CHAPTER-II
REVIEW OF LITERATURE

Epidermis forms the outer layer of skin, creating a tough, renewable, waterproof barrier against the environment. It is superficial, thinner portion composed of layers of epithelial cells and embedded keratin.

Fig 2.1 Structure of skin


With its multiple layers of epithelial cells, the epidermis protects the body from the world outside. It acts as a barrier to infection, however if its defenses are disrupted a variety of micro-organisms can cause diseases. Globally it has been suggested that epidermal infection is responsible for more discomfort and illness than any other disease process (Graham and Bourke, 1998). Many wound and epidermal infections that complicate lesions are caused by mixed bacterial flora. Aerobic, anaerobic, gram-negative and gram-positive organisms, whose origins are the endogenous oral, gastro-intestinal and skin flora may be present in such infections,
where they exist synergically. Accidental cuts, abrasions and burns in combination with contaminants may predispose infection if left untreated (O’Dell, 1998).

The various epidermal infections include:

- **Folliculitis:** Inflammation of hair follicles with infection by bacteria like *Staphylococcus aureus*.

- **Impetigo:** It is the most common and highly contagious infection affecting children (Koning et al., 2002). It is characterized by honey coloured crusted sores on face.

- **Pitted Keratolysis:** It is a bacterial infection that produces crateriform pitting and depressed discoloured areas.

Other common epidermal infections include acne, cellulite, erythrasama, furuncle etc.

Most epidermal infections are caused by bacteria, some are listed below:

- **Staphylococcus aureus:** *Staphylococcus aureus* is gram-positive, coagulase positive bacteria with diameters of 0.5 – 1.5 μm and characterised by individual cocci, which divide in more than one plane to form grape-like clusters. *S. aureus* is a major pathogen of increasing importance due to the rise in antibiotic resistance (Lowy, 1998). *S. aureus* is considered to be a major pathogen that colonises and infects both hospitalised patients with decreased immunity, and healthy immuno-competent people in the community. This bacterium is found naturally on the skin and in the nasopharynx of the human body. It can cause local infections of the skin, nose, urethra, vagina and gastrointestinal tract.

- **Staphylococcus epidermidis:** *Staphylococcus epidermidis* is gram-positive bacteria with diameter of 0.5 to 1.5 mm. It differs from *S. aureus* in possessing coagulase enzyme. It has emerged as an important opportunistic human pathogen, reflecting the increased use of indwelling medical devices and an increasing number of patients with impaired immune systems, e.g. patients receiving immune-suppressive therapy, preterm infants, AIDS patients, and drug abusers. It is now considered one of the most frequent causes of nosocomial infections (Vuong, 2004).
its infections significantly contribute to morbidity and health care costs (Von Eliff et al., 2002). Hospital-acquired S. epidermidis often display resistance against many antimicrobials in use today, such as methicillin and aminoglycosides (Biavasco et al., 2009). An increasing prevalence of antibiotic resistance in S. epidermidis is partly due to the increasing use of broad-spectrum antibiotics, which encourage selection of multiresistant strains (Raad et al., 1998).

**Staphylococcus hominis:** Staphylococcus hominis is a gram-positive bacterium having a diameter of 1–2 mm. It is coagulase-negative member of the bacterial genus Staphylococcus, consisting of spherical cells in clusters. It occurs very commonly as a commensal on human and animal skin. However, like many other coagulase-negative staphylococci, it causes infection in patients whose immune system is compromised, for example by chemotherapy or predisposing illness.

**Pseudomonas aeruginosa:** Pseudomonas aeruginosa is a gram-negative bacterium; its cells are rod shaped and generally range from 1-5 μm long. It is commonly found in soil and ground water. Community-acquired infections are associated with prolonged contact with P. aeruginosa contaminated water. Although it is an opportunistic, it can cause a wide range of infections, particularly among immunocompromised people (HIV or cancer patients) and persons with severe burns, diabetes mellitus or cystic fibrosis (Gerald, 2002). It is well-adapted to the respiratory tract environment, especially in patients with chronic obstructive bronchopulmonary disease, who are immunocompromised, or who are hospitalized in intensive care units (Crinch et al., 2005, Ferrara 2006, Shaw, 2005). Skin and bone infections are rare, but can occur after puncture wounds (Gerald, 2002). P. aeruginosa is intrinsically resistant to several antibiotics because of the low permeability of its outer-membrane, the constitutive expression of various efflux pumps, and the production of antibiotic-inactivating enzymes e.g. cephalosporinases (Hancock, 1998).

**Klebsiella Pneumoniae:** Klebsiella Pneumoniae is a gram-negative bacterium. It is rod-shaped having a diameter of 0.3-1.0μm. It can cause different types of healthcare-associated infections, including pneumonia, bloodstream infections, wound
or surgical site infections, and meningitis. These bacteria are normally found in the human. They are also found in human stool. In healthcare settings, *Klebsiella* infections commonly occur among sick patients who are receiving treatment for other conditions. Patients whose care requires devices like ventilators or intravenous catheters, who are taking long courses of certain antibiotics are most at risk for *Klebsiella* infections. Certain diseases such as malignancy, cirrhosis, biliary tract disorders, diabetes mellitus and alcoholism may impair an individual’s defenses and increase the risk of *K. pneumoniae* infection (Haddy et al., 1989., Feldman et al., 1990, Lee 1994, Tsay 2002). Metastatic infections such as pyogenic brain abscess, meningitis and endophthalmitis are the most important characteristics of *K. pneumoniae* infections (Lederman and Crum 2005, Ma Lc et al., 2005, Fang et al., 2007). *Klebsiella* bacteria have developed antimicrobial resistance, most recently to the class of antibiotics known as carbapenems.

**Proteus vulgaris:** *Proteus vulgaris* is a rod-shaped, gram-negative bacterium having 0.4-0.8 mm diameter. It inhabits the intestinal tracts of humans and animals. It can be found in soil, water and fecal matter. It is grouped with the enterobacteriaceae and is an opportunistic pathogen of humans. It is known to cause urinary tract infections and wound infections. Patients with recurrent infections, those with structural abnormalities of the urinary tract, those who have had urethral instrumentation, and those whose infections were acquired in the hospital have an increased frequency of infection caused by *Proteus*.

**Antibiotic resistance:** The development of antibiotics in 1940s offered a powerful weapon against bacterial infections and saved the lives of many people. A recent World Health Organization report indicated that infectious diseases in non-industrialized countries caused 45% in all and 63% of death in early children. In many parts of world the emergence of new, rare or already forgotten infectious diseases has stimulated interest to generate new drugs against antibiotic resistant strains. There are various social and medical factors responsible for the development of antibiotic resistance among these antibiotics. In hospitals, 190 million doses of antibiotics are administered each day. More than 133 million courses of antibiotics are coursed by non hospitalized patients. About 50% of these prescriptions are unnecessary. In many
cases full dosage is also not done. Such improper use and abuse of antibiotics contribute high in generating these antibiotic resistant bacterial strains. Besides direct consumption, agricultural practices account for over 60% antibiotic usage. The bacteria silently develop several ways to resist antibiotics. Since the bacteria multiply rapidly, this mutation quickly becomes dominant throughout the microbial population.

**Fig 2.2 Mechanism of Antibiotic Resistance in Bacteria**

![Mechanism of Antibiotic Resistance in Bacteria](http://www.chembio.uoguelph.ca)

Antibiotic resistance mechanisms can be broadly divided into three categories (Walsh, 2007).

(i) Inactivation of the antibiotic, e.g. the enzymatic hydrolysis of β-lactam antibiotics by β-lactamases, and adenylation, phosphorylation, or acetylation of aminoglycosides.

(ii) Removal of the antibiotic from the bacterial cell, via membrane-bound efflux proteins that pump the drugs out faster than they diffuse in, thereby keeping the intracellular concentration of drug lower than that required to exert the antibiotic effect. The classic example of this second mechanism is the resistance to tetracycline antibiotics in both Gram-negative and Gram-positive bacteria in which tetracycline is actively pumped out of the bacterial intracellular space.
(iii) Modification of the antibacterial target such that the antibiotic no longer binds with high enough affinity to be effective.

This increasing prevalence of multidrug resistance strains of bacteria and recent appearance of strains with reduced susceptibility to antibiotics raises the specter of untreatable bacterial infections and adds urgency to the search for new infection fighting strategies (Sieradzki et al., 1999).

**Plants as antimicrobial agents:** Plant kingdom is a gold mine for novel and affordable antimicrobials. Plant derived medicines have been part of traditional health care in most of the world for thousands of years and there is increasing interest in them as source of agents to fight microbial diseases (Ajayi and Akintola, 2010).

The medicinal effects of plants are due to metabolites especially secondary compounds produced by plant species. Phytochemical constituents such as alkaloids, flavonoids, tannins, phenols, saponins and several other aromatic compounds are secondary metabolites of plants that serve a defense mechanism against predation by many micro-organisms, insects and herbivores (Bonjor et al., 2007).

An essential oil is a concentrated hydrophobic liquid containing volatile aromatic compounds from the plants, they arise from a secondary metabolism of plant normally formed in special cells or a group of cells or as glandular hair found on many leaves and stems. They have long been found as plant’s chemical defense against insects, fungi and other invaders (Taso and Coats, 1995). Essential oils are chiefly used for the flavors and fragrances but they also possess antibacterial, antifungal, antiviral, insecticidal and antioxidant properties (Burt 2004 and Kordali et al., 2005). Antiseptic properties of plant volatile oils have been recognized since antiquity (Dorman and Deans, 2002).
Mode of Action of Antimicrobials: Since different class of antibiotics act on bacteria at different sites. Similarly the active compounds responsible for antimicrobial activity of plant targets specific sites. The action mechanisms of natural compounds are related to:

- Disintegration of cytoplasmic membrane
- Destabilization of the proton motive force (pmf)
- Electron flow
- Active transport
- Coagulation of the cell content.

Table 2.1
List of few plants showing Antimicrobial activity

<table>
<thead>
<tr>
<th>S.No.</th>
<th>Medicinal plant name</th>
<th>Activity against microbes/diseases</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Acalypha wilkesiana</td>
<td>Staphylococcus aureus (Antimethicillin resistant)</td>
<td>Akinyemi et al., 2005</td>
</tr>
<tr>
<td>2.</td>
<td>Alangium salviifolium</td>
<td>B. subtilis, Micrococcus luteus, Staphylococcus epidermis, E. coli, Pseudomonas aeruginosa,</td>
<td>Pandian et al., 2006</td>
</tr>
<tr>
<td>3.</td>
<td>Amomum subulatum and Elettaria cardamomum</td>
<td>Dental caries causing microbes</td>
<td>Aneja and Joshi, 2009</td>
</tr>
<tr>
<td>4.</td>
<td>Azadirachta indica</td>
<td>E. coli, Klebsiella pneumoniae, Neisseria gonorrhoea, Proteus vulgaris, Pseudomonas aeruginosa, Salmonella typhimurium, Shigella dysenteriae, Staphylococcus aureus, Streptococcus faecalis, Vibrio cholerae, Bacillus subtilis</td>
<td>Hussain and Deeni, 1991</td>
</tr>
<tr>
<td>5.</td>
<td>Bixa orellana</td>
<td>Staphylococcus aureus, Bacillus cereus, E. coli and Candida albicans</td>
<td>Rojas et al., 2006</td>
</tr>
<tr>
<td>6.</td>
<td>Caesalpinia pulcherrima</td>
<td>Staphylococcus epidermis, B. subtilis, Pseudomonas pseudoalcaligenes, Proteus vulgaris, Salmonella typhimurium</td>
<td>Parekh et al., 2005</td>
</tr>
<tr>
<td>7.</td>
<td>Calotropis procera</td>
<td>Bacteria</td>
<td>Meena et al., 2010</td>
</tr>
<tr>
<td>8.</td>
<td>Capsicum annum</td>
<td>Bacteria</td>
<td>Keskin et al.,</td>
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11
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<thead>
<tr>
<th></th>
<th>Plant Species</th>
<th>Bacterial Species</th>
<th>Year</th>
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</thead>
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<tr>
<td>9</td>
<td><em>Casuarina equisetifolia</em></td>
<td><em>Staphylococcus epidermis, B. subtilis, Pseudomonas pseudoalcaligenes, Proteus vulgaris, Salmonella typhimurium</em></td>
<td>2005</td>
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<tr>
<td>10</td>
<td><em>Cinnamomum verum</em></td>
<td>Bacteria, Fungi</td>
<td>2008</td>
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<td>11</td>
<td><em>Coriandrum sativum</em></td>
<td>Bacteria</td>
<td>2012</td>
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<tr>
<td>12</td>
<td><em>Delonix regia</em></td>
<td><em>Staphylococcus epidermis, B. subtilis</em></td>
<td>2005</td>
</tr>
<tr>
<td>13</td>
<td><em>Eucalyptus camaldulensis</em></td>
<td><em>Staphylococcus aureus, B. subtilis</em></td>
<td>2004</td>
</tr>
<tr>
<td>14</td>
<td><em>Euphorbia hirta</em></td>
<td><em>Staphylococcus epidermis, B. subtilis, Pseudomonas pseudoalcaligenes, Proteus vulgaris, Salmonella typhimurium</em></td>
<td>2005</td>
</tr>
<tr>
<td>15</td>
<td><em>Euphorbia tirucalli</em></td>
<td><em>Staphylococcus epidermis, B. subtilis, Pseudomonas pseudoalcaligenes, Proteus vulgaris, Salmonella typhimurium</em></td>
<td>2005</td>
</tr>
<tr>
<td>16</td>
<td><em>Ficus benghalensis</em></td>
<td><em>Staphylococcus epidermis and B. subtilis</em></td>
<td>2005</td>
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<tr>
<td>17</td>
<td><em>Glycyrrhiza glabra</em></td>
<td><em>Staphylococcus aureus, Streptococcus mutans, Bacillus subtilis, Vibrio cholerae, Sarcina subflava</em></td>
<td>1984</td>
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<td>18</td>
<td><em>Gmelina asiatica</em></td>
<td><em>B. subtilis and Pseudomonas pseudoalcaligenes</em></td>
<td>2005</td>
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<td>19</td>
<td><em>Hypericum perforatum</em></td>
<td><em>Staphylococcus aureus, Streptococcus mutans, Staphylococcus oxford, E. coli, Proteus vulgaris, Streptococcus sanguis, Pseudomonas aeruginosa</em></td>
<td>1987</td>
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<tr>
<td>20</td>
<td><em>Justicia secunda</em></td>
<td><em>E. coli and Candida albicans</em></td>
<td>2006</td>
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<tr>
<td>21</td>
<td><em>Laurus nobilis</em></td>
<td><em>E. coli, Pseudomonas aeruginosa, Staphylococcus aureus, Bacillus cereus, Sarcina lutea, Bacillus subtilis</em></td>
<td>1994</td>
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<tr>
<td>22</td>
<td><em>Matricaria chamomilla</em></td>
<td><em>E. coli, Klebsiella pneumoniae, Pseudomonas aeruginosa, Staphylococcus aureus, Staphylococcus epidermidis, Streptococcus salivarius, Moraxella gleuclidolytica</em></td>
<td>1991</td>
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<tr>
<td>23</td>
<td><em>Musa paradisiaca</em></td>
<td><em>E. coli, Klebsiella aerogenes, Pseudomonas aeruginosa, Staphylococcus aureus</em></td>
<td>1989</td>
</tr>
<tr>
<td>No.</td>
<td>Species</td>
<td>Antibacterial Activity</td>
<td>Authors</td>
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<tr>
<td>24.</td>
<td><em>Ocimum gratissimum</em></td>
<td><em>Staphylococcus aureus</em> (Antimethicillin resistant)</td>
<td>Akinyemi et al., 2005</td>
</tr>
<tr>
<td>25.</td>
<td><em>Phylantus discoideus</em></td>
<td><em>Staphylococcus aureus</em> (Antimethicillin resistant)</td>
<td>Akinyemi et al., 2005</td>
</tr>
<tr>
<td>26.</td>
<td><em>Piper pulchrum</em></td>
<td><em>Bacillus cereus</em> and <em>E. coli</em></td>
<td>Rojas et al., 2006</td>
</tr>
<tr>
<td>27.</td>
<td><em>Santalum album</em></td>
<td><em>B. subtilis</em></td>
<td>Parekh et al., 2005</td>
</tr>
<tr>
<td>28.</td>
<td><em>Tanacetum parthenium</em></td>
<td><em>Streptococcus pneumoniae</em>, <em>Streptococcus pyogenes</em>, <em>E. coli</em>, <em>Bacillus subtilis</em>, <em>Klebsiella oxytoca</em>, <em>Salmonella sp.</em>, <em>Serratia marinorubra</em>, <em>Shigella sonnei</em>, <em>Bacillus cereus</em>, <em>Citrobacter freundii</em></td>
<td>Gottshall et al., 1949</td>
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<td>29.</td>
<td><em>Tecomella undulata</em></td>
<td><em>Staphylococcus epidermis</em> and <em>B. subtilis</em></td>
<td>Parekh et al., 2005</td>
</tr>
<tr>
<td>30.</td>
<td><em>Terminalia avicennioibes</em></td>
<td><em>Staphylococcus aureus</em> (Antimethicillin resistant)</td>
<td>Akinyemi et al., 2005</td>
</tr>
<tr>
<td>31.</td>
<td><em>Terminalia catappa</em></td>
<td><em>Staphylococcus aureus</em>, <em>B. subtilis</em></td>
<td>Babayi et al., 2004</td>
</tr>
</tbody>
</table>

Taxonomical details of the plants evaluated for antibacterial activity in the present study:

*Amomum subulatum* (Greater Cardamom)

**Description:** *Amomum subulatum* is a member of the family Zingiberaceae. It is a large perennial spice crop cultivated in the swamplike places in north-eastern and the central Himalayan regions of India. An herbaceous plant grows up to 1 meter in height. Leaves are oblong-lanceolate, flowers white in globose spikes, fruits reddish brown, capsules, with many aromatic seeds held together by a pulp.

**Therapeutic uses:** Traditionally, large cardamom has been used as preventive as well as a curative for throat trouble, congestion of lungs, inflammation of eyelids, digestive disorders and in the treatment of pulmonary tuberculosis (Verma et al., 1999).
2010). Petroleum ether extracts of *A. subulatum* possess antibacterial activity against *S. aureus, E. coli* and *P. aeruginosa* (Kumar et al., 2010). It also showed activity against *Streptococcus mutans* and *S. aureus* and two fungi *Candida albicans* and *Saccharomyces cerevisiae* (Aneja and Joshi, 2009).

**Azadirachta indica** (Neem)

**Description:** *Azadirachta indica* tree belongs to family Meliaceae. It is evergreen tree found in most tropical countries having small bright green leaves. It goes up to 100 feet tall. The stem of a neem tree can grow up to a diameter of 2.5-3 m. The bark is rough and can be pale or greyish-black in color. Tree bears small white coloured flowers and star shaped, with a pleasant smell. Tree bears fruits between the age of 3 and 5, and the fruits are edible.

**Therapeutic uses:** Neem leaves have antibacterial properties and could be used for controlling airborne bacterial contamination in the residential premise (Khan et al., 2008, El-Mahmood et al, 2010). Leaves are also used against leprosy, eye problem, epistaxis, intestinal worms, anorexia, biliousness, skin ulcers. Extracts of neem leaf, neem oil and seed kernels are effective against certain human fungi, including *Trichophyton, Epidermophyton, Microsporum, Trichosporon, Geotricum* and *Candida* (Khan et al., 2008)

**Calotropis procera** (Aak)

**Description:** *Calotropis procera* is a member of the plant family Asclepiadaceae. It is often found as a weed throughout India in more or less warm dry places, predominantly in Sub Himalayan tracts, Deccan to Kanya-Kumari. It is a small to medium - sized shrub up to 5.5m high, occasionally branches to a height of 2.5 m. Leaves sub-sessile, opposite, decussate, broadly ovate-oblong, elliptic or obovate, acute, thick, glaucous, green, covered with fine cottony pubescent hair on young but glabrous later and base cordate. Flowers are in umbellate-cymes. The bark is fibrous, scaly, deeply fissured when old, grey to light brown. Early glabrescent parts of the plant exude white latex when cut or broken.
Therapeutic uses: Different parts of the plant have been reported to possess a number of biological activities such as proteolytic (Atal and Sethi, 1961), antimicrobial (Malik and Chugati 1979), larvicidal (Girdhar et al., 1984), nematocidal (Masood et al., 1980), anticancer (Ajoub and Kingston, 1981; Dhar et al., 1968) and antiinflammatory (Basu and Chaudhary, 1991). Leaves, stems, fruits, roots and latex of C. procera extracts exhibited antimicrobial activity against four types of bacteria namely *Staphylococcus aureus*, *Bacillus subtilis*, *E. coli* and *Pseudomonas aeruginosa* and two species of fungi i.e. *Aspergillus niger* and *Candida albicans* (Sadaabi et al., 2012).

*Cassia fistula* (Amaltas)

Description: *Cassia fistula* belongs to family Leguminosae. It is a semi-wild Indian Labernum. It is distributed in various countries including Asia, South Africa, Mexico, China, West Indies, East Africa and Brazil. It is a medium-sized tree, growing to 10–20 m tall. The leaves are deciduous, 15–60 cm long, pinnate. The flowers are produced in pendulous racemes. The fruit is a legume, 30–60 cm long and 1.5–2.5 cm broad, with a pungent odor and containing several seeds.

Therapeutic uses: This plant is widely used by tribal people to treat various ailments including ringworm and other fungal skin infections and it is widely used in traditional medicinal system of India. It has been reported to possess hepatoprotective, anti-inflammatory, antitussive, antifungal and antibacterial properties (Gupta, 2010). Abu et al., 1999 revealed that pods of *C. fistula* exhibited significant antibacterial activity when compared to that of ampicillin. The root is used in cardiac disorders, biliousness, rheumatic condition, haemorrhages, wounds, ulcers and boils and various skin diseases (Ben et al., 2009)

*Catharanthus roseus* (Sadabahar)

Description: *Catharanthus roseus* is an important member of the family Apocynaceae. It is native to Madagascar. It is an evergreen sub shrub or herbaceous plant growing to 1 m tall. The leaves are oval to oblong, 2.5–9 cm long and 1–3.5 cm
broad, glossy green, hairless, with a pale midrib and a short petiole 1–1.8 cm long; they are arranged in opposite pairs. The flowers are white to dark pink with a darker red centre. The fruit is a pair of follicles 2–4 cm long and 3 mm broad.

**Therapeutic uses:** Extracts from the dried or wet flowers and leaves of plants are applied as a paste on wounds in some rural communities. The fresh juice from the flowers of *C. roseus* made into a tea has been used by Ayurvedic physicians in India for external use to treat skin problems, dermatitis, eczema and acne. The plant has more than 70 types of alkaloids (mostly monoterpenoid indole alkaloids) and some are known to be effective in treating various types of cancers including breast and lung cancer, uterine cancer, melanomas, and Hodgkin's and non-Hodgkin's lymphoma (El-Sayed and Cordall, 1981). Muhammad *et al.*, 2009 reported that the antibacterial potential in crude extracts of different parts (viz., leaves, stem, root and flower) of *C. roseus* against clinically significant bacterial strains. Traditionally, *C. roseus* has been used in folk medication to take care of diabetes, high blood pressure and diarrhea (Adeyemi *et al.*, 2003; Abdulkarim *et al.*, 2005; Appidi *et al.*, 2008).

**Capsicum annuum (Red pepper)**

**Description:** *Capsicum annuum* belongs to family Solanaceae. It grows into a large perennial shrub. The single flowers are an off-white (sometimes purplish) color while the stem is densely branched and up to 60 cm tall. The fruit is a berry and may be green, yellow or red when ripe.

**Therapeutic uses:** *C. annuum* is used as carminative, an appetizer and a stomachic. Externally, it is used as a counter irritant in the treatment of rheumatism and neuralgia (Kokate *et al.*, 1999). The fruits with seeds are used commonly in spices and food due to their pungent flavour, known to possess several medicinal properties like anti-inflammatory, analgesic, carminative, rubefacient and its antioxidant (Sim and Sil, 2008), hypoglycemic (Monsereenusorn, 1980), antifungal (De Lucca *et al.*, 2006) and antimicrobial (Ribeiro *et al.*, 2007) properties have been reported. Keskin and Toroglu, 2011 reported antibacterial activity of acetone extracts
against *Pseudomonas aeruginosa* and *Rhodospirillum rubra*, and ethyl acetate extracts against *P. aeruginosa* and *K. pneumoniae*.

*Cinnamomum cecidodaphne* (Sugandh kokila)

**Description:** *Cinnamomum cecidodaphne* belongs to family Lauraceae. It is an evergreen tree with straight stem, growing up to a height of 8 m and with an average girth of 1.5 m. The leaves are 12-18 cm long and 5-8 cm broad, elliptic with acuminate tip, dark green, lossy above and waxy below and with 4-5 lateral nerves. The fruits are fragrant and are sold as sugandha kokila and is highly valued for its essential oil which is used in perfumery.

**Therapeutic uses:** *C. cecidodaphne* benefits the nervous system and is useful in treatment of stress-related conditions such as headache, insomnia and nervous tension. It is useful in the treatment of circulation, muscles and joints complications and relieves arthritis, inflamed joints, muscular pains, rheumatism and sprains. It benefits the digestive system and helps improve appetite. The fruits have medicinal properties and are used as demulcent and stimulant in indigenous system of medicine (Khanna *et al.*, 1988).

*Cinnamomum zeylanicum* (Cinnamon)

**Description:** *Cinnamomum zeylanicum* is a member of the family Lauraceae. It is a tropical evergreen tree, native to Sri Lanka and the Malabar Coast of India. The tree grows up to thirty feet tall with ovate to ovate-lanceolate leaves that can be four to seven inches long. The tree shows small, yellow white cluster of flowers in summer after which oval, purple berries appear.

**Therapeutic uses:** Cinnamon is a pungent, sweet smelling, warming herb that stimulates the circulation, relieves spasms and helps to control high blood pressure, bleeding and indigestion. It has been used for treatment of diarrhea, stomach upset, against respiratory ailments and externally as a skin antiseptic and rubefacient (Mishra *et al.*, 2008; Inouye *et al.*, 2001; Juglal *et al.*, 2002). Aqueous and alcoholic extracts of cinnamon have demonstrated antibacterial effects against *Helicobacter*


*H. pylori* (Tabak et al., 1997 and O’Mahony et al., 2005). Cinnamon inhibits the growth of both Gram positive and Gram negative food borne pathogens, yeast and moulds (Snyder, 1997 and Paster et al., 1995).

**Coriandrum sativum (Coriander, Dhania)**

**Description:** *Coriandrum sativum* is an annual herb in the family Apiaceae. Coriander is native to southern Europe and North Africa to southwestern Asia. It is a soft, hairless plant growing to 50 cm tall. The leaves are variable in shape, broadly lobed at the base of the plant, and slender and feathery higher on the flowering stems. The flowers are borne in small umbels, white or very pale pink, asymmetrical, with the petals pointing away from the centre of the umbel longer (5–6 mm) than those pointing towards it (only 1–3 mm long). The fruit is a globular, dry schizocarp 3–5 mm diameter.

**Therapeutic uses:** In holistic and traditional medicine, it is used as a carminative and in digestive disorders. It also, has spasmolytic activity and used as a medication for oral infection and diarrhoea (Chaudhry and Tariq, 2005). Coriander seeds have been referred as antidiabetic (Gray and Flatt, 1999). It was reported that Aqueous extracts of Coriander showed antibacterial activity against *E. coli* and *B. subtilis* (Cao et al., 2012). Uma et al., 2009 reported aqueous, methanol and chloroform extracts exhibited antimicrobial activity against *E. coli*, *Salmonella sp* and *Shigella Sp*. and *Candida sp*.

**Curcuma longa (Turmeric)**

**Description:** *Curcuma longa* is a member of Zingiberaceae family. It is a perennial plant having a short stem with large oblong leaves and bears ovate, pyriform or oblong rhizomes, which are often branched and brownish-yellow in colour.

**Therapeutic uses:** Turmeric has been used to treat many health disorders like liver problems, digestive disorders, treatment for skin diseases and wound healing, it has long been used in Medicinal system as an anti-inflammatory agent. Curcumin is the active ingredient in turmeric which has been shown to have a wide range of
therapeutic effects (Bhowmik et al., 2008). Indian medicine uses turmeric powder for the treatment of biliary disorders, anorexia, coryza, cough, diabetic wounds, hepatic disorders, rheumatism and sinusitis. Gur et al., 2006, reported that the ethanolic extract of turmeric was effective in extraction of antimicrobially active substances as compared to water and hexane.

**Cuminum cyminum (Cumin, Jeera)**

**Description:** *Cuminum cyminum* is a small, slender, herbaceous annual plant in the family umbelliferae. It usually reaches up to a height of 25 cm. The blue green leaves are linear, 5-10 cm long. The white or pink flowers bloom in small compound umbels. The fruit is a lateral fusiform or ovoid achene which is 4-5 mm long and contains a single seed.

**Therapeutic uses:** Cumin is regularly used as a flavoring agent in a number of ethnic cuisines. Cumin seeds have been found to possess significant biological activities, such as antibacterial, antifungal, anti-carcinogenic (Gagandeep et al., 1976), anti-diabetic, anti-thrombotic (Dhandapani et al., 2002), and antioxidant properties (Ferrie et al., 2011). It is also considered as a stimulant, carminative and astringent and its therapeutic effects have been described on gastrointestinal, gynecological and respiratory disorders, and also for the treatment of toothache, diarrhoea and epilepsy (Zargary, 2001).

**Cyperus scariosus (Nagarmotha)**

**Description:** *Cyperus scariosus* is a small grass-like herb with angular soft stem and underground rhizomatous tubers belonging to cyperaceae family. It grows wild in the Madhya Pradesh region of India.

**Therapeutic uses:** *C. scariosus* is widely used as a phyotherapeutic agent against dysentery. The rhizome of this plant contains an amber or light brown viscous essential oil and the extract of the tuber is used as a remedy for fever, diarrhoea, dysentery, cholera and vomiting (Ghani, 1998). Essential oil isolated from *C. scariosus* showed anti-inflammatory activity (Gupta et al., 1972).
**Diospyros melanoxylon** (Tendu)

**Description:** *Diospyros melanoxylon* is a species of flowering tree in the family Ebenaceae that is native to southern India and Sri Lanka. It is a medium-sized tree or shrub up to 25 m, and 1.9 m girth. The bark is pelican in colour, exfoliating in rectangular scales. The roots form vertical loops in sucker-generated plants. Leaves are opposite or alternate and coriaceus, up to 35 cm long, tomentose on both sides when young, becoming glabrous above when fully grown. Fruits are one to many seeded berries.

**Therapeutic uses:** *D. melanoxylon* is used in an Indian cigarette product known as beedi in wrapping the tobacco together to be smoked (Sastry, 1952). The plant and parts, especially the fruit has been used as an anti-inflammatory and antipyretic drug in many local traditional medicines (Kirtikar and Basu, 1999). The bark exhibited strong anticandidal activity which may be used in the treatment of candidiasis (Pandya et al., 2010).

**Elettaria cardamomum** (Small cardamom)

**Description:** *Elettaria cardamomum* belongs to family Zingiberaceae and is historically known as the “Queen of all Spices”. It is cultivated commercially. The fruits are thin walled, smooth skinned, oblong, green capsules containing 15-20 aromatic reddish brown seeds.

**Therapeutic uses:** *E. cardamomum* was traditionally used in various gastrointestinal, cardiovascular and neural disorders (Arora and Kaur, 2007; Dhulap et al., 2008). Studies have revealed its use as an effective skin penetration enhancer for certain drugs, anticarcinogenic agent, anti ulcerogenic agent and anti microbial and anti convulsant agent (Dhulap et al., 2008). The seeds contain essential oil in concentration of about 4% of dry weight. The main compound is 1,8-cineole (representing 50% or more), with smaller amounts of α-terpineol, borneol, camphor, limonene, α-terpenyl acetate, and α-pinene (Agaoglu et al., 2005 and Miyazawa and Kameoka, 1975). It also acts as Ayurvedic aphrodisiac and remedy in case of
digestive problems, asthma, bronchitis, and urinary complaints and several other human ailments (Wyk and Wink, 2004 and Korikontimath 1999). Ethanol and Acetone extracts of *E. cardamomum* can be used as potential source to treat dental caries (Aneja and Joshi, 2009).

**Eucalyptus globulus** (Eucalyptus)

**Description**: *Eucalyptus globulus* belongs to the family Myrtaceae. It is an evergreen tree, one of the most widely cultivated trees native to Australia. It typically grows from 30 to 55 m tall. The broad juvenile leaves are borne in opposite pairs on square stems. They are about 6 to 15 cm long and covered with a blue-grey, waxy bloom, which is the origin of the common name "blue gum". The mature leaves are narrow, sickle-shaped and dark shining green. They are arranged alternately on rounded stems and range from 15 to 35 cm in length. The buds are top-shaped, ribbed and warty and have a flattened operculum (cap on the flower bud) bearing a central knob. The cream-colored flowers are borne singly in the leaf axils and produce copious nectar that yields a strongly flavored honey. The fruits are woody and range from 1.5 to 2.5 cm in diameter.

**Therapeutic uses**: Eucalyptus leaf extracts have been used to treat influenza, chest problems, and skin rashes while their vapour is inhaled to fight inflammation (Musyimi and Ogur, 2008). Essential oil possesses a significant activity against different microorganisms, including human pathogens, food poisoning and spoilage bacteria, and blastomycete opportunistic fungus *C. albicans* (Vratnica et al., 2011).

**Foeniculum vulgare** (Fennel, Saunff)

**Description**: *Foeniculum vulgare* is a biennial or short lived perennial herb belonging to family Apiaceae. It grows up to a height of 2 m. Stem is erect, furrowed and branched. Leaves are pinnate; flowers are yellow and appear in terminal compound umbels. The seeds are oval, ribbed, 5-10 mm long with strong and sweet smell.
Therapeutic uses: Fennel and its preparations are used to cure various disorders, and also act as a carminative, digestive and diuretic agent. Fennel increases elasticity of connective tissues and act as anti-aging agent (Arslan et al., 1989). Herbal drugs and essential oils of fennel have hepatoprotective effects (Ozbek et al., 2003), as well as antispasmodic effects (Reynolds, 1982). They are also known for their diuretic, anti-inflammatory, analgesic and antioxidant activities (Choi and Hawang, 2004). Anand et al., 2008, reported that fennel seed possesses anticancer activity.

**Lawsonia inermis** (Henna, Mehandi)

Description: *Lawsonia inermis* belongs to family Lythraceae. It is a perennial plant. It is native to North Africa and South East Asia, and often cultivated as an ornamental plant throughout India, Persia, and along the African coast of the Mediterranean Sea. It is a glabrous branched shrub or small tree (2 to 6 m in height). Leaves are small, opposite, entire margin elliptical to broadly lanceolate, sub-sessile, about 1.5 to 5 cm long, 0.5 to 2 cm wide, greenish brown to dull green, petiole short and glabrous acute or obtuse apex with tapering base. Fruits are small, brownish capsules, 4–8 mm in diameter, with 32–49 seeds per fruit, and open irregularly into four splits.

Therapeutic uses: Henna leaves, flowers, seeds, stem bark and roots are used in traditional medicine to treat a variety of ailments as rheumatoid arthritis, headache, ulcers, diarrhoea, leprosy, fever, leucorrhoea, diabetes, cardiac disease, hepatoprotective and colouring agent. (Chetty 2008; Chopra et al., 1956; Reddy 1988). Lawson, the antimicrobial agent in henna (Malekzadeh, 1968 and Sharma et al., 1995) exerted inhibitory effects upon common nosocomial urinary tract pathogens such as *E. coli*, *P. mirabilis*, *K. pneumoniae*, *P. aeruginosa* and *S. aureus* at certain concentrations (Bhuvaneswari et al., 2002).
Melaleuca alternifolia (Tea Tree)

**Description:** *Melaleuca alternifolia* is a member of the Myrtaceae family. It is native to Southeast Queensland and the Northeast coast of New South Wales, Australia. It yields a pale yellow color to nearly colorless and clear essential oil with a fresh camphoraceous odor.

**Therapeutic uses:** Tea tree oil has a broad spectrum of antimicrobial activity against gram-positive and gram-negative bacteria, both aerobic and anaerobic, against yeasts and fungi. It is also active against clinically isolated fluconazole-resistant *Candida* strains (Hammer *et al*., 2004 and Carson *et al*., 2006).

Murraya Koenigii (Meethi neem)

**Description:** *Murraya koenigii* belongs to family Rutaceae. It is a small tree, growing 4–6 m tall, with a trunk up to 40 cm diameter. The leaves are pinnate, with 11-21 leaflets, each leaflet 2–4 cm long and 1–2 cm broad. They are highly aromatic. The flowers are small, white, and fragrant. The small black shiny berries are edible, but their seeds are poisonous.

**Therapeutic uses:** The plant has been widely used in traditional Indian system of medicine for various ailments. It is used as a stimulant, antidysentric and for the treatment of diabetes Mellitus (Xie *et al*., 2006 and Vinthun *et al*., 2004). The pastes of leaves are applied externally to treat the bites of poisonous animals (Parmar and Kaushal, 1982). Crushed leaves applied externally cures skin eruption and relieves from burns. Suvitha *et al*., 2011 reported that girinimbine, a carbazole alkaloid isolated from this plant, inhibited the growth and induced apoptosis in human hepatocellular carcinoma, HepG2 cells in vitro.

Myristica fragrans (Nutmeg, Jaiphal)

**Description:** *Myristica fragrans* belongs to the family Myristicaceae. It is a spreading aromatic evergreen tree usually growing to about 5 to13 m high, occasionally 20 m. The bark contains watery pink or red sap. The pointed dark green
leaves are arranged alternately along the branches and are borne on leaf stems about 1 cm long. Flowers are pale yellow, waxy, fleshy and bell-shaped. The fruits are fleshy, drooping, yellow, smooth, 6 to 9 cm long with a longitudinal ridge.

**Therapeutic uses:** Nutmeg has been used as a folklore medicine for treating diarrhea, mouth sores and insomnia (Somani and Singhai, 2008). In traditional medicine, it has been widely used as carminative, astringent, hypolipidaemic, antithrombotic, antiplatelet aggregation, antifungal, aphrodisiac (Sonavane et al., 2002). The essential oil of nutmeg is used externally for rheumatism and possesses analgesic and anti inflammatory properties (Olajide et al., 2000).

**Nardostachys jatamansi (Jatamansi)**

**Description:** *Nardostachys jatamansi* is a perennial herb belonging to family valerianaceae. The plant is about 10 to 60 cm in height and with stout and long woody root stocks. The leaves are rosy, slightly pink or blue in dense cymose. Rhizomes are dark grey in colour and are crowned with reddish brown tufted fibers. Internally they are reddish brown in colour.

**Therapeutic uses:** The rhizomes of the plant were used since antiquity in the indigenous systems of medicine. The rhizomes and roots of plant are used as antistress agents in traditional medicine and marketed in India as an anticonvulsant Ayurvedic drug, Ayush 56 (Chatterjee et al., 2005). The essential oil obtained from the roots of jatamansi showed fungi toxic activity (Mishra et al., 1993), antimicrobial (Rao, 1986), antifungal (Girgune et al., 1978) and anticonvulsant activity (Rao et al., 2005).

**Nicotiana tabacum (Tobacco)**

**Description:** *Nicotiana tabacum* is a stout herbaceous plant that belongs to the family solanaceae. It is a thick-stemmed viscid (gummy) plant that can grow 1 to 3 m tall. The ovate to lanceolate leaves are alternate, spiraling around the stem, the tubular flowers grow in a large, branching terminal clusters, with individual flowers 3.5 to 5 cm (1.25 to 2 inches) long. Fruits are oval to elliptical capsules that contain several to
numerous small brown seeds. It originated in the tropical Americas (South America, Mexico, and the West Indies) and now cultivated worldwide as the primary commercial source of tobacco, which is smoked or chewed as a drug for its mild stimulant effects.

**Therapeutic uses:** Tobacco nicotine inhibits the growth of pathogens which is dose dependent (Maria *et al*., 2007; Wang *et al*., 2008; Suresh *et al*., 2008). Yildirim *et al*., (2000) reported that the ether extracts of both the leaves and seeds and ethanol extract of leaves had shown antimicrobial activities against *Staphylococcus*. Wang *et al*., 2008, reported inhibition of the activities of *Escherichia coli, Staphylococcus aureus* and *Bacillus subtilis* by crude polyphenols extracted from tobacco leaf by 80% ethanol solution.

**Olea europeae** (Olive)

**Description:** *Olea europea* is an evergreen tree or shrub in the family Oleaceae. It can grow up to 12 m tall, and has a gnarled branching pattern. It has oblong, silver green leaves, growing opposite to one another. Flowers are small, white and fragrant, growing on a long stem which appears on the leaf axils. The fruit is a small green or black-purple drupe, usually smaller in wild plants. Olive prefers subtropical and temperate regions of the world. It is native to northern Iran, coastal areas of southeastern Europe, western Asia and northern Africa.

**Therapeutic uses:** Olive leaf and extracts are utilized in the complementary and alternative medicine community for its perceived ability to act as a natural pathogen killer by inhibiting the replication process of many pathogens. Olive leaves extract is usually used as a natural antibiotic. It can easily combat different viral infections, such as influenza, herpes and Epstein Barr Virus. Olive leaf is also proving in beneficial effects concerning certain cardiovascular conditions. It reduces LDL cholesterol and blood pressure levels. It also increases blood flow and reduces blood sugar levels.
**Piper nigrum** (Black pepper)

**Description:** *Piper nigrum* is a flowering vine in the family Piperaceae, cultivated for its fruit, which is usually dried and used as a spice and seasoning. The fruit, known as a peppercorn when dried, is approximately 5 mm in diameter, dark red when fully mature, and like all drupes, contains a single seed. It is native to India.

**Therapeutic uses:** Black pepper is used to treat asthma, chronic indigestion, colon toxins, obesity, sinus, congestion, fever (Ravindran, 2000), intermittent fever, cold extremities, colic, gastric ailments and diarrhea (Ao et al., 1998). It has been shown to have antimicrobial activity (Dorman and Deans, 2000). The major constituent of black pepper is Piperine. It is bioactive compound and has been reported to be the major contributors to the antimicrobial activity of spices (Choudhary and Tariq, 2006).

**Psidium guajava** (Guava)

**Description:** *Psidium guajava* belonging to family Myrtaceae is a low evergreen tree or shrub 6 to 25 feet high, with wide spreading branches and square downy twigs. The branches are crooked and have opposite leaves. The flowers are white, incurved petals, 2 or 3 in the leaf axils. The fruits are pear shaped and turn reddish yellow when ripe.

**Therapeutic uses:** Guava has been used as an agent for the treatment of diarrhea, fever, gastritis and ulcers (Robineau and Soejarto, 1996) and possess numerous therapeutic uses including analgesic, anti-inflammatory (Garrido et al., 2001), antiamoebic (Tona et al., 2000) antihelminthic, antiallergic (Garcia et al., 2003) and antibacterial applications (Bairy et al., 2002). The boiled water extract of guava plant leaves and bark are used in medicinal preparations which are utilized as remedies for dysentery, diarrhoea and upper respiratory tract infections (Dutta, 1998). Leaf, root, and bark extracts are used for treatment of diarrhoea, leukorrhea, cholera, external ulcers, and skin diseases (Biazzi, 1996).
Rosa indica (Rose)

Description: Rosa indica is a perennial flower shrub or vine, within the family Rosaceae. The species form a group of erect shrubs, and climbing or trailing plants, with stems that are often armed with sharp prickles. Most are native to Asia, with smaller numbers of species native to Europe, North America, and Northwest Africa. The aggregate fruit of the rose is a berry-like structure called a rose hip.

Therapeutic uses: Rose tea can bring down fever and also works as diuretic. Rose water is used as an antiseptic. Its oil is used for skin treatment to smooth and moisturise the skin and to relieve skin irritation. Rose petals possess antimicrobial activity (Koday et al., 2010). It was reported that leaves, stem and flower of R. indica have bacteriocidal effects on pathogenic microorganisms (Mishra et al., 2011). Gram-negative bacteria were found to have more susceptibility to the extracts of different parts of the rose plants as compared to Gram-positive bacterial species (Kumar et al., 2012).

Syzygium aromaticum (Clove)

Description: Syzygium aromaticum are the aromatic dried flower buds of a tree in the family Myrtaceae. It grows to a height ranging from 8–12 m, having large leaves and sanguine flowers in numerous groups of terminal clusters. The flower buds are at first of a pale color and gradually become green, after which they develop into a bright red, when they are ready for collection. Cloves are harvested when 1.5–2 cm long, and consist of a long calyx, terminating in four spreading sepals, and four unopened petals which form a small ball in the center.

Therapeutic uses: Syzygium species have been reported to possess antibacterial and anti-inflammatory activity. It was reported that the buds of S. aromaticum were used in folk medicine as diuretic, odontalgic, stomachic, toniccardiac, aromatic condiment properties and condiment with carminative and stimulant activity (Boulos, 1983). Ethanolic extracts of clove possessed antimicrobial activity against P. aeruginosa, S. typhi, S. paratyphi and S. aureus. Cloves are used as a carminative, to increase hydrochloric acid in the stomach and to improve peristalis
Phyllis and James, 2000). It is also used in dentistry where the essential oil of clove is used as an adyne for dental emergencies (Prashar et al., 2006).

**Tectona grandis** (Teak)

**Description:** Tectona grandis is a large deciduous tree in the family Lamiaceae. It is commonly found in India and other South-East Asian countries (Kjaer et al., 1995). It has small, fragrant white flowers and papery leaves that are often hairy on the lower surface. Teak timber is particularly valued for its durability and water resistance, and is used for boat building, exterior construction, furniture, carving, turnings and other small wood projects.

**Therapeutic uses:** Extracts from various parts of teak shows expectorant, anti-inflammatory, anthelmintic properties and is also used against bronchitis, biliousness, hyperacidity, dysentery, diabetes and leprosy. In traditional medicine, a wood powder paste has been used against bilious headache and swellings. They are also used for treating inflammatory swelling (Varier, 1996 and Khare, 2007).

**Tagetes erecta** (Marigold)

**Description:** Tagetes erecta belongs to Family Asteraceae. It is an aromatic annual herb that reaches a height between 50-100 cm. It has pinnate green leaves. The flowers are hermaphrodite.

**Therapeutic uses:** The whole herb is anthelmintic, aromatic, digestive, diuretic, sedative and stomachic, different parts of this plant including flower are used in folk medicine to cure various diseases (Farjana et al., 2009). Petroleum ether extract of leaves and ethyl acetate extract of flower of *Tagetes erecta* significantly inhibit the growth of bacteria (Kiranmai and Ibrahim, 2012). Externally it is used to treat sores, ulcers, eczema, sore eyes and rheumatism (Kim et al., 2005). Das and Mishra, 2011 observed that alkaloids isolated from the leaves of *Tagetes* showed potent antimicrobial activity against bacterial strains of skin, mouth and ear microflora.
**Terminalia chebula (Haritkari, Harad)**

**Description:** *Terminalia chebula* belongs to the family Combretaceae. It is a medium- to large-sized tree distributed throughout tropical and sub-tropical Asia. It is a deciduous tree growing to 30m tall, with a trunk up to 1m in diameter. The leaves are alternate to sub opposite in arrangement. The fruit is drupe-like, 2–4.5-cm long and 1.2–2.5-cm broad, blackish, with five longitudinal ridges.

**Therapeutic uses:** Aqueous and ethanolic extract of *T. chebula* have strong antimicrobial activity against the uropathogen *E. coli* (Chatopadhyay et al., 2007). Gallic acid and its ethyl ester isolated from ethanolic extract of *T. chebula* showed antimicrobial activity against MRSA. It has reported to have antioxidant and free radical scavenging activities (Cheng et al., 2003). It is effective in inhibiting *Helicobacter pylori* (Malckzadeh et al., 2001), *Xanthomonas campestris* (Afzalakhtar et al., 1997) and *Salmonella typhi* (Rani and Khullar, 2004). It is reported to be hepatoprotective (Tasaduq et al., 2003; Tasduq et al., 2006), anti-inflammatory (Pratibha et al., 2004), immunomodulatory (Srikumar et al., 2005), and adaptogenic (Rege et al., 1999).

**Thymus vulgaris (Thyme)**

**Description:** *Thymus vulgaris* is a wide bush belonging to family Lamiaceae, It is native to Europe and found in all Mediterranean areas. It grows to 15–30 cm tall by 40 cm wide, it is an evergreen sub shrub with small, highly aromatic, grey-green leaves and clusters of purple or pink flowers in early summer.

**Therapeutic uses:** Essential oils of thyme containing high amount of thymol and carvacrol were reported to possess the highest antioxidant activity (Aeschbach et al., 1994). Thyme showed broad antibacterial activity by inhibiting the growth of both gram-positive and gram-negative bacteria. However, gram positive bacteria *Clostridium botulinum* and *Clostridium perfringens* appeared to be more sensitive than the gram-negative organisms (Nevas et al., 2004).
**Trigonella foenum graecum** (Fenugreek)

**Description:** *Trigonella foenum graecum* belongs to the Family Leguminosae. Fenugreek is an annual, leguminous plant. It has tri-foliate, obovate and toothed, light green leaves. Its stems are erect, long and tender. Blooming period occurs during summer. Flowers are yellow-white, occurring singly or in pairs at the leaf axils. Fruit is a curved seed-pod, with ten to twenty flat and hard, yellowish-brown seeds. They are angular- rhomboid, oblong or even cubic, and have a deep furrow dividing them into two unequal lobes.

**Therapeutic uses:** The seeds of the plant are used as a spice and leaves are edible and used as vegetable. Seed is reported to have antidiabetic, antimicrobial, anticancer, antifertility, antiparasitic, lactation stimulant and hypocholesterolemic effects. Ethanol extract of Fenugreek leaf is an important source for antibacterial components and phenolic antioxidants (Ramya *et al*., 2011).

**Valeriana officinalis** (Valerian)

**Description:** Valerian is a pungent perennial herb that is widely distributed in various temperate regions of globe, including Asia, Europe, and North America. The flowers are sweetly scented pink or white flowers which bloom in the summer months.

**Therapeutic uses:** Valerian root has been demonstrated to possess sedative and anxiolytic effects (Medscape, 2000). It has been used in Europe as a mild sedative for many centuries and was also used to treat epilepsy in the 17th century (Spinella, 2005). Valerian has been used for centuries in diverse parts of the globe to treat mild nervousness and insomnia (Boon and Smith, 2004; Wichtl, 2004; Schulz *et al*. 2004). Its oil possesses antibacterial activity against *A. tumefaciens, S. haemolyticus and B. subtilis* (Wang *et al*., 2010).
Zanthoxylum rhetsa (Teppal)

**Description:** *Zanthoxylum rhetsa* is a lofty, deciduous tall tree belonging to family Rutaceae. It is found in the evergreen monsoon forests of the foothills of Assam and Meghalaya and in the eastern and western ghats in peninsular India. The fruits yield an essential oil called Mullilam oil, which is obtained by steam distillation of the dried ripe fruits. The oil has pleasant odour resembling that of sweet orange and tangerine.

**Therapeutic uses:** It is used in the indigenous system of medicine for the treatment of cholera. The oil is also used as an antiseptic, a disinfectant, and for the treatment of asthma, toothache and rheumatism (Ambasta, 1986).

Zingiber officinale (Ginger)

**Description:** *Zingiber officinale* belongs to the family Zingiberaceae. It is a perennial herb with thick tuberous rhizomes. The erect leafy aerial stem grows up to approximately 1 m in height and has purple flowers. Its roots are used as spice in cooking throughout the world.

**Therapeutic uses:** It is widely used as an ingredient in the food, pharmaceutical, cosmetic and other industries. Traditionally ginger has been used to treat headaches, nausea, rheumatism, and colds (Grantz and Lutz, 2000). Methanolic extracts of ginger exhibit antibacterial activity against *S. aureus*, *P. aeruginosa*, *B. subtilis*, *S. typhi* and *Enteroamoeba faecalis* (Khalid et al., 2011). In another study the ginger extracts inhibited *B. subtilis*, *B. nutto*, *P. aerugenosa*, *Rhodoturola sp.*, *Salmonella newport*, *Salmonella enteritidis* and *Fusarium sp* (Sa-Nguanpuag, 2011). Ginger oils showed very good inhibition of *Salinococcus roceus*, *Halococcus turkmenicus* and *Halococcus morrhuae* isolated from salt cured fish (Prasad and Seenayya, 2000).
PLANTS USED IN THE STUDY

A. indica (Neem)  A. subulatum (Large cardamom)  C. annum (Red Pepper)

C. cecidodaphne (Sugandh kokila)  C. cyminum (Cumin)  C. fistula (Amaltas)

C. longa (Turmeric)  C. procura (Aak)  C. roseus (Sadabahar)

C. sativum (Coriander)  C. scarious (Nagarmotha)  C. zeylanicum (Cinnamon)
D. melanoxylon (Tendu) (Eucalyptus)
E. cardamomum (Small cardamom)
E. globules
F. vulgare (Fennel)
L. inermis (Heena)
N. jatamansi (Jatamansi)
O. europaea (Olive)
P. guajava (Guava)
P. nigrum (Black Pepper)
M. fragrans (Nutmeg)
M. koenigii (curry leaves)
M. alternifolia (Tea tree)
R. indica (Rose)
S. aromaticum (Clove)

T. chebula (Haritkari)
T. erecta (Marigold)
T. graecum (Fenugreek)

T. grandis (Teak)
T. vulgaris (Thyme)
V. officinalis (Valerian)

Z. officinale (Ginger)
Z. rhetsa (Teppal)
**Phytochemical analysis:** Plants have the ability to synthesize a wide variety of chemical compounds that are used to perform important biological functions, and to defend against attack from predators such as insects, fungi and herbivorous mammals. Many of these phytochemicals have beneficial effects on long-term health when consumed by humans, and can be used to effectively treat human diseases. At least 12,000 such compounds have been isolated so far, a number estimated to be less than 10% of the total (Tapsell 2006 and Lai 2004). Phytochemical constituents such as alkaloids, flavonoids, tannins, phenols, saponins, and several other aromatic compounds are secondary metabolites of plants that serve a defense mechanism against predation by many microorganisms, insects and other herbivores (Bonjar *et al.*, 2004).

**Phenols:** Phenols are aromatic chemical compounds with weakly acidic properties and characterized by a hydroxyl group attached to aromatic ring. Presence of phenols is considered to be potentially toxic to the growth and development of pathogens (Okwu and Okwu, 2004).

**Flavonoids:** Flavonoids are 15-carbon compounds generally distributed throughout the plant kingdom. They are known to be synthesized by plants in response to microbial infection and have been found to be effective against a wide array of microorganisms (Harborne, 1973).

**Alkaloids:** Alkaloids comprise the largest class of secondary plant substances which contain one or more nitrogen atoms (Harborne, 1973). They are often toxic to humans and many have dramatic physiological activities, hence they are widely used in medicine for the development of drugs (Okwu, 2005).

**Saponins:** Saponins are glycosides of both triterpines and steroids that are characterized by their bitter taste, foaming property, haemolytic effect on red blood cells and cholesterol binding properties (Okwu, 2005).

Various techniques have been used for the qualitative and quantitative estimation of phytochemicals. High Performance Liquid Chromatography (HPLC) is one such technique for checking purity and identity of crude drugs (Pemp *et al.*, 2007).
Gas Chromatography and Mass Spectroscopy (GC-MS) technique is versatile in its applications. Besides being commonly employed to study biomarkers in soluble bitumen fractions, it also finds application in other areas such as the medical, pharmacological, environmental, chemical engineering, law enforcement fields, etc. Thus in geochemical context, individual components or compounds in the soluble extracts or oil samples can be studied or identified by utilizing the GC-MS (Akande, 2012). This technique is very useful for the detection of biological volatile organic compounds and corresponding volatile profile characteristics (Zhang et al., 2009).

Synergism: Synergism has been defined as a phenomenon in which two different compounds are combined to enhance their individual activity. Synergy is often associated with the cliche “the whole is greater than the sum of the parts”, an idea which emerged at the time of Aristotle (350 AC), and is described in his work Metaphysics. Ayurvedic medicaments are also made from herbs or mixture of herbs, either alone or in combination with minerals, metals and other ingredients thereby reflecting the importance of synergism. Plant antimicrobials have been found to be synergistic enhancers in that though they may not have any antimicrobial properties alone, but when they are taken concurrently with standard drugs they enhance the effect of that drug (Kamatou, 2006). The synergistic effect from the association of antibiotic and plant extracts and between various forms of plants against resistant bacteria leads to new choices for the treatment of infectious diseases. In phytotherapy, there are potentially significant advantages associated with the synergistic interactions which may be of different antibiotics, or plant extracts or the synergy may be of antibiotic and plant extract. The advantages are (1) increased efficiency (2) reduction of undesirable effects (3) increase in stability or bioavailability of the free agents and (4) obtaining an adequate therapeutic effect with relatively small doses, when compared with a synthetic medication (Inui, 2007).