All fractions produced concentration dependent increment in percent mortality of Brine Shrimp nauplii indicating the presence of cytotoxic principles in these extractives.

Vincristine sulphate > Petroleum ether fraction (PECS) > Ethanolic extraction (ETCS) > Aqueous extraction (AQCS)

Table 4: Brine Shrimp lethality bioassay of the different extraction of Coriandrum Sativum Leaf (Cilantro)

<table>
<thead>
<tr>
<th>Test solution</th>
<th>Conc. (µg/ml)</th>
<th>Log conc.</th>
<th>% mortality</th>
<th>LC$_{50}$ (µg/ml)</th>
</tr>
</thead>
<tbody>
<tr>
<td>ETCS</td>
<td>1</td>
<td>0</td>
<td>30</td>
<td></td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>0.699</td>
<td>40</td>
<td></td>
</tr>
<tr>
<td></td>
<td>10</td>
<td>1</td>
<td>20</td>
<td></td>
</tr>
<tr>
<td></td>
<td>20</td>
<td>1.301</td>
<td>30</td>
<td>133.0047</td>
</tr>
<tr>
<td></td>
<td>50</td>
<td>1.699</td>
<td>50</td>
<td></td>
</tr>
<tr>
<td></td>
<td>100</td>
<td>2</td>
<td>40</td>
<td></td>
</tr>
<tr>
<td></td>
<td>200</td>
<td>2.301</td>
<td>50</td>
<td></td>
</tr>
<tr>
<td></td>
<td>500</td>
<td>2.699</td>
<td>70</td>
<td></td>
</tr>
<tr>
<td>PECS</td>
<td>1</td>
<td>0</td>
<td>10</td>
<td>77.0076</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>0.699</td>
<td>10</td>
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<td></td>
<td>10</td>
<td>1</td>
<td>30</td>
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<tr>
<td></td>
<td>20</td>
<td>1.301</td>
<td>20</td>
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</tr>
</tbody>
</table>
IN VITRO ANTIMICROBIAL SCREENING OF CORIANDRUM SATIVUM

The diameter of zones of inhibition produced by three different extracts of Coriandrum sativum: ETCS extract, PECS extract and AQCS extract is measured in mm. Extractions of *Coriandrum sativum* leaf (Cilantro) mainly showed result against *Staphylococcus aureus*, *Pseudomonas aeruginosa* and *Salmonella typhi*.

**Table 5**: The zone of inhibition produced by the different extraction of Coriandrum Sativum Leaf (Cilantro) against some gram positive and gram negative bacteria

<table>
<thead>
<tr>
<th>Test microorganisms</th>
<th>Diameter of zone of inhibition (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>ETCS</td>
</tr>
<tr>
<td><strong>Gram positive bacteria</strong></td>
<td></td>
</tr>
<tr>
<td><em>Bacillus subtilis</em></td>
<td>Insignificant</td>
</tr>
<tr>
<td><em>Staphylococcus aureus</em></td>
<td>8.5</td>
</tr>
<tr>
<td><strong>Gram negative bacteria</strong></td>
<td></td>
</tr>
<tr>
<td><em>Escherichia coli</em></td>
<td>...</td>
</tr>
<tr>
<td><em>Pseudomonas aeruginosa</em></td>
<td>...</td>
</tr>
<tr>
<td><em>Salmonella typhi</em></td>
<td>14.5</td>
</tr>
<tr>
<td><em>Klebsiella pneumoniae</em></td>
<td>...</td>
</tr>
</tbody>
</table>
ETCS= Ethanolic extraction, PECS= Pet. ether extraction, AQCS= Aqueous extraction of the different extraction of Coriandrum Sativum Leaf (Cilantro); DMSO= Dimethyl sulfoxide (used as solvent) and DW= Distilled water (used as solvent).

DISCUSSION

Preliminary phytochemical screening of three different extracts of the Coriandrum sativum leaf revealed the presence of various bioactive components like Carbohydrate, glycoside, flavonoid, alkaloids, tanins and steroids (Table 1). Most of the plant derived drugs of our present world are alkaloid containing. Alkaloids have remarkable physiologic and pharmacologic properties like stimulant, spasmolytic, vasodilator, anti-asthmatic, anti-arrhythmic etc. Coriandrum sativum showed positive results in case of presence of alkaloid.

It is established that anthraquinone and related glycosides exert their action by increasing the tone of the smooth muscle. As Coriandrum sativum showed positive results for both glycoside & tannins, it is quite obvious that it has pronounced astringent and antimicrobial properties. Moreover, C. sativum also showed positive results for saponin and steroids. So Cilantro has a very high potential for various medicinal value propositions.

C. sativum also contains good amount of flavonoids and it has been ensured from total flavonoid content that Pet ether extraction contains the highest amount of flavonoid among three extracts tested (Table 3).

Phenolic compounds and flavonoids have been reported to be associated with antioxidative action in biological systems, acting as scavengers of singlet oxygen and free radicals (Rice-Evans et al., 1997; Jorgensen et al., 1999)

Total antioxidant capacity of the fractions (Table 2) is also showing promising outcome. Total antioxidant capacity was expressed as the number of equivalents of ascorbic acid. The phosphomolybdenum method, used, is based on the reduction of Mo (VI) to Mo (V) by the antioxidant compound and the formation of a green phosphate/Mo (V) complex with a maximal absorption at 695 nm.

In DPPH radical scavenging assays, the three different extractions showed dose dependent scavenging of DPPH in a way similar to that of the reference antioxidant ascorbic acid (Figure
1). DPPH radical scavenging is a popular and reliable method for screening the free radical scavenging activity of compounds or antioxidant capacity of plant extracts.

In addition, *C. sativum* extracts displayed moderate reducing power which was found to rise with increasing concentrations. The reducing ability of a compound generally depends on the presence of reductants (*Duh et al.*, 1999) \(^{[15]}\), which have been reported to exhibit antioxidative potential by breaking the free radical chain, donating a hydrogen atom (*Gordon*, 1990) \(^{[14]}\). In Figure 2 the reductive capabilities of the plant extract compared to ascorbic acid is evident. Here all the three extractions of *C. sativum* have showed good phenolic content. Among them Ethanolic extraction (ETCS) was found to contain the highest amount of phenols (Table 2). The water/aqueous extraction (AQCS) also contains good amount close to ETCS extraction. Though Pet. Ether extract (PECS) decreased more compared to other ones, this PECS extract Phenolic contents is also noteworthy. These results rationalize that the Cilantro (Leaf of *Coriandrum sativum*) is a very good source of phenolic compounds.

The antioxidant activity of the three extractions of *C. sativum*, as measured by several *in vitro* tests, was found to correlate with total phenol and total flavonoid contents. Several reports have conclusively shown close relationship between total phenolic content and antioxidative activity of the fruits and vegetables (*Vinson et al.*, 1998) \(^{[8]}\). However, the observed antioxidant action correlates more with total flavonoid contents of the fractions than with their total phenol contents.

The antioxidant capacity of phenolic compounds in coriander leaves (Cilantro) was higher than that of the seeds in three different bioassays, namely scavenging of free radical by DPPH, inhibition of 15-lipoxygenase (15-LO) and inhibition of Fe\(^{2+}\) induced phospholipid peroxidation in brain. (*Wangensteen*Hvet al., Samuelsen AB et al., Malterud KE et al., 2006) \(^{[9]}\).

The brine shrimp lethality assay (BSLA), used to assess the cytotoxic properties, the lethality of three extractions of *C. sativum* to the Brine Shrimp nauplii. The degree of lethality shown by the extractives was found to be directly proportional to the concentration of the extractives ranging from the lowest concentration (5 \(\mu\)g/ml) to the highest concentration (500 \(\mu\)g/ml). This
concentration dependent increment in percent mortality of Brine Shrimp nauplii produced by *C. sativum* extractions indicates the presence of cytotoxic principles in these extractives.

The plant was reported to contain several phytochemical constituents most notably alkaloids, flavonoids and sterols ((Meyer et al., 1982; Karmakar et al., 2011)\(^{[16, 17]}\). Preliminary phytochemical screening revealed the presence of alkaloids, flavonoids and steroids. So the observed cytotoxic action may be due to the presence of such compounds. But the LC\(_{50}\) of the different extractions of *C. sativum* has shown that the plant is moderately toxic (Table 4). From this result it can be well predicted that the crude extract possesses cytotoxic principle. More precise results can be drawn from pure compounds.

In 2002, a study by Delaquis et al.\(^{[7]}\), reported that cilantro oil strongly inhibited gram-positive bacteria (*Listeria monocytogenes* and *Staphylococcus aureus*) and *S. cerevisiae*, but had little effect against gram-negative bacteria like *Pseudomonas fragi*, *Escherichia coli*, *Salmonella typhimurium* (Delaquis et al., 2002)\(^{[7]}\). Methanol and water extracts of coriander leaves and stems were tested for antimicrobial activity towards *Bacillus subtilis* and *Escherichia coli* by determining cell damage. The greater bacterial cell damage caused by the methanol stem extracts resulted in a greater growth inhibition of the bacteria, which corresponded to the ferrous sequestering activity of the methanol-derived stem extracts.

Another review tells that crude aqueous and hydro-alcoholic extracts of the seeds of *C. sativum* completely inhibited hatching of nematode eggs at concentrations lower than 0.5 mg/mL with no statistically significant difference between both extracts. But the hydro-alcoholic extract showed better *in vitro* activity against adult parasites than the aqueous one (Eguale T, et al., 2007)\(^{[13]}\). However, in well method ETCS extract (Ethanolic extraction and Petroleum ether extraction) showed efficacy against some gram positive and gram negative bacteria (Table 5).

**CONCLUSION**

Based on the study results of the phytochemical screening of three different solvent extracts of *Coriandrum sativum* leaves, cilantro (Ethanolic extraction, Pet. Ether extraction and water extraction) it can be proposed that it has strong antioxidant, cytotoxic and antimicrobial
properties. Again, these findings may justify scientifically the basis for the use of this plant in folk medicine for various purposes such as to improve appetite, relieve flatulence and indigestion, arthritis, rheumatism, sore muscles, diabetes, anxiolytic, anthelmintic, etc. These results also lend support to the relevant phytochemical and pharmacological works carried out so far on *C. sativum*. Various phytochemical constituents like alkaloid, glycoside, flavonoid, steroid and saponin present in the plant, as evident from phytochemical analyses, may be responsible for the observed bioactivities.

However, further studies are suggested to be undertaken to look for further constituents in other parts of *C. sativum* to look for other unexplored activities and to understand the underlying mechanism of the observed activities and to isolate, purify and characterize active phytochemical ingredient(s) responsible for the bioactivities in animal models.

**REFERENCE**


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