

## Antibacterial activities of wild rhizomatous plants - *Curcuma aromatica*, *Curcuma longa* (Zingiberaceae) and synergistic effects of both collected from southern Western Ghats, India

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**Abstract**— Rhizome extracts of *Curcuma aromatica* and *Curcuma longa* (Zingiberaceae) from southern Western Ghats of Tamil Nadu, India were investigated for their antibacterial activity by agar well diffusion method against bacterial human pathogens such as *Escherichia coli*,  $\beta$ -haemo streptococci, *Klebsiella pneumoniae*, *Staphylococcus aureus*, *Salmonella typhi*, *Bacillus subtilis* and *Pseudomonas aeruginosa*. The study revealed that except *Pseudomonas aeruginosa*, all the pathogens were inhibited by various extracts (Methanol, Ethanol, n-Butanol and Acetone) of *Curcuma* spp. sometimes far better than the control antibiotic Amoxicillin. *Pseudomonas aeruginosa* was inhibited by n-Butanol extract of *C. longa* as equal as standard antibiotic. These results clearly elucidates that *Curcuma aromatica* and *Curcuma longa* collected from wild have higher antibacterial activity than that of standard antibiotic.

**Keywords**— Antibacterial activity, *Curcuma aromatica*, *Curcuma longa*, Western Ghats

### I. INTRODUCTION

*Curcuma longa* L. (syn. *C. domestica* Vahl.) is a perennial rhizomatous herb of the family Zingiberaceae. The rhizome is the source of turmeric, which has use as a condiment and coloring agent in medicines, confectionery and curry powder [1]. The extracts of turmeric roots has traditionally been used as an insect repellent, antimicrobial [2], antidiabetic [3], rheumatism, bodyache, skin diseases, intestinal worms, diarrhea, intermittent fever, hepatic disorders, biliousness, urinary discharges, dyspepsia, inflammations, constipation, leukoderma, amenorrhea and colic inflammatory disorders [4]. The most important compounds responsible for the antioxidant activity of turmeric are phenolic compounds, such as curcuminoid dyes and essential oils [5]. Traditionally, the leaves of *C. longa* extensively used in culinary preparation are aromatic and contain essential oil. *C. longa* leaves oil bestowed with medicinal values has been used for treatment of various ailments and many of its therapeutic properties have been experimentally validated including its antimicrobial activity [6-7]. Therefore, much attention has been focused on application of plant derived antimicrobials to control pathogens in foods. Consequently,

alternative additives are needed, which possess antimicrobial activity and cause no health problems [8-11].

*Curcuma aromatica* belongs to the family Zingiberaceae and is distributed throughout India and is widely used as a flavouring agent, Condiment and a source of yellow dye. Rhizomes are aromatic and pungent with a ginger – sour – lemon flavour. It is a perennial tuberous herb, flowers pink, lip yellow, obovate, subentive or obscurely three lobed, fruit dehiscent globose three valved capsules. The rhizomes and roots are frequently used in cosmetics and spas for skin nourishment. There are many literatures reporting the medicinal values of *Curcuma longa* and *Curcuma aromatica*. On the other hand, emergence of new disease, development of Multi Drug Resistance (MDR) among pathogens and tumorous cells have resulted in ineffective treatment. This imbalance has pushed the pharmaceutical sector for the discovery of novel drugs from wild plants. Hence, this paper attempts to show the antimicrobial potential of these two wild plants collected from southern Western Ghats.

### II. MATERIALS AND METHODS

#### Plant collection and extraction

The rhizomatous plants were collected randomly from the regions where plenty of water is present. *Curcuma aromatica* and *Curcuma longa* were collected for the study of antibacterial activity from southern Western Ghats. Of these two species, *Curcuma longa* collected from Kulasekharam and *Curcuma aromatica* collected from Muttaikadu of Kanyakumari district of Tamil Nadu, India. The plant species were collected by hand or by using a knife. The plant species were transported to the laboratory in polythene bags. The unwanted plant materials were removed by using knife and the rhizome part is taken and washed with fresh water to remove the soil particles.

### Extraction of compounds

The extraction was carried out with different solvents such as Methanol, Ethanol, n-Butyl alcohol and Acetone. Ten gram of the dried powder was soaked in 50 ml of different solvents with periodic shaking at room temperature. The extraction with different solvents were carried out individually for each sample. Each extracts were filtered through muslin cloth and collected in separate test tubes.

### Test on human pathogens

The bacterial strains were identified strains, which obtained from Scudder laboratory, Nagercoil. The bacterial strains used for the study were *Escherichia coli*,  $\beta$ -haemo streptococci, *Klebsiella pneumoniae*, *Staphylococcus aureus*, *Salmonella typhi*, *Bacillus subtilis* and *Pseudomonas aeruginosa*.

### Preparation of test microorganisms

A loop full of the bacterial strains were inoculated in 20 ml of nutrient broth kept in a conical flask and incubated at 37°C for 18 hours to activate the bacterial strains. This was used as inoculums for the further study.

### Preparation of natural disc

Sterile discs were obtained and stored at 4°C. Discs were handled using a pair of presterilized forceps. The extract was loaded on to the disc carefully using capillary tube, without spreading out. Thus, the disc completely saturated with the extract was used for testing antibacterial activity.

### Culture of Test microorganisms

Solid media of nutrient agar was prepared by dissolving 2.8 gm of nutrient agar in 100 ml of distilled water. About 25ml of nutrient agar media was poured in to a petridish, allowed to solidify. The inoculum of bacteria was transferred to petriplates containing solid nutrient agar media using a sterile swab.

### Implementation of disc

Antibacterial activity was evaluated using agar disc diffusion technique. When the culture medium was solidified, dried test discs impregnated with extracts and synthetic discs were

transferred on bacterial lawn under aseptic conditions using spirit flame sterilized forceps. The petridish was incubated at room temperature for 24 hours. The resulting, zones of inhibition around the disc were observed and recorded as positive and negative results. The inhibitory zone around the discs indicates absence of bacterial growth and was recorded as positive test (+), the absence of zones as negative test (-).

## III. RESULTS AND DISCUSSION

Extract of *Curcuma aromatica* using Ethanol, Methanol, n-Butyl alcohol and Acetone showed varying activities. A perusal of Table 1 indicates the varied activities as measured by zone of inhibition with extracts made with Ethanol on selected human pathogens such as *Escherichia coli* (10 mm),  $\beta$ -haemo streptococci (20 mm), *Klebsiella pneumoniae* (10 mm), *Staphylococcus aureus* (10 mm), *Salmonella typhi* (10mm), *Bacillus subtilis* (10 mm) and *Pseudomonas aeruginosa* (10mm) (Figure – 2). Moreover, the zone of inhibition measured with Methanol extract on *Escherichia coli* (10mm),  $\beta$ -haemo streptococci (15 mm), *Klebsiella pneumoniae* (10 mm), *Staphylococcus aureus* (10 mm), *Salmonella typhi* (10mm), *Bacillus subtilis* (15 mm) and *Pseudomonas aeruginosa* (12mm) (Figure – 1). The zone obtained from inhibition measured with n-Butyl alcohol extract *Escherichia coli* (15 mm),  $\beta$ -haemo streptococci (10mm), *Klebsiella pneumoniae* (10mm), *Staphylococcus aureus* (15 mm), *Salmonella typhi* (10 mm), *Bacillus subtilis* (10mm) and *Pseudomonas aeruginosa* (10mm) (Figure – 3). As well as, the zone of inhibition measures with Acetone extract on *Escherichia coli* (10 mm),  $\beta$ -haemo streptococci (10mm), *Klebsiella pneumoniae* (10mm), *Staphylococcus aureus* (15 mm), *Salmonella typhi* (10 mm), *Bacillus subtilis* (10 mm) and *Pseudomonas aeruginosa* (10 mm) (Figure – 4). All the extracts of *C. aromatica* were inhibiting pathogens effectively.

Table 1. Growth Inhibition of Human pathogenic Bacteria by Rhizome extracts of *Curcuma aromatica* and *Curcuma longa* (diameter of zone in mm)

| Human Pathogens              | Solvents | <i>C. aromatica</i> | <i>C. longa</i> | <i>C. aromatica</i> with <i>C. longa</i> | Amoxi cillin |
|------------------------------|----------|---------------------|-----------------|--|--------------|
| <i>Escherichia coli</i>      | Mt       | 10                  | 20              | 10                                       | 19           |
|                              | Et       | 10                  | -               | -  |              |
|                              | n-But    | 15                  | 25              | 12                                       |              |
|                              | Ac       | 10                  | -               | -  |              |
| $\beta$ -haemo streptococci  | Mt       | 15                  | 9               | 10                                       | -            |
|                              | Et       | 20                  | 11              | 15                                       |              |
|                              | n-But    | 10                  | 13              | 10                                       |              |
|                              | Ac       | 10                  | 9               | 23                                       |              |
| <i>Klebsiella pneumoniae</i> | Mt       | 10                  | 7               | 12                                       | 12           |
|                              | Et       | 10                  | -               | 10                                       |              |
|                              | n-But    | 10                  | -               | 15                                       |              |
|                              | Ac       | 10                  | -               | 10                                       |              |
| <i>Staphylococcus aureus</i> | Mt       | 10                  | -               | 20                                       | -            |
|                              | Et       | 10                  | 12              | 10                                       |              |
|                              | n-But    | 15                  | 20              | 10                                       |              |

|                               |       |    |    |    |    |
|-------------------------------|-------|----|----|----|----|
| <i>Salmonella typhi</i>       | Ac    | 15 | -  | 10 | -  |
|                               | Mt    | 10 | 15 | 10 |    |
|                               | Et    | 10 | -  | 20 |    |
|                               | n-But | 10 | -  | 10 |    |
| <i>Bacillus subtilis</i>      | Ac    | 10 | -  | 20 | 10 |
|                               | Mt    | 15 | 9  | 12 |    |
|                               | Et    | 10 | 10 | 10 |    |
|                               | n-But | 10 | 13 | 10 |    |
| <i>Pseudomonas aeruginosa</i> | Ac    | 10 | -  | 15 | 16 |
|                               | Mt    | 12 | -  | 10 |    |
|                               | Et    | 10 | -  | 10 |    |
|                               | n-But | 10 | 15 | 10 |    |

(-) = NZI – No Zone of Inhibition/Absence of susceptibility; Mt – Methanol; Et – Ethanol; n-But – n-Butanol; Ac – Acetone

Extract of *Curcuma longa* using Ethanol, Methanol, n – Butyl alcohol and Acetone showed varying activities. A perusal of Table 1 indicates the varied activities as measured by zone of inhibition with extracts made with Ethanol on selected human pathogens such as *Escherichia coli* (NZI),  $\beta$ -haemo streptococci (11 mm), *Klebsiella pneumoniae* (NZI), *Staphylococcus aureus* (12 mm), *Salmonella typhi* (NZI), *Bacillus subtilis* (10 mm) and *Pseudomonas aeruginosa* (NZI) (Figure – 2). The zone obtained from inhibition measured with Methanol extract *Escherichia coli* (20 mm),  $\beta$ -haemo streptococci (9 mm), *Klebsiella pneumoniae* (7 mm), *Staphylococcus aureus* (NZI), *Salmonella typhi* (15 mm), *Bacillus subtilis* (9mm) and *Pseudomonas aeruginosa* (NZI) (Figure – 1). Moreover, the zone of inhibition measured with n-Butyl alcohol extract on *Escherichia coli* (25 mm),  $\beta$ -haemo streptococci (13 mm), *Klebsiella pneumoniae* (NZI), *Staphylococcus aureus* (20 mm), *Salmonella typhi* (NZI), *Bacillus subtilis* (13 mm) and *Pseudomonas aeruginosa* (15 mm) (Figure – 3). In addition, the zone of inhibition measured with Acetone extract on *Escherichia coli* (NZI),  $\beta$ -haemostreptococci (9 mm), *Klebsiella pneumoniae* (NZI), *Staphylococcus aureus* (NZI), *Salmonella typhi* (NZI), *Bacillus subtilis* (15 mm) and *Pseudomonas aeruginosa* (NZI) (Figure – 4).

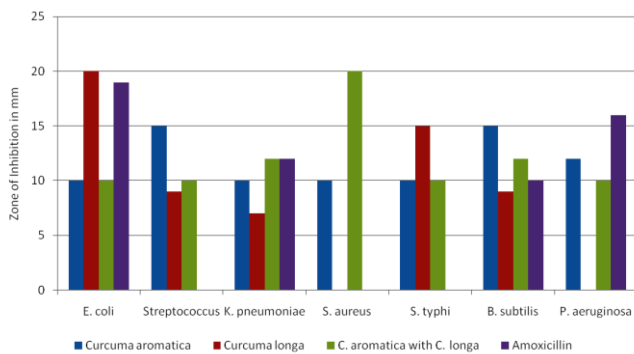


Figure 1. Sensitivity pattern of pathogenic bacteria with methanolic extract of *Curcuma* spp.

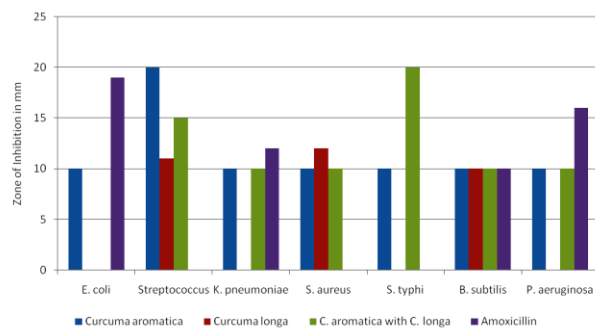


Figure 2. Sensitivity pattern of pathogenic bacteria with ethanolic extract of *Curcuma* spp.

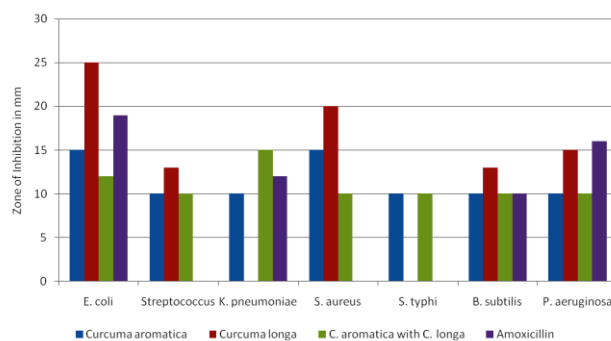


Figure 3. Sensitivity pattern of pathogenic bacteria with n-butanol extract of *Curcuma* spp.

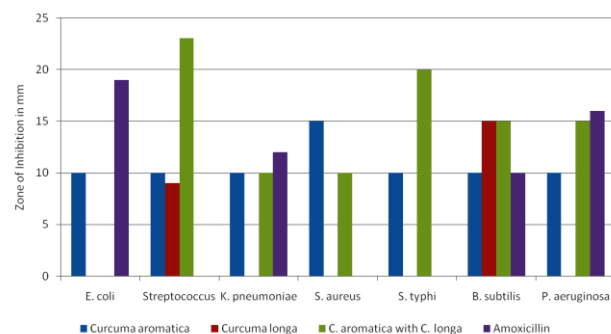


Figure 4. Sensitivity pattern of pathogenic bacteria with acetone extract of *Curcuma* spp.

Combined extracts of *Curcuma aromatica* and *Curcuma longa* using Ethanol, Methanol, n-Butyl alcohol, and Acetone showed varying activities. A perusal of Table 1 indicates the varied activities as measured by zone of inhibition with extracts made with Ethanol selected human pathogens such as *Escherichia coli* (NZI),  $\beta$ -haemo streptococci (15 mm), *Klebsiella pneumoniae* (10 mm), *Staphylococcus aureus* (10 mm), *Salmonella typhi* (20 mm), *Bacillus subtilis* (10 mm) and *Pseudomonas aeruginosa* (10 mm) (Figure – 2). Moreover, the zone of inhibition

measured with Methanol extract *Escherichia coli* (10 mm),  $\beta$ -haemo streptococci (10 mm), *Klebsiella pneumoniae* (12 mm), *Staphylococcus aureus* (20 mm), *Salmonella typhi* (10 mm), *Bacillus subtilis* (12 mm) and *Pseudomonas aeruginosa* (10 mm) (Figure – 1). The zone obtained from inhibition measured with n-butyl alcohol extract on *Escherichia coli* (12 mm),  $\beta$ -haemostreptococci (10 mm), *Klebsiella pneumoniae* (15 mm), *Staphylococcus aureus* (10 mm), *Salmonella typhi* (10 mm), *Bacillus subtilis* (10 mm) and *Pseudomonas aeruginosa* (10 mm) (Figure – 3). In addition, the zone of inhibition measured with Acetone extract *Escherichia coli* (NZI),  $\beta$ -haemostreptococci (23 mm), *Klebsiella pneumoniae* (10 mm), *Staphylococcus aureus* (10mm), *Salmonella typhi* (20 mm), *Bacillus subtilis* (15 mm) and *Pseudomonas aeruginosa* (15 mm) (Figure – 4).

### Discussion

The methanolic extract of *C. longa* showed better inhibition against *E. coli* than the standard antibiotic. Similarly, *C. aromatica* showed better inhibition of growth of  $\beta$ -haemo streptococci whereas the synergic effect of *C. longa* and *C. aromatica* against *K. pneumoniae* is far better than antibiotic amoxicillin. Both *C. longa* and *C. aromatica* individually inhibit the growth of *S. aureus* than the standard antibiotic. *C. longa* inhibits the growth of *S. typhi* better than antibiotic however *C. aromatica* equally inhibits the growth of *S. typhi* with that of standard. The growth of *B. subtilis* was inhibited by *C. aromatica* better than the standard antibiotic amoxicillin (Figure – 1). The ethanolic extract of *C. aromatica* showed better inhibition against  $\beta$ -haemo streptococci than the standard antibiotic. Similarly, all three had exhibits better inhibition of growth of *S. aureus* when standard antibiotic has no effect on this. Likewise, *C. aromatica* and the synergic effect of *C. longa* and *C. aromatica* against *S. typhi* also show far better inhibition when antibiotic amoxicillin has no effect on this pathogen. All three exhibited better inhibition of growth of *B. subtilis* than the standard antibiotic amoxicillin (Figure – 2).

The n-butanol extract of *C. longa* showed better growth inhibition than the antibiotic against *E. coli*. Similarly, all three had exhibits better inhibition of growth of  $\beta$ -haemo streptococci and *S. aureus* when standard antibiotic has no effect on this. The synergic effect of *C. longa* and *C. aromatica* against *K. pneumoniae* is also far better than antibiotic amoxicillin. *C. aromatica* against *S. typhi* also show far better inhibition when antibiotic amoxicillin has no effect on this pathogen (Figure – 3). The acetone extract of *C. aromatica* showed better inhibition of *S. aureus* and *S. typhi* when antibiotic amoxicillin has no effect on these pathogens. Similarly, the synergic effect of *C. longa* and *C. aromatica* against  $\beta$ -haemo streptococci is also far better than antibiotic amoxicillin (no effect). All three had exhibits better inhibition of growth of *B. subtilis* than the standard antibiotic amoxicillin (Figure – 4).

The development of bacterial resistance to the available antibiotics is a matter of discussion in an era of modern medicines and increasing popularity of traditional medicine has led researchers to investigate the antibacterial compounds in plants [1, 12]. It was reported that the use of alternative medicinal therapy had increased the interest of pharmacologists and herbalists over the past decade. Natural products from plants may offer new agents for antimicrobial use. A special feature of higher plants is their capacity to produce a large number of organic chemicals of high structural diversity the so called secondary metabolites [13]. It was found out that turmeric is well known for their antimicrobial properties and has been aptly known as the village dispensary for the past 2000 years [14,1]. It was reported that rhizome of *Curcuma longa* is locally called as zerdecad It is traditionally used in the treatment of infectious diseases, hepatitis and liver diseases [15]. This plant increases the bile level and makes stomachaches to disappear. It was documented that Turmeric extract and the essential oil of *Curcuma longa* inhibit the growth of a variety of bacteria, parasites and pathogenic fungi. A study of chicks infected with the caecal parasite *Eimeria maxima* demonstrated that diets supplemented with 1- percent turmeric resulted in a reduction in small intestinal lesion scores and improved weight gain [16].

The crude extracts of curcuminoids and essential oil of *Curcuma longa* varieties were studied for their antibacterial activity against four bacterial strains viz., *Bacillus subtilis*, *Bacillus macerans*, *Bacillus licheniformis* and *Azotobacter* using agar well diffusion method. Ethanol was used for the extraction of curcuminoids. Both curcuminoids and oil showed zone of inhibition against all tested strain of bacteria. Among all the bacterial strains *Bacillus subtilis* was the most sensitive to turmeric extracts of curcuminoids and oil. The MIC value for different strains and varieties ranged from 3.0 to 20.6 mm in diameter [17].

Kasur curcuminoid showed that *Bacillus subtilis*, *Bacillus macerans*, *Bacillus licheniformis* and *Azotobacter* were inhibited at all concentrations and Kasur oil was also effective against all tested strains while *Bacillus licheniformis* was resistant only at lower concentration ranged from 4 to 10 mg / ml. kasur Curcuminoids showed higher MIC against only *Bacillus subtilis* as compared to all other tested organisms. They concluded that faisalabad variety showed antibacterial activity against all tested microorganisms and its curcuminoid had large MIC than oil. Faisalabad curcuminoids gave higher zone of inhibition against *Bacillus subtilis* (12.2mm) and followed by *Bacillus licheniformis* (8.1 mm), *Bacillus macerans* (7.6mm) and *Azotobacter* (7.1 mm). Its oil also gave higher MIC against *Bacillus subtilis* (10.0 mm) and followed by *Bacillus licheniformis* (7.0 mm), *Azotobacter* (6.0 mm) and

*Bacillus macerans* (5.0 mm). Bannu curcuminoid and oil was also effective against tested microorganisms at higher concentrations. It gave higher MIC against *Bacillus subtilis* (7.0 mm) and lower MIC against *Azotobacter* (5.3 mm). Bannu oil also showed higher MIC against *Bacillus subtilis* (8.0 mm) and lower MIC against *Azotobacter* (5.5 mm) [17].

It was documented that the components of turmeric are named curcuminoids, which include mainly curcumin (diferuloyl methane), demethoxy curcumin and bisdemethoxycurcumin. Curcumin is the most important fraction which is responsible for the biological activities of turmeric. The melting point of curcumin, C<sub>22</sub>H<sub>20</sub>O<sub>6</sub>, is 184<sup>o</sup>c. It is soluble in Ethanol and Acetone, but insoluble in Water. Curcumin 95%, a potent antioxidant is believed to be the most bioactive and soothing portion of the herb turmeric and possesses the properties like antioxidant, anti-inflammatory, antibacterial and antifungal effects. It contains a mixture of powerful antioxidant phytonutrients known as curcuminoids and inhibits cancer at initiation, promotion and progression stages of tumour development [18]. Curcumin was first isolated in 1815 [19]. Its chemical structure was determined by Roughley and Whiting (1973) [20]. In the molecule of curcumin, the main chain is aliphatic, unsaturated and the aryl group can be substituted or not. *Curcuma longa* oil was tested against cultures of *Staphylococcus albus*, *Staphylococcus aureus* and *Bacillus typhosus*, inhibiting the growth of *Staphylococcus albus* and *Staphylococcus aureus* in different concentrations.

It was cited that the antibacterial activities of 1,4-Dioxan and DMF extracts of Ginger, Mango ginger and Turmeric against *Bacillus subtilis*. The 1,4-Dioxan extract of Mango ginger was highly active against *Bacillus subtilis*, followed by Turmeric and Ginger. The Dimethyl formamide (DMF) extract of Mango ginger also showed the highest activity followed by Turmeric and Ginger. The mixture of 1,4-Dioxan extracts of Turmeric and Mango ginger showed the highest activity, followed by Ginger and Mango ginger and Ginger and Turmeric. Similar activity was found with the mixture of DMF extracts. As well as the antibacterial activities of 1,4-Dioxan and DMF extracts of Ginger, Mango ginger and Turmeric against *Staphylococcus aureus*. The 1,4-Dioxan extract of Mango ginger showed the highest activity followed by Turmeric and Ginger. However, the DMF extract of all the 3 spices did not show any activity. The mixture of 1,4-Dioxan extracts of Ginger and Mango ginger showed the highest activity, followed by Turmeric and Mango ginger, Ginger and Turmeric. Here too the mixture of DMF extracts did not show any activity. It was reported that the antibacterial activities of four synthetic compounds, i.e. HC-1, HC-2, HC-3 and HC-4 in 1,4-Dioxan as well as in DMF extracts against *Escherichia coli*. In 1,4-Dioxan, HC-2 and HC-3 showed the highest activity followed by HC-1 while HC-4 had the lowest

activity. The synthetic compound HC-1 in DMF showed very little activity against *Escherichia coli* while the other compounds did not show any activity. The antibacterial activity of synthetic compounds of HC-3 in 1,4-Dioxan and DMF extracts against *Bacillus subtilis* showed highest activity. The antibacterial activity of HC-2 in 1,4-Dioxan and DMF extracts against *Staphylococcus aureus* showed highest activity [21].

It was concluded that the antibacterial activities of heated and unheated extracts of Ginger, Mango ginger and Turmeric were almost identical and the heated extracts also showed slightly higher activity compared to unheated extracts. Mixtures of heated extracts of Ginger, Mango ginger and Ginger and Turmeric were slightly more active against *Bacillus subtilis* compared to those of Turmeric and Mango ginger. The antibacterial activity of mixture of spices and peels showed good antibacterial activity against *Escherichia coli*. The activity of heated extracts was greater than that of unheated extracts. The maximum activity was that of peels followed by the 3 spices mixtures i.e., Ginger Turmeric and Ginger Mango ginger and Turmeric mango ginger. Heated and unheated extracts of Ginger were more active against *Staphylococcus aureus* compared to the heated and unheated extracts of Mango ginger and heated and unheated extracts of Turmeric did not show any activity against *Staphylococcus aureus*. The mixture of heated extracts of Ginger Turmeric displayed the highest activity, followed by the mixture of Ginger Mango ginger and the mixture of heated peel extracts. When the extract of Turmeric mango ginger was considered both heated and unheated extracts failed to show any activity against *Staphylococcus aureus* [22].

It was explained that the antibacterial activity of turmeric on pathogenic strains of Gram positive bacteria, *Staphylococcus aureus* and clinical isolate and *Staphylococcus epidermidis* and Gram negative bacteria *Escherichia coli* and clinical isolate, *Pseudomonas aeruginosa* and clinical isolate, *Salmonella typhimurium* by zone of inhibition assay [23]. It was analysed that Turmeric consists of 3-5% curcuminoids. Curcumin is the most important fraction which is responsible for the biological activities of turmeric. The melting point of curcumin is 184<sup>o</sup>C and it is soluble in Ethanol and Acetone. It exists in solution as keto-enol tautomers [24]. It was reported that for the last few decades extensive work has been done to establish the biological activities and pharmacological action of turmeric and its extracts [24-25].

It was cited that the antimicrobial effect of turmeric, ginger root and linseed against test microorganisms, only the alcoholic extract was tested, as alcohol was found to be better solvent for extraction of antimicrobially active substances compared to Water and Hexane [26]. However, some reported that the antibacterial effect of *Curcuma longa* showed better results with different fractions of solvent

against UTI isolates [27]. But some reported that the essential oil fraction from turmeric possess significant ( $P < 0.001$ ) antibacterial activity at very low concentration (20  $\mu\text{g}/\text{disc}$ ) on pathogenic Gram positive *Staphylococcus aureus* bacteria [28].

It was reported that the hydro ethanolic extract of *Curcuma zeodaria* and *Curcuma aromatica* rhizomes were found to have potent antimicrobial activity against *Bacillus cereus* at 1000  $\mu\text{g}/\text{ml}$  and showed moderate activity against *Klebsiella pneumoniae* and *Candida albicans*. In the case of MIC, hydro ethanolic extract of *Curcuma aromatica* inhibited *Bacillus cereus* at 15.625  $\mu\text{g}/\text{ml}$ , *Klebsiella pneumoniae* was inhibited at 62.5  $\mu\text{g}/\text{ml}$  and *Candida albicans* at 125  $\mu\text{g}/\text{ml}$ . Hydro ethanolic of *Curcuma zeodaria* inhibited *Bacillus cereus* at 31.25  $\mu\text{g}/\text{ml}$  where as *Klebsiella pneumoniae* and *Candida albicans* were inhibited at 125  $\mu\text{g}/\text{ml}$  [29].

#### IV. CONCLUSION AND FUTURE SCOPE

Turmeric has an important role as an antimicrobial agent against multi drug resistant bacteria. They are natural, cheap, easily available and safe. Due to increase in antibiotic resistance, they can be used for prevention of many infections such as diarrheal diseases (caused by *E.coli*), skin infections etc. Rhizomatous extracts of *Curcuma* from wild areas like Western Ghats can be a possible source to obtain new and effective herbal medicines to treat disease caused by multiple drug resistant strains of bacteria. However it is necessary to isolate their active constituents from different ecotypes and determine their toxicity, side effects and pharmaco-kinetic properties.

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