Chapter-I
Nature surrounds predominantly with the various shades of brilliant colours yellow, red and blue found in plant parts are due to the presence of one or more flavonoid group of compounds which form the largest group of phenolic compounds, one of the major secondary metabolites. Surveys reveals that 40% out of 300 million new prescriptions of natural drug origin contains one or more active ingredients, needs the knowledge of the biological activity and chemical constituents of plants is desirable not only for the discovery of new therapeutic agents and also to give scientific basis for the Phytomedicine from folk and herbal medicine. All indigenous medicines have their root in one way or the other in folk and Ethnomedicine. Indigenous medicines generally used as stimulants of digestion, antispasmodics, antiemetics, purgatives, antidiarrhoeals, anthelmintics, amoebicides and carminatives.

Folk medicine includes the diverse practices followed by nearly 5,000 ethnic communities across the country. The recipes and formulae have been handed down orally from generation to generation. Traditional birth attendants manage 90% of rural deliveries. It is also estimated that traditional bonesetters handle 60% of orthopedic cases in the country. Folk healers skills range from treating common ailments like Hepatitis, Visha (Poisonous) and mental diseases. According to World Health Organization 3.5 billion people in developing countries are using plant based medicines for their primary healthcare. About 20,000 plants are marketed for medicines and cosmetics. Almost 90% of the marketed plant drugs are from wild resources and over 120 important drugs are of plant origin (phytochemicals). Approximately half of the drugs currently in clinical use are of natural origin.

Pharmacology is the study of drug action, more specially the study of interactions that occur between a living organism and exogenous chemicals that alter normal biochemical function. It deals with the drugs interaction within biological systems to affect function. Early 19th century pharmacologists focused on natural substances, mainly plant extracts, as a biomedical source of principal therapeutic contents.

Pharmacognosy is defined as the branch of medicine which deals with drugs in their crude. Pharmacognosy is interdisciplinary including botany, ethnobotany,
medical anthropology, marine biology, microbiology, herbal medicine, chemistry, biotechnology, phytochemistry, pharmacology, pharmaceutics, clinical pharmacy and pharmacy practice.

Many angiospermic species have been discovered with medicinal properties (Kirtikar and Basu, 1975; Chopra et al., 1986). Millions of rural households use medicinal plants in a self-help mode. The plant based raw drugs in trade are consumed by the manufacturing units engaged in preparing formulations under different Indian systems of medicine (Table-1). They are estimated to be around 25,000 effective plant based formulations used in folk medicine known to rural communities all over India. Around 10,000 brilliantly designed formulations are available in the indigenous medical texts. Analysis of habit wise distribution of medicinal plants indicates that a little more than one third are trees and climbers are very less (Graph - 1).

### Table -1: Systems of medicine - species

<table>
<thead>
<tr>
<th>Systems of Medicine</th>
<th>No. of species</th>
</tr>
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<tbody>
<tr>
<td>Ayurveda</td>
<td>1769</td>
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<tr>
<td>Folk</td>
<td>4671</td>
</tr>
<tr>
<td>Homeopathy</td>
<td>482</td>
</tr>
<tr>
<td>Siddha</td>
<td>1121</td>
</tr>
<tr>
<td>Tibetan</td>
<td>279</td>
</tr>
<tr>
<td>Unani</td>
<td>751</td>
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</tbody>
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### Graph – 1: Medicinal Plants - Habitwise

Taxonomical distribution of Medicinal Plants (Graph -2)

Of the 386 Angiosperm families 2200 genera are medicinal plants from the major families of Asteraceae, Euphorbiaceae, Lamiaceae, Fabaceae, Rubiaceae, Poaceae, Acanthaceae, Rosaceae and Apiaceae share the large proportion of species, with the highest number of species (419) under Asteraceae.
Herbal products – Parts used (Graph-3)

An estimated 800 species are currently used in Industry for large scale production of herbal products. The highest plant part used in the industry is root with 29% followed by whole plant. But less than 20 species are under commercial cultivation more than 95% of medicinal plants are used by the Indian Industry are collected from the wild source. This poses a definite threat to the genetic stock and to the diversity of medicinal plants.

**Graph-2:**
**Taxonomical - distribution**

**Graph-3:**
**Medicinal Plants – Parts used**

**Phytochemistry** deals with the study of chemical structure of plant constituents, their biosynthesis, metabolism, natural distribution and biological functions. The subject of phytochemistry has developed in recent years as a distinct discipline between natural products, organic chemistry and plant biochemistry (Harborne, 1973). The medicinal values of the phytochemicals lies in bioactive constituents that produce definite physiological action on the human body, which work with nutrients to form an integrated part of defense system against various diseases and stress conditions. A large variety of chemical compounds are found in plants and these compounds differ in various plant groups. The natural constituents are conveniently divided as primary metabolites and secondary metabolites according to their functions in plant metabolism.

**Primary Metabolites:** Primary metabolites involve in vital metabolic pathways. Most of them are universal in plants and are of little taxonomic importance. *Aconitic acid* and *citric acid* are first discovered from *Aconitum* and *Citrus*. Plants
synthesize most of their simple and complex compounds known as primary metabolites (Margulin and Schwarz, 1986). Primary metabolites like proteins, sugars, carbohydrates, aminoacids, chlorophyll and fats are utilized by the other living organisms.

**Secondary Metabolites:** Secondary metabolites perform non-vital functions and are less under spread in plants compared to primary metabolites. These are generally by-products of metabolism. They were earlier considered to be waste products having no important role, but recently it was realized that during evolution, the success of plants in coping with all sorts of changes is dependent to a large extent on their ability to modify the rate of synthesis, and turnover of the compounds which control their growth and development and to produce specific compounds which act as toxins (or) deterrents to pathogens, herbivores and competitors or attract necessary symbionts for protective purposes (Nitecki, 1982; Demo and Meclure, 1983). Such compounds are biosynthesized through specifically evolved path ways (Salisbury, 1985) external to the primary biochemical mechanisms of the cell and are hence designated as **secondary metabolites** (Vickery and Vickery, 1901). The importance of these secondary metabolites in regulating various physiological processes were recognised and admitted.

**Biological activities of Secondary metabolites**

The secondary metabolites comprise a host of different classes including flavonoids, tannins, lignins, terpenoids, alkaloids, cyanogenic glycosides, glucosinolates, non-protein aminoacids and many others which have the ability to interact with primary metabolites. Almost all these compounds are found exclusively in plants, but the different classes show extensive variation in their quality and control.

**Alkaloids:** These are organic nitrogen contain bases with a heterocyclic ring. Alkaloids exhibit diversity of structures and also show an extra ordinary spectrum of Pharmacological activities, because of their characters, they are important for clinical, physiological, taxonomic and biogenic nature. **Vincistine, Vinblastine** are the alkaloids derived from Madagascar periwinkle **Catharanthus roseus** are used to treat cancer. Other alkaloids such as **Atropine** found in deadly Night Shade, **Atropa**
have a direct effect on the reducing fever, relieving pain and drying up of bodily secretions. Most of the alkaloidal drugs works on the central nervous system (Farnsworth, 1966). *Erythrina macrophylla* (papilionaceae) leaf contains *Erysodine*, and the seeds contain *Erysopine alkaloids* (Chawla et al., 1982). Alkaloids, one of the earliest isolated bioactive compounds from plants, are heterocyclic nitrogen compounds. They are derived from amino acids, and the nitrogen gives them alkaline properties. The mechanism of antibacterial action is attributed to their ability to intercalate with DNA, inhibition of enzymes (esterase, DNA, RNA-polymerase), inhibition of cell respiration (Kovacevic, 2004).

**Phenolic compounds:** Among the secondary metabolites, phenolic compounds form the major group. Consisting of *phenolic acids, phenols, flavonoids, phenylproponoids* and *phenolic quinones* with a single aromatic ring which differ in position of OH group substituents. They are widely distributed among plant kingdom and present as Phenolic acids, Phenols, Flavonoids, Phenyl proponoids, Phenolic quinines, can acts as antiseptic and anti-inflammatory. Flavones, Flavanones, Isoflavones, Isoflavans, Chalcones and Pterocarpanes are isolated from *Glycyrhiza glabra* (Al-Hazimi et al., 2003). Phenolic compounds are known for their multiple pharmacological properties such as insecticidal, antifungal, antibacterial, antiviral, antimicrobial and antiamoebic properties. Of all the groups of secondary metabolites used by chemotaxonomy phenolic compounds has more taxonomic value than the other compounds. Plant phenolics are numerous, are shown by Bate-Smith (1956); Harborne (1967) and Ribereau Gayon (1972).

**Polyphenols** (Fairbairn, 1959; Pridham, 1960; Thomson, 1995) comprise a distinct group with a wide range of substances such as *flavonoids, coumarins, quinones*, etc. Considerable interest has now been shown on plant flavonoids as human dietary components which acts as therapeutic agents having significant activity in a variety of isolated animal cell systems.

**Phenolic acids:** Phenolic compounds form a group of compounds based upon a *phenol* (C₆H₅OH). Simple phenols are made up of a single aromatic ring which differs in position of OH group substituents. These are widely distributed in plant kingdom, common examples are *catechol, orcinol, Hydroquinone, phloroglucinol*
and pyrogallol. Coumarins a group of natural phenols have a characteristic smell. Phenolic substances tend to be water soluble, since they most frequently combined with sugar as glycosides and they are usually located in the cell vacuole (Harborne, 1973).

**Glucosinolates:** Glucosinolates convert into isothionates (with sulfur) and indoles (without sulfur). They are found in Brassicaceae, particularly in Cauliflower and Cabbage. Glucosides are also present in mustard oil. They act against cancer by phase 2 enzyme induction. They have irritant effect on the skin causing inflammation and blisters, increase blood flow to the affused areas helping to remove the waste products, and also help to reduce thyroid function. Apiaceae and Capparaceae are placed in the order Capparales based on the presence of these chemicals (Gurucharan Singh, 2000).

**Non-proteinic aminoacids:** A large number of aminoacids are not associated with proteins. These proteins are distributed specific to certain groups. Lathrine is present only in Lathyrus, Canavanine occurs in Canavalia of papilionaceae are known to be protects against insect larvae. These aminoacids are usually present in storage roots (Gurucharan Singh, 2000).

**Terpenoids:** Terpenoids include a large group of compounds derived from mevalonic acid precursor and are mostly polymerized isoprene derivatives. Terpenoids are abundantly found in volatile oils, consisting complex mixture of terpenes, alcohols, ketones, aldehydes and esters. Separation of individual components is accomplished by vaccum fractionation and chromatography methods. Terpenoids can be divided into four groups as.

a) **True Terpenes:** These are the common group of terpenes are known as Iridoids and are largely present in waxy coatings of leaves and fruits, which helps in repelling insect and microbial attack. Lebbeakanin-A is isolated from seeds of Albizzia lebbeck (Varshney et al., 1973).

b) **Steroids:** Steroids are the terpenoid lipids characterized by a carbon skeleton with four fused rings, generally arranged in a 6-6-6-5 fashion. Steroids vary by the functional groups attached to these rings and in the oxidation state. Steroids
exhibit a variety of biological functions as the formation of cell membrane to regulate physiological functions. Many of the steroids and also the synthetic analogs are used extensively in the present day medicines. γ-Sitosterol (bark), Stigmasterol (root) are isolated from Albizia lebbeck (Tripathi and Dasgupta, 1981).

c) Saponins: Saponins are the glycosides of both steroids and triterpenes. They are mostly non-nitrogenous water soluble glycosides which reduce surface tension and produce lather on shaking. They are hydrolysed by acid to yield gums and sugars. They have been reported as asphyxiation of lice and other skin parasites. Therefore used in shampoos and other cosmetic preparations. Recently, saponins have been found to possess spermicidal, cardiovascular spasmolytic, expectorant, antihistaminic, antitusive activity and fungicidal properties.

Medicagenic acid is present in Medicago sativa.

d) Cardiac glycosides: Cardiac glycosides are an important group of naturally occurring drugs which functioned as both beneficial and harmful to the heart. They are used in the treatment of congestive heart failure and cardiac arrthonia. Cardiac glycosides inhibits the Na+/ K+ pump and increases the level of sodium ions in the myocytes, leads to a rise in the level of Ca²⁺ ions. This inhibition improves cardiac outputs, reduces distension of the heart.

Volatile oils: Volatile oils are the important plant constituents extracted from the plants to produce essential oils. The odorous, volatile principles of plant and animal sources are known as volatile oils and evaporate at ordinary temperatures. They are used as therapeutics in large extent and also as antiseptic and anti-inflammators. Cinnamic acid, Benzoic acid, Benzoylbenzoate, Toluresinotannol are the volatile oils found in Hydroxylon balsamum (Kokate et al., 2007).

Tannins: Tannins are the flavouring agents and antiseptic secondary metabolites which are present in liquid form in the cell sap and also in distinct vacuoles. They have been known since long time as the astringents substances having the capacity to combine with tissue proteins and precipitate them. They are therefore used in medicines for allied purposes or as mild antiseptics, in treatment of diarrhoea and as a check for small haemorrhages. Tannins have been reported as cytotoxic and anti-
neoplastic activities. Commercially they are employed in tanning leather and as mordants in dyeing, etc. **Catechol** is extracted from dried stem bark of *Saraca indica* (Ashoka) used as uterine tonic and oxytocic. **Kinotannic acid** from dried juice of *Pterocarpus marsupium* is used as hypoglycemic astringent (Kokate et al., 2007).

**Mucilages:** These are polysaccharide compounds found in many plants, when soak in water produce a sticky- jelly like mass. Mucilages are protecting the mucous membrane in the digestive tract of human against irritation, acidity and inflammation. This soothing and protecting activity shows its effect on the mucous membranes of the throat, lungs, kidneys and urinary tubules. The mucilaginous seeds of *Mimosa pudica* contain D-Xylose and D-glucuronic acid (Kokate et al., 2007).

**MAJOR PHENOLIC COMPOUNDS–SIGNIFICANT THERAPEUTIC ACTIVITIES**

Universal phenolic compounds among the angiosperms are p-hydroxy Benzoic acid, Protocatechuic acid, Vanillic, Syringic, Gentiisic, Ferulic, Sinapic, O-coumaric, P-coumaric, Chlorogenic, Isochlorogenic and Neochlorogenic acids. Coumarins have a characteristic smell (Gurucharan singh, 2000). The crushed leaves of *Anthoxanthum odoratum* can be identified by the characteristic smell. Flavonoids appear to be important in regulatory control of growth in peanut (*Arachis hypogaea*) and their presence in *Spinacia oleracea* (spinach) chloroplasts involved in photosynthesis. **Salicylic acid** is the fore runner of aspirin and is found in many plants like *Gaultheria procumbens* (winter green) and *Salix alba* (white willow). Another phenol is **thymol** a constituent of *Thymus vulgaris* (thyme).

Phenolics occur in several forms, in plants as soluble compounds extractable with water, methanol, aqueous and acetone (proanthocyanidins, flavonols, flavonols glycosides) and some as non extractable forms. Phenolics may remain in the residue after extraction as a result of their inherent insolubility due to their large molecular weights or covalently bonded in complexes with other constituents (Beart et al., 1985b; Hartley and Bucham, 1979; Hartley and keene, 1984; Muller-Harvey et al., 1986). Several simple phenolics are the derivatives of cinnamic acid, Benzoic acid and aldehydes in smaller amounts (Jung et al., 1983a; Hartley and keene 1984).
Aldehydes are apparently linked at their phenolic groups to cell wall polysaccharides (Hartley and Keene, 1984). Ferulic acids and P-Coumaric acids are esterified carbohydrates in plant cell walls (Muller-Harvey et al., 1986). The beneficial effects derived from phenolic compounds have been attributed to their anti oxidant activity (Heim et al., 2002). Polyphenols and phenolic acids are powerful antioxidants and have been reported to demonstrate antibacterial, antiviral, anticarcinogenic, anti inflammatory and vasodilatory actions (Shahidi and Naczk, 1995; Breinholt, 1999; Duthie, 2000).

**Caffeic acid** is a naturally occurring organic compound having the molecular formula C_9H_8O_4. This yellow solid consists of both phenolic and acrylic functional groups. It is found in all plants because it is a key intermediate in the biosynthesis of lignin, one of the principle source of biomass. Caffeic acid and its derivative caffeic phenyl ester (CAPE) and it is produced in many kinds of plants (Olthof et al., 2001).

**Protocatechuic acid** is a simple phenolic compound capable of modulating certain cellular enzymes as well as having anti-oxidative and anti-mutagenic activities (Tanaka et al., 1995). It shows chemopreventive nature against tumor production found in Hibiscus sabdariffa (Tsuit-Hwa Tsenga et al., 1997; Mori et al., 1999). The polymers of protocatechuic acid acts as antiviral agents against influenza virus (Lu et al., 2001). It has been reported to induce apoptosis in human leukaemia cells as well as malignant HSG cells taken from oral cavities (Babich et al., 2002). PCA has mixed effects on normal and cancer cells in vitro and in vivo studies (Linn et al., 2007). Depending on the amount of PCA and the time of application, PCA could reduce or enhance tumor growth (Wakamura et al., 2000). PCA was reported to increase proliferation and inhibit apoptosis of neural stem cells (Gunn et al., 2009).

**P-hydroxy Benzoic acid** acts as major antifungal and antibacterial agent (Dymicky and Hahtamen, 1979). **Ferulic acid** another important phytochemical compound found in plant cell wall components. It is related to trans cinnamic acid (Iiyama et al., 1994). It is biosynthesized from caffeic acid with C_{10}H_{10}O_{4} molecular formula. **Scopoletin** is a yellow crystalline powder belongs to the group of coumarins. It is found in nomi, manaca, passiflower, stevia etc. Scopoletin seems to
regulate blood pressure, has bacteriostatic activity against *E. coli*, *Staphylococcus aureus* and on *Streptococcus sps*. It has anti-inflammatory activity and is used to treat bronchial illness and asthma. It regulates hormone serotonin which helps to reduce anxiety and depression.

**Melilotic acid** is shown choleretic, analgesic, diuretic, anti-ulcerogenic activity in *Cinnamonum, Cassia* and *C. aromaticum*, it is the major constituent of bark. These plants used for gastro intestinal disorders (WHO monograph, 2002). This compound is derived from coumarin metabolic pathway as a main product (Kosuge, 1959). Presence of melilotic acid might shows a broad spectrum of antimicrobial properties and antispasmodic activity (Lewis and Lewis, 1977).

**Gentisic acid** is an aromatic carboxylic acid used as a sample matrix assisted laser desorption/ionization (MALDI) mass spectroscopy (Strupat et al., 1991). As a hydroquinone it is readily oxidized and is used as an anti-oxidant excipient in some pharmaceutical preparations (Levy and Tsuchiya, 1972). It is crystalline water soluble acid CH(OH) COOH, whose sodium salt has been used in medicine as an analgesic. **Salicylic acid** from bark of *Salix alba*, (willow tree) is a beta hydroxyl acid with molecular formula C₇H₆O₃ (C₆H₄ (OH) COOH). This colourless crystalline organic acid is widely used in organic synthesis and functions as a plant hormone, is chemically similar to aspirin (acetyl salicylic acid).

Flavonoids and bioflavonoids have been reported as antibacterial, anti-inflammatory, anti-allergic, anti-mutagenic, anti-viral, anti-neoplastic, anti-thrombic and vasodilatories (Vedavathy, 1992). Intake of flavonoids may be associated with decreased risk of cancer, cardiovascular and inflammatory diseases in humans (Haytowitz et al., 2000). Flavonoid, Quercetin is known for its ability to relieve hay fever, eczema, sinusitis and asthma. Quercetin and kaempferol were isolated and identified as active antimicrobial compounds (Swinder, 1985).

**Rutin** with molecular formula C₂₇H₃₁O₁₆ is also called rutinoside, quercetin-3-rutinoside and sophorin, is a citrus flavonoid glycoside found in buck wheat, leaves and petioles of *Rheum* and *Asparagus* (Kreft et al., 1999). **Myricetin** is a naturally occurring flavonol found in grapes, berries, fruits, vegetables with molecular formula C₁₅H₁₀O₈. **Apigenin** is a flavone aglycone of several glucosides
with molecular formula \( \text{C}_{15}\text{H}_{10}\text{O}_{5} \). It is a yellow crystalline solid that has been used to dye wool. **Orientin** is a flavone found in the passion floe, the Acai palm and *Adenanthera peregrine* with molecular formula \( \text{C}_{23}\text{H}_{20}\text{O}_{11} \) (Pastene *et al*., 2000). It is also reported in millets and *phylostachys nigra* (Linda Dukes, 2006). **Kaempferol** is a natural flavone that has been isolated from tea, broccoli, grapes, apples, onions and other plant sources (Jun Seong park *et al*., 2006), with molecular formula \( \text{C}_{13}\text{H}_{10}\text{O}_{6} \) yellow crystalline solid. **Quercetin** is a plant derived flavonoid specifically used as a nutritional supplement with molecular formula \( \text{C}_{15}\text{H}_{10}\text{O}_{7} \).

**MAJOR ANTHOCYANIDINS – THERAPEUTIC ACTIVITIES**

Anthocyanins as glycosides are having glucose, galactose, rhamnose, xylose, arabinose attached to the aglycon nucleus. Beautiful colours may result from the types of anthocyanins present and from their relative concentrations. Depending on the pH and the presence of chelating metal ions, they are intensively coloured in blue, violet or red. Extensive studies have indicate that anthocyanins have strong anti oxidant activities, and are easily damaged by heat (cooking). Proanthocyanidins (colourless substances sometimes called pycnogenols) are short-chained polymers of anthocyanidins that release anthocyanins, can protect endothelial cells from oxidative damage. Recent investigations have showed that pelargonidin-3-monoglucoside act as antibacterial (Mazza, 2004). Epidemiological investigations have shows that the Anthocyanins acts as lowering risk on coronary heart disease. They play important role in prevention against mutagenesis and carcinogenesis by showing inhibitory effect on the growth of some cancer cells. Taxonomists identified the role of anthocyanins in plant classification. The anthocyanins exists in several forms with a few structural variation as **Apigenin**, **Cyanidin**, **Delphidin**, **Hirsutidin**, **Luteolinidin**, **Malvidin**, **Pelargonidin**, **peonodin**, **petunidin**, **Rosindin** and **Tricetinidin**.

**Delphidin** is a primary plant pigment and also antioxidant (Farrukh *et al*., 2007), molecular formula with \( \text{C}_{15}\text{H}_{11}\text{O}_{7} \). Delphidin gives blue hues to flowers like violas and delphiniums, berries and in pomegranate. **Malvidin** is a primary plant pigment with molecular formula \( \text{C}_{17}\text{H}_{15}\text{O}_{7} \). It is primarily responsible for red color fruits of wine *Vitis vinifera*, and in *Primula polyanthus* plant. Slightly acidic and
neutral solutions of malvidin are characteristically red, while basic solutions yield a blue color. **Peonidin** with the molecular formula $C_{16}H_{13}O_{6}^+$, gives purplish red hues to flowers, and pH sensitive changes from red to blue. Because of its usual color or instability, safely-acylated buffer formulation has been patented to use as food coloring. **Cyanidin** is a natural organic compound, found in many red berries. It can also change its color along with pH, molecular formula $C_{15}H_{11}O_{6}^+$, is red when pH below 3, blue at higher than 11 and violet at neutral pH. In plants cyanidin is bound to a sugar molecule to form cyanidin 3-0-beta-glucoside.

**ANTI MICROBIAL ACTIVITY**

Resistance to antimicrobial agents has become an increasingly important and pressing global problem. Ample evidences have been obtained in the past three decades for a wide range of functions of secondary metabolites. Arrays of antimicrobial compounds defend against pathogens (Dixon, 2001; Hahlbrock et al., 2003). The increasing failure of chemotherapeutics and antibiotic resistance exhibited by pathogenic microbial infectious agents has led to the screening of several medicinal plants for their potential antimicrobial activity (Colombo and Bosisio, 1996; Iwu et al., 1999). The Phenolics and polyphenols are one of the largest groups of secondary metabolites that have exhibited antimicrobial activity. Plants should be investigated for the better understanding of their properties of safety and efficiency (Ellof, 1998). Also flavonoids are reported to possess many useful properties, including anti-inflammatory, oestrogenic activity, enzyme inhibition and antimicrobial activities (Havsteen, 1983, Harborne, 1999). The antimicrobial properties of propolis have been attributed to its high flavonoid content and in particular the presence of the flavonoids galangin and pinocembrin (Grange and Davey, 1990; Bosio et al., 2000). The flavonoid 7-hydroxy-3,4-(methylenedioxy)flavan, isolated from *Terminalia bellerica* fruit rind, has also been shown to possess activity against *Candida albicans* (Valsaraj et al., 1997). Two new flavones from *Artemisia giralda*, identified as 6,7,4-trihydroxy-3,5-dimethoxyflavone and 5,5-dihydroxy-8,2,4-trimethoxyflavone, together with 5,7,4-trihydroxy-3,5-dimethoxyflavone exhibit activity against *Aspergillus flavus* (Zheng et al., 1996). It was found that *Escherichia coli* DNA gyrase was inhibited to different extents of the compounds, including quercetin, apigenin and 3,6,7,3,4-
pentahydroxyflavone (Ohemeng et al., 1993). Coumarins have been found to stimulate macrophages, which could have an indirect negative effect on infections (Cowan, 1999).

There is renewed interest in search for plants with anti-microbial activity including Azandirachta indica, Camelia sinensis, Hypericum perforatum, Allium sativum displayed considerable activity (Ray et al., 2004). Oils of Rynchosia minima shows that it contains β-caryophyllene (30.4%), gemaacrene B (17.9%), camphor (7.8%), α-humulene (7.4%) and γ-muurolene (7.3%), shown significant inhibition against Bacillus cereus, Staphylococcus aureus and Micrococcus luteus (Mwangi et al., 2005). Rosmarinus officinalis, Salvia officinalis, Cinnamomum cassia and Syzygium aromaticum have been examined against Pseudomonas aeruginosa with Syzygium aromaticum methanolic extract showing high inhibition activity against the bacterial strain resistant to several antibiotics including ampicillin and erythromycin (Bassam et al., 2004). Biologically active flavonoids from Gossypium arboreum observed significant activity against some bacteria. Camellidius saponins from Camellia japonica showed anti fungal activity (Nagata et al., 1985).

ANTHELMINTIC ACTIVITY

Helminth infections are among the most common infections in man, affecting a large proportion of the world’s population. In developing countries they pose a large threat to public health, and contribute to the prevalence of malnutrition, anaemia, eosinophilia and pneumonia. Although the majority of infections due to worms are generally limited to tropical regions, they can occur to travellers who have visited those areas, and some of them can be developed in temperate climates. Parasitic diseases causing severe morbidity include lymphatic filariasis (a cause of elephantiasis), onchocerciasis (river blindness) and schistosomiasis. These infections can affect most availability and affordability of pharmaceutical medicines mean that the world’s population depends to a great extent on traditional medicinal remedies. Most diseases caused by the helminths are of a chronic and debilitating in nature; they probably cause more morbidity and greater economic and social deprivation among humans and animals than any single group of parasites. The parasitic gastroenteritis is caused by mixed infection with several species of stomach and
intestinal worms, which results in weakness, loss of appetite, decreased feed efficiency, reduced weight gain and decreased productivity (Gibbs, 1986).

Allopathy is the only treatment and effective tool to cure and control helmintic infection. There are no effective vaccines against helminths developed so far. Indiscriminate use of synthetic anthelmintics can lead to resistance of parasites (Singh et al., 2002). Herbal drugs have been in use since ancient times for the treatment of parasitic disease in human and could be of value in preventing the development of resistance (Chopra et al., 1956). Some synthetic phenolic anthelmintics e.g. niclosamide, oxyclosamide and bithinol are shown to interfere with the energy generation in helminth parasites by uncoupling oxidative phosphorylation (Martin, 1997). It is possible that tannins present in the plant extracts produced similar results. Another possible anthelmintic effect of tannins is that they can bind to free proteins in the gastro intestinal tract of host animal (Athanasiadou et al., 2001) or glycoprotein on the cuticle of the parasite and cause death (Thomson and Geary, 19995) (Fig-1).

Fig–1: Possible mechanism of action of different phytochemicals as anthelmintics
ROLE OF ANTIOXIDANT ACTIVITY

Antioxidants protect the cells and organ systems of the body against reactive oxygen species. Humans have evolved a highly sophisticated and complex antioxidant protection system. It involves a variety of components, both endogenous and exogenous in origin, that function interactively and synergistically to neutralize free radicals. Numerous other antioxidant phytonutrients present in a wide variety of plant foods. Reactive oxygen species (ROS) is a term which encompasses all highly reactive, oxygen-containing molecules, including free radicals. Types of ROS include the hydroxyl radical, the superoxide anion radical, hydrogen peroxide, singlet oxygen, nitric oxide radical, hypochlorite radical, and various lipid peroxides. All are capable of reacting with membrane lipids, nucleic acids, proteins and enzymes, and other small molecules, resulting in cellular damage (Table-2).

An **antioxidant** is a molecule capable of inhibiting the oxidation of other molecules. Oxidation is a chemical reaction that transfers electrons from a substance to an oxidizing agent. Oxidation reactions can produce free radicals in turn; these radicals can start chain reactions that damage cells. Antioxidants terminate these chain reactions by removing free radical intermediates, and inhibit other oxidation reactions. They do this by being oxidized themselves, so antioxidants are often reducing agents such as thiols, ascorbic acid or polyphenols (Sies, 1997). Although oxidation reactions are crucial for life, they can also be damaging; hence, plants and animals maintain complex systems of multiple types of antioxidants, such as glutathione, vitamin C, and vitamin E as well as enzymes such as catalase, superoxide dismutase and various peroxidases. Low levels of antioxidants, or inhibition of the antioxidant enzymes, cause oxidative stress and may damage or kill cells.

Antioxidants are widely used as ingredients in dietary supplements in the hope of maintaining health and preventing diseases such as cancer and coronary heart disease. In addition to these uses of natural antioxidants in medicine, and have many industrial uses, such as preservatives in food and cosmetics and preventing the degradation of rubber and gasoline. The action of one antioxidant may therefore depend on the proper function of other members of the antioxidant system (Vertuani
et al., 2004). The amount of protection provided by any one antioxidant will also depend on its concentration, its reactivity towards the particular reactive oxygen species being considered, and the status of the antioxidants with which it interacts (Vertuani et al., 2004). Antioxidants are found in varying amounts in foods such as vegetables, fruits, grain cereals, eggs, meat, legumes and nuts. Some antioxidants such as lycopene and ascorbic acid can be destroyed by long-term storage or prolonged cooking. Other antioxidant compounds are more stable, such as the polyphenolic antioxidants in foods such as whole-wheat cereals and tea. The effects of cooking and food processing are complex, as these processes can also increase the bioavailability of antioxidants, such as some carotenoids in vegetables (Maiani, 2008). In general, processed foods contain fewer antioxidants than fresh and uncooked foods, since the preparation processes may expose the food to oxygen.

**TYPES OF ANTIOXIDANTS (Table -2)**

Nutrient-derived antioxidants like ascorbic acid (Vitamin C), tocopherols and tocotrienols (Vitamin E), carotenoids, and other low molecular weight compounds such as glutathione and lipoic acid. Antioxidant enzymes like superoxide dismutase, glutathione peroxidase, and glutathione reductase, which catalyze free radical quenching reactions. Metal binding proteins, such as ferritin, lactoferrin, albumin, and ceruloplasmin that sequester free iron and copper ions that are capable of catalyzing oxidative reactions.

**Table-2: Types of ROS**

<table>
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<tr>
<th>ROS</th>
<th>NEUTRALIZING ANTIOXIDANTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hydroxyl radical</td>
<td>Vitamin C, glutathione, flavonoids, lipoic acid</td>
</tr>
<tr>
<td>Superoxide radical</td>
<td>Vitamin C, glutathione, flavonoids, SOD</td>
</tr>
<tr>
<td>Hydrogen peroxide</td>
<td>Vitamin C, glutathione, beta carotene, vitamin E, CoQ10, flavonoids, lipoic acid</td>
</tr>
<tr>
<td>Lipid peroxides</td>
<td>Beta carotene, Vitamin E, Ubiquinone, flavonoids, glutathione peroxidase</td>
</tr>
</tbody>
</table>