ANTIBACTERIAL ACTIVITY AND PHYTOCHEMICAL SCREENING OF SELECTED MEDICINAL PLANTS AGAINST \textit{Salmonella enterica} serovar \textit{Typhimurium} STRAINS

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ABSTRACT

Human beings have been utilizing plants for basic preventive and curative health care since ancient time. Preliminary screening of phytochemicals is a valuable step in the detection of bioactive principles present in medicinal plants and may lead to novel environmentally friendly bioherbicides and drug discovery. In the present study, eight plants employed in Indian traditional system of medicine, Ayurveda and Unani for treatment of manifestations caused by microorganisms were collected, dried and extracted using distilled water, 70% methanol and ethyl acetate solvents for evaluating their antibacterial potential against wild type (NKS70) strain, knockout (NKS174) strain and over expressive (NKS773) strain. Qualitative phytochemical analysis of effective extracts was assessed by using standard methods. Antibacterial activity was determined by agar well diffusion method at 50 mg/ml, 80 mg/ml and 100 mg/ml of plant extracts. The maximum activity was observed in methanolic extract of \textit{M. officinalis} with zone of inhibition between 15 mm to 21 mm, followed by ethyl acetate extract of \textit{M. charantia} with zone of inhibition between 17 mm to 21 mm against \textit{Salmonella enterica} serovar \textit{Typhimurium} strains. Aqueous extract do not exhibit any activity. The results revealed the best inhibition of bacterial strains by methanol extracts followed by ethyl acetate extracts at 100 mg/ml and Qualitative phytochemical analysis of effective methanolic and ethyl acetate extracts confirms the presence of
carbohydrates, alkaloids, flavonoids, reducing sugars, terpenoids, saponin and quinones. The results suggest that the methanolic extract shows the presence of maximum phytochemical compounds than ethyl acetate extract during screening. It can be concluded from the results of this study that using herbal plants instead of antibiotics can resolve some antibiotic resistant problems.

**Keywords:** Antibacterial, ethyl acetate, Medicinal plants, Methanol, *Salmonella enterica* serovar *Typhimurium*, Phytochemical

**INTRODUCTION**

Infectious diseases are a major cause of death and disability in humans as they are responsible for about 22% of the disease burden globally [1]. The number of multi-drug resistant microbial strains and the appearance of strains with reduced susceptibility to antibiotics are continuously increasing from last few years. Antibiotics have contributed to improving quality and expectancy of life over the last century [2]. Intractable problems of microbial resistance to antibiotics led to the resurface of herbal products as a source of potential compounds to suppress or possibly eradicate the ever increasing problems of emergence of newer diseases [3, 4]. The medicinal plants are useful for healing as well as for curing of human diseases because of the presence of phytochemical constituents [5]. Plant based medicines have been a part of traditional healthcare in most parts of the world for thousands of years [6, 7]. Plants contain numerous biologically active compounds, many of these have been shown to exhibit antimicrobial properties and therefore they were in use as antimicrobial drugs in traditional medicines. These are the reservoirs of potentially useful chemical compounds which could serve as newer leads and clues for modern drug design [8].

According to a report of World Health Organization, more than 80% of the world’s populations depend on traditional medicine for their primary health care needs. A large number of secondary metabolites such as alkaloids, tannins, and flavonoids extracted from different medicinal plants have shown antimicrobial potential [9]. The investigation of certain indigenous plants for their antimicrobial properties may yield useful results. A large number of plants are used to combat different diseases and are known to possess antimicrobial activity [10]. The medicinal value of plant lies in the bioactive phytochemical constituents of the plant and which shows various physiological effects on human body. Therefore, phytochemical
screening could detect the various important compounds which could be used as the base of modern drugs for curing various diseases. The systematic screening of plant extracts or plant derived substances still remains an interesting strategy to find new lead compounds in many plant species. Keeping this in view, the present study investigates on the antibacterial potential of different plant extracts (aqueous, methanol and ethyl acetate) and their qualitative phytochemical analyses to identify their bioactive compounds. Hence, the search for novel antimicrobial compounds or alternative therapy for these resistant infectious agents is inevitable.

**MATERIALS AND METHODS**

**Collection of plant materials**

The present study included plant species namely, *Melissa officinalis*, *Elettaria cardamomum*, *Momordica charantia*, *Withania somnifera*, *Centella asiatica*, *Zingiber officinale*, *Ocimum sanctum* and *Aloe vera*, which were selected on the basis of traditional applications and pharmacological reports and collected from herbal gardens, surroundings and local market into plastic zip lock bags with appropriate labelling and got identified from Botany department of Shoolini University of Biotechnology and Management Sciences, Bajhol, Solan. Voucher specimens have been submitted to the University herbarium.

**Table 1: Medicinal Plant Species selected for their antibacterial and phytochemical screening**

<table>
<thead>
<tr>
<th>S. no.</th>
<th>Plant names (Voucher no.)*</th>
<th>Local name</th>
<th>Family name</th>
<th>Part used</th>
<th>Traditional medicinal uses</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td><em>Melissa officinalis</em> (SUBMS/BOT-S217)*</td>
<td>Lemon balm</td>
<td>Lamiaceae</td>
<td>Leaves</td>
<td>Carminative, diaphoretic, surgical dressing for wounds, strengthening the memory and relief from headache</td>
</tr>
<tr>
<td>2</td>
<td><em>Elettaria cardamomum</em> (SUBMS/BOT-S220)*</td>
<td>Cardamom</td>
<td>Zingiberaceae</td>
<td>Seeds</td>
<td>Asthma, constipation, colic, diarrhea, dyspepsia, hypertension, epilepsy, antibacterial, antifungal, antiviral, carminative, diuretic and stomachic</td>
</tr>
<tr>
<td>3</td>
<td><em>Momordica charantia</em> (SUBMS/BOT-S214)*</td>
<td>Bitter gourd</td>
<td>Cucurbitaceae</td>
<td>Seeds</td>
<td>Constipation, eczema, fever, gout, hydrophobia, jaundice, kidney stones, leprosy, liver, pneumonia, rheumatism, snakebite, diabetes mellitus and enhances eyesight.</td>
</tr>
<tr>
<td>4</td>
<td><em>Withania somnifera</em> (SUBMS/BOT-S203)*</td>
<td>Ashwagandha</td>
<td>Solanaceae</td>
<td>Leaves</td>
<td>Tumors, ulcers, nervous exhaustion, memory related conditions, insomnia, skin problems and coughing.</td>
</tr>
<tr>
<td>5</td>
<td><em>Centella asiatica</em> (SUBMS/BOT-S207)*</td>
<td>Gotu kola</td>
<td>Apiaceae</td>
<td>Whole plant</td>
<td>Leprosy, varicose veins, blood purifier, ulcers, lupus, eczemas, general longevity, and mental retardation</td>
</tr>
<tr>
<td>6</td>
<td><em>Zingiber officinale</em> (SUBMS/BOT-S222)*</td>
<td>Ginger</td>
<td>Zingiberaceae</td>
<td>Rhizome</td>
<td>Stimulates blood circulation, digestive disorders, arthritis, ointment in pains.</td>
</tr>
<tr>
<td>7</td>
<td><em>Ocimum sanctum</em> (SUBMS/BOT-S210)*</td>
<td>Tusli</td>
<td>Lamiaceae</td>
<td>Leaves</td>
<td>Expectorant, analgesic, anticancer, antiasthmatic, antidiabetic, antiinflammatory, hepatoprotective and antistress agents.</td>
</tr>
<tr>
<td>8</td>
<td><em>Aloe vera</em> (SUBMS/BOT-S208)*</td>
<td>Aloe</td>
<td>Liliaceae</td>
<td>Leaves</td>
<td>Coughs, wounds, ulcers, gastritis, diabetes, cancer, headaches, arthritis and immune-system deficiencies</td>
</tr>
</tbody>
</table>

**Chemicals and reagents used**

Fehling solution A and fehling solution B, ethanol, distilled water, aqueous HCl,
acetic anhydride, methanol, ethyl acetate, chloroform, iodine, potassium iodide, mercuric chloride, DMSO, Molisch’s reagent, glacial acetic acid, sodium hydroxide, gelatin, sodium chloride, concentrated sulphuric acid and ferric chloride were obtained from Sigma-Aldrich Chemical Co. (India). All the chemicals and solvents used were of standard analytical grades.

Preparation of plant extracts
The fresh plant materials of selected plant (Table 1) were carefully washed under running tap water to remove debris and dust particles, followed by washing with 0.1% mercuric chloride to remove the contamination and after that washed with distilled water and shade dried for 4-5 days. The dried plant materials were ground to powder and stored in airtight containers. Ethyl acetate, distilled water and 70% methanol were used as extraction solvents. 10 g of powdered sample was soaked in conical flask containing 100 ml of solvents with occasional shaking followed by keeping all the flasks on rotary shaker at 200 rpm and filtered through a sterilized Whatman No. 1 filter paper after 48 hours. The plant residue was re-extracted with addition of solvents, and after 24 hours it was filtered again. Combined filtrates were concentrated to dryness at 40 °C on a rotary evaporator. The dried extract, thus, obtained was sterilized by overnight UV-irradiation, checked for sterility on nutrient agar plates and stored at 4°C in refrigerator for further use [11].

Microbial strains and culture conditions
Three strains of Salmonella enterica serovar Typhimurium NKS70 (wildtype), NKS 174 (TolC Knockout) and NKS773 (AcrAB overexpressive) were used as test organisms in the present study. All three strains were a generous gift given by Kunihiko Nishino, Associate professor of Osaka University (Japan). All strains were maintained in 30% (v/v) glycerol at -80°C until required. The pure bacterial cultures were maintained on bismuth sulphite agar and Luria-Bertani medium (LB media were obtained from Acumedia and Agar from Oxoid). Each bacterial culture was further maintained by subculturing on the same medium and stored at 4 ºC before further use. Cell growth (optical density) was assessed with a spectrophotometer at 600nm. Cells were used for experiments in mid-log growth phase (optical density at 600 nm, ~0.4 to 0.8 or 10^8/ml).

Screening of medicinal plants for antimicrobial activity
For antimicrobial testing, 100 mg of the dry residue was dissolved in 5% Dimethyl sulphoxide (DMSO) and evaluated through well diffusion assay against the three strains (NKS70 wildtype, NKS 174
knockout, NKS773 overexpressive). The antibacterial activity test was done according to Lino and Deogracious, 2006 [12] with some modifications using agar well diffusion method for methanol, ethyl acetate and aqueous extracts of eight medicinal plants. Briefly, about 1 ml of the standardized 24 hour old culture of the tested organisms was spread into sterile prepared Mueller Hinton agar plates. These plates were then allowed to set. With the aid of a sterile cork borer, wells of about 6 mm in diameter were bored on the plates. About 40 µl of each extracts was dispensed into the wells and then allowed to stand for about 15 minutes for prediffusion of the extracts. Tetracycline (obtained from Himedia Laboratory, India) was used as positive control, while DMSO was employed as a negative control. These plates were then incubated at 37 ºC for 24 hours. At the end of the period, inhibition zones formed on the agar were evaluated in millimeter (mm) [13]. The diameter of the zones of inhibition in the triplicate plates was measured by calculating the difference between cork borer (6 mm) and the diameters of inhibition [14]. Samples were tested in triplicate and results expressed as mean ± standard deviation.

Qualitative screening of Phytochemicals

Screening of the above selected medicinal plants for various phytochemical constituents were carried out using standard methods [15-21]

**Test for alkaloids (Wagner’s reagent)**

A fraction of the extract was treated with 3-5 drops of Wagner’s reagent [1.27 g of iodine and 2 g of potassium iodide in 100 ml of water] and observed for the formation of reddish brown precipitate (or coloration).

**Test for carbohydrates (Molisch’s test)**

Few drops of Molisch’s reagent were added to 2 ml portion of the various extracts. This was followed by addition of 2 ml of conc. H2SO4 down the side of the test tube. The mixture was then allowed to stand for two-three minutes. Formation of a red or dull violet colour at the interphase of the two layers was a positive test.

**Test for cardiac glycosides (Keller Kelliani’s test)**

5 ml of each extract was treated with 2ml of glacial acetic acid in a test tube and a drop of ferric chloride solution was added to it. This was carefully underlayed with 1ml concentrated sulphuric acid. A brown ring at the interface indicated the presence of deoxysugar characteristic of cardenolides. A violet ring may appear below the ring while in the acetic acid layer, a greenish ring may form.

**Test for reducing sugars (Fehling test)**
2 ml of the filtrates treated with equal volume of fehling A and fehling B solutions placed on boiling water bath for 5-10 minutes. Formation of red colour indicates presence of reducing sugars.

**Test for flavonoids (Alkaline reagent test)**

2 ml of extracts was treated with few drops of 20% sodium hydroxide solution. Formation of intense yellow colour, which becomes colourless on addition of dilute hydrochloric acid, indicates the presence of flavonoids.

**Test for amino acids and proteins (1% ninhydrin solution in acetone)**

2 ml of filtrate was treated with 2-5 drops of ninhydrin solution placed in a boiling water bath for 1-2 minutes and observed for the formation of purple colour.

**Detection of phenols (Ferric Chloride Test)**

Extracts were treated with 3-4 drops of ferric chloride solution. Formation of bluish black colour indicates the presence of phenols.

**Test for tannins (Gelatin Test)**

To the extract, 1% gelatin solution containing sodium chloride was added. Formation of white precipitate indicates the presence of tannins.

**Test for terpenoids (Salkowki’s test)**

1 ml of chloroform was added to 2 ml of each extract followed by a few drops of concentrated sulphuric acid. A reddish brown precipitate produced immediately indicated the presence of terpenoids.

**Test for quinones**

A small amount of extract was treated with concentrated HCl and observed for the formation of yellow precipitate (or colouration).

**Test for saponins**

About 0.5 g of crude extract was introduced into a tube containing 5.0 ml of distilled water, the mixture was vigorously shaken for 2 min, formation of froth indicated the presence of saponins.

**RESULTS AND DISCUSSION**

Medicinal plants are of great importance for both individual and community health. Out of three different concentration of plant extracts used, only 100 mg/ml concentration was found to be effective. Diameters of zone of inhibition in (mm) measured for biological activities in the methanolic and ethyl acetate extracts at 100 mg/ml against the bacterial strains are shown in Tables 2 and 3. Zones of inhibition indicate the effect of the extracts on the microorganisms. From this study, it was found that water is not the best solvent, since the bacterial strains were completely resistant to aqueous plant extracts. Therefore, methanol and ethyl acetate
extracts were found to be effective against Salmonella Typhimurium strains. The preliminary phytochemical screening of methanolic and ethyl acetate extracts have revealed the presence of secondary metabolites of therapeutical importance. The presence of these phytochemical components may be responsible for the observed antimicrobial activity of the plant extracts. Effective methanol and ethyl acetate extracts were selected for preliminary phytochemical analysis of various secondary metabolites of which carbohydrates, alkaloids, flavonoids, reducing sugars, terpenoids, saponin were the most prominent. Methanolic extract yielded more phytochemicals than ethyl acetate. Carbohydrates were present in all extracts except methanolic extract of Z. officinale. Alkaloids are present in all extracts except methanolic extract of O. sanctum, E. cardamomum and C. asiatica. Glycosides were present in extracts of O. sanctum, Z. officinale and A. vera as well as in ethyl acetate extract of M. charantia. Terpenoids were present in all extracts except methanolic extracts of O.sanctum, W.somnifera and A. vera as well as in ethyl acetate extracts of Z.officinale and M.officinalis (Table 4). It is not surprising that there are differences in the antimicrobial effects of plant groups, due to phytochemical properties and difference among species.

### Table 2: Antibacterial activity of medicinal plant extracts using methanol solvent

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Plant names</th>
<th>NKS70 (wild type strain)</th>
<th>NKS174 (knockout strain)</th>
<th>NKS773 (over expressive strain)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Diameter of zone of inhibition (mm)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>M. officinalis</td>
<td>19±0.0</td>
<td>21±0.0</td>
<td>15±0.0</td>
</tr>
<tr>
<td>2</td>
<td>E. cardamomum</td>
<td>13±0.0</td>
<td>11±0.5</td>
<td>12±0.5</td>
</tr>
<tr>
<td>3</td>
<td>M. charantia</td>
<td>11±0.1</td>
<td>11±0.2</td>
<td>12±0.1</td>
</tr>
<tr>
<td>4</td>
<td>W. somnifera</td>
<td>12±0.4</td>
<td>13±0.2</td>
<td>11±0.5</td>
</tr>
<tr>
<td>5</td>
<td>C. asiatica</td>
<td>12±0.0</td>
<td>13±0.0</td>
<td>11±0.0</td>
</tr>
<tr>
<td>6</td>
<td>Z. officinale</td>
<td>6.0±0.1</td>
<td>6.4±0.4</td>
<td>5.7±0.4</td>
</tr>
<tr>
<td>7</td>
<td>O. sanctum</td>
<td>10±0.0</td>
<td>10±0.2</td>
<td>10±0.0</td>
</tr>
<tr>
<td>8</td>
<td>A. vera</td>
<td>6.7±0.1</td>
<td>7.2±0.2</td>
<td>5.3±0.6</td>
</tr>
<tr>
<td>9</td>
<td>Tetracycline (15µg/ml) (positive control)</td>
<td>21±0.0</td>
<td>28±0.0</td>
<td>20±0.7</td>
</tr>
<tr>
<td>10</td>
<td>DMSO (negative control)</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

(-) = no inhibition zone; DMSO = Dimethyl sulfoxide; Values are mean of triplicate readings (mean ± S.D).

### Table 3: Antibacterial activity of medicinal plant extracts using ethyl acetate solvent

<table>
<thead>
<tr>
<th>S. No</th>
<th>Plant names</th>
<th>NKS70 (wild type strain)</th>
<th>NKS174 (knockout strain)</th>
<th>NKS773 (over expressive strain)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Diameter of zone of inhibition (mm)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>M. officinalis</td>
<td>10±0.0</td>
<td>13±0.0</td>
<td>15±0.0</td>
</tr>
<tr>
<td>2</td>
<td>E. cardamomum</td>
<td>10±0.0</td>
<td>15±0.5</td>
<td>14±0.0</td>
</tr>
<tr>
<td>3</td>
<td>M. charantia</td>
<td>18±0.0</td>
<td>21±0.0</td>
<td>17±0.0</td>
</tr>
<tr>
<td>4</td>
<td>W. somnifera</td>
<td>16±0.5</td>
<td>17±0.0</td>
<td>20±0.5</td>
</tr>
<tr>
<td>5</td>
<td>C. asiatica</td>
<td>11±0.0</td>
<td>12±0.0</td>
<td>13±0.0</td>
</tr>
<tr>
<td>6</td>
<td>Z. officinale</td>
<td>7.0±0.1</td>
<td>7.4±0.2</td>
<td>6.2±0.1</td>
</tr>
<tr>
<td>7</td>
<td>O. sanctum</td>
<td>10±0.0</td>
<td>11±0.0</td>
<td>10±0.0</td>
</tr>
<tr>
<td>8</td>
<td>A. vera</td>
<td>6.7±0.1</td>
<td>6.2±0.5</td>
<td>4.3±0.3</td>
</tr>
<tr>
<td>9</td>
<td>Tetracycline (15µg/ml) (+ve control)</td>
<td>19±0.0</td>
<td>28±0.5</td>
<td>16±0.5</td>
</tr>
<tr>
<td>10</td>
<td>DMSO (negative control)</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

(-) = no inhibition zone; DMSO = Dimethyl sulfoxide; Values are mean of triplicate readings (mean ± S.D).
Table 4: Preliminary phytochemical analysis of plant extracts

<table>
<thead>
<tr>
<th>S. No</th>
<th>Plant species</th>
<th>Carbohydrates</th>
<th>Flavonoid</th>
<th>Alkaloids</th>
<th>Reducing sugars</th>
<th>Cardiac glycosides</th>
<th>Tannins</th>
<th>Saponins</th>
<th>Phenols</th>
<th>Quinones</th>
<th>Amino acids</th>
<th>Terpenoids</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>O.sanctum</td>
<td>M + - - + + + + - + - + - +</td>
<td>EA + + + - + + - - - + - -</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>2</td>
<td>E.cardamomum</td>
<td>M + + - + + - - + - + + - +</td>
<td>EA + - + + + - + - - - + -</td>
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</tr>
<tr>
<td>3</td>
<td>M. charantia</td>
<td>M + + + - - + - - - - + -</td>
<td>EA + + + + - + + + - - +</td>
<td></td>
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<td></td>
</tr>
<tr>
<td>4</td>
<td>W. somnifera</td>
<td>M + + + - - + + + - - - -</td>
<td>EA + - + + + - + - - - +</td>
<td></td>
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<tr>
<td>5</td>
<td>C. asiatica</td>
<td>M + - + + + - + + + - - -</td>
<td>EA + + + - + + + + - -</td>
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<tr>
<td>6</td>
<td>Z. officinale</td>
<td>M - + + + + - - + + - + +</td>
<td>EA + - + + + - + - + -</td>
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<tr>
<td>7</td>
<td>M. officinalis</td>
<td>M + - + + + + + + + - + +</td>
<td>EA + + + + + + + + - +</td>
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<tr>
<td>8</td>
<td>A. vera</td>
<td>M + - + + + + + + + + + -</td>
<td>EA + - + + + - + - + -</td>
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</tr>
</tbody>
</table>

(+) = indicates presence of phytochemicals, (-) = indicates absence of phytochemicals

Aqueous plant extracts of these plants do not contain antibacterial compounds against Salmonella typhimurium strains. With no antibacterial activity, extracts may be active against other bacterial species which were not tested [22]. Antibiotic resistance does not interfere with the antimicrobial action of plant extracts and these extracts might have different modes of action on test organisms. The screening and scientific evaluation of plant extracts against microbes may provide new antimicrobial substances. Plant derived antimicrobials have enormous therapeutic potential as they can serve the purpose with lesser side effects that are often associated with synthetic antimicrobials [23]. Comparisons of pertinent data from the literature indicate that, the present study is consistent with the previous studies in which Mentha longifolia, Syzygium aromaticum, Emblica officinalis, Ficus religiosa, Ficus racenosa, Commiphora wightii, Hibiscus cannabinus, Ficus benghalensis, Ficus tisela, Caryophyllus aromaticus, Psidium guajava, Allium sativum, Zingiber officinale, Cymbopogon and Mikania species, reported antibacterial activity against Salmonella Typhimurium by various researchers [24-27]. However, Indu et al. [28], using a different method of ginger extract preparation, also verified an antimicrobial activity of garlic extracts against E. coli and Salmonella species. Qualitative analysis of phytochemicals revealed the presence of carbohydrates, alkaloids, flavonoids, reducing sugars, terpenoids, glycosides, saponin, phenols, amino acids and quinones, bioactive compounds that have a broad range of biological activities which is consistent with the previous study which revealed that alkaloids possessing plants exerts an analgesic, antispasmodic and antibacterial...
activities [29]. Elmarrie and Johan [30], reported antibacterial activity of tannins. Tannins and flavonoids are thought to be responsible for antidiarrheal activity [31]. The mechanisms through which these secondary metabolites exert their antimicrobial activities differ. The saponin, alkaloids, and flavonoids are documented as the most active ingredients to which the antimicrobial activities of many plant species can be attributed [32]. The flavonoids and phenolic compounds in plant have been reported to exert multiple biological effects including antioxidant, free radical scavenging abilities, anti inflammatory, anti carcinogenic etc [33]. One of the previous study showed that saponins have anti-inflammatory effects [34] and tannins exhibit antioxidant, antimicrobial and antiviral effects [35]. Phytochemicals are biologically active constituents that might be responsible for the antimicrobial activity of the plants.

Hence, the present investigation clearly confirms the antibacterial nature of the methanolic and ethyl acetate plant extracts against *Salmonella enterica* serovar *Typhimurium*, and suggests that these plants could be exploited in the management of diseases caused by these bacterial strains in human systems.

**CONCLUSION**

Medicinal herbs are rich source of synthetic and herbal drugs. They contain a wide range of chemical compounds, commonly referred to as phytochemicals. Amongst the plant species investigated, methanol extract of *M. officinalis* and ethyl acetate extract of *M. charantia* showed the remarkable antibacterial activity against *Salmonella Typhimurium* strains. The phytochemical compounds identified in this study have earlier been proved to be bioactive. Therefore, these plants can be further subjected to isolation, purification and characterization of the therapeutic antimicrobial compounds or active constituents which might be carried out further pharmacological evaluation.

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**CONFLICT OF INTERESTS**

The authors have no conflict of interest to report.

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