A REVIEW ON: PHARMACOLOGY WITH MEDICINAL PLANTS

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ABSTRACT
India has been identified as one of the top twelve mega biodiversity centre of the world. This is because India has a vast area with wide variation in climate, soil, altitude and latitude. India with its biggest repository of medicinal plants in the world may maintain an important position in production of raw material either directly for crude drugs or as the bioactive compounds in the formulations of pharmaceuticals and cosmetics etc.
INTRODUCTION:
Herbal medicines have been main source of primary health care in all over the world. From ancient times, plants have been catering as rich source of effective and safe medicines. About 80% of the world’s populations are still depending on traditional medicines. In India 20000 medicinal plants have been recorded (Dev, 1997). However, traditional communities are using only 7000 to 7500 plants for curing different diseases (Perumalsamy and Ignacimuthu, 1998; 2000; Kamboj, 2000; Kala, 2005; Jagtap et al., 2006; Perumalsamy et al., 2008).
In India, medicinal plants are listed in various indigenous systems such as Siddha (1121), Ayurveda (2000), Amchi (600), Unani (751), Allopathy (30) and Tibetan (337) plants species for different ailments. (Rabe and Staden, 1997; Kala and Mathur, 2002). Even from early civilization, herbs are considered to be a powerful tool in treating various illnesses. In places where physicians cannot reach, these herbal treatments have proved more superior and effective than its chemical counter parts. The knowledge of these valuable plant remedies have not been documented and was orally dissipated by the tribal populations. But these tribal possessed remarkably accurate knowledge about the medicinal use of the plants around them and still collect and preserve locally available wild and cultivated plant species and practice herbal medicine to treat a variety of diseases and disorders. (Mahishi et al., 2005; Meena et al., 2009).
Numerous drugs have entered the global market and international pharmacopoeia through the study of ethano-pharmacology and traditional medicine (Waxler, 1988). Major thrust by whole of the pharmaceutical industry is focused towards design and development of new innovative/indigenous plant based drugs through investigation leads from traditional system of medicine (Patwardhan et al., 2004).
According to World Health Organization (WHO), 80% of the world’s population primarily those of developing countries rely on plant derived medicines for their health care needs (Gurib – Fakim, 2006). Folkoric uses are supported by a long history of human experience and numerous biological active plants are discovered by evaluation of ethano pharmacological data and these plants may offer the local population immediately accessible therapeutic products (Perumalsamy et al., 2006). Indian folk medicine comprises hundreds of herbal preparations for the therapeutic purposes which may be
as varied as healing wounds treating inflammation due to infection, skin lesion, leprosy, diarrhea, scabies, venereal diseases, snake bite, arthritis, ulcer etc. (Ayyanar and Ignacimuthu, 2008).

The ethnic people all over the world have emotional and symbiotic relationship with biodiversity which they have been protecting and conserving since ancient times. Sacred groves, the tract of virgin forest harboring rich biodiversity protected by the local people are the repositories of rare and endemic species. It is essential to have a proper documentation of such plants to know the potential and values of medicinal plants for the improvement of health and hygiene through eco friendly system (Khumbongmayum et al., 2005). Several works on medicinal plants in relation to their utilization and conservation have been conducted in many parts of India (Airi et al., 2000; Dhar, 2002; Sumit and Dhar, 2002; Biswas et al., 2003; Srinivasamurthy et al., 2003).

Traditional medicine is widely used and accounted for around 40% of all health care delivered. Herbal medicines have good value in treatment of various diseases.

In many countries scientific investigation of medicinal plants have been initiated because of their potential (Patrick, 2002). About 85% of traditional medicines (TM) are plant derived (Fransworth, 1988). Traditional medicine and ethano botanical information play an important role in scientific research (Awadh et al., 2004; Kala, 2005). In India scientific interest in TM has continuously been increasing. The contribution made by the TM to modern system of medicine is worth noting. Many drugs have been developed by the scientists after analyzing the chemical constituents of plants traditionally used by tribal and villager (Jain et al., 2010).

The claims of local healers to offer drugs for diseases such as cancer, hypertension, asthma, jaundice, tuberculosis, leprosy, rheumatism etc. have been clinically examined by number of researches in pilot trials. Attempts are in progress to prepare compendium of house hold remedies from different parts of India, for the treatment of various ailments.

The efforts of World Health Organization (WHO) in compiling a global inventory of medicinal plants are noteworthy and if adopted by the Primary Health Care (PHC) as strategy, it could provide the people of all nations especially in developing countries, with comprehensive health care.
PHYTOCHEMICAL SCREENING

Plants are an essential component of the universe. Human beings have used plants as medicine from the very beginning of time. Medicinal plants are identified as a source of important medicine, treatment through these medicinal plants began in the early stages of human civilization. Several phytochemical surveys have been published. The major phytochemical profile present in medicinal plants are polyphenols, tannins, alkaloids, saponins, steroids, terpenoids, glycosides etc., attract the attention of researchers to investigate their chemical, toxicological and pharmacological features (Olayinka et al., 2010; Aberoumand, 2012).

Phytochemicals are biologically active naturally occurring chemical compounds present in plants, provide health benefits for human beings. (Hasler and Blumberg, 1999). Recently it is known that these phytochemicals have their role in protection of human health when their dietary intake is significant. More than 4000 phytochemicals have been catalogued and about 150 phytochemicals have been studied in detail. (American Cancer Society, 2000).

Preliminary phytochemical screening of Thymus capitapus exhibited the presence of saponins, resins, flavonoids, essential and fixed oils (Kandil et al., 1994). Ten fodder trees and shrub species growing in the Mediterranean zone were subjected to the quantitative analysis. The content of total phenolics and tannins ranges from 18.28 mg g\(^{-1}\) (Medicago sativa) to 218.15 mg g\(^{-1}\) (Arbutus unedo) and from 8.56 mg g\(^{-1}\) (M.sativa) to 27.99 mg g\(^{-1}\) (Robinia pseudoacacia), respectively. (Koukoura and Nastis, 1994).

Phytochemical screening of 155 plants collected from Peninsular Malaysia indicated that 29 species contained alkaloids, 119 species contained saponins and 126 species contained triterpenes/steroids. Six species were devoid of any of the natural products tested (Abu – Said et al., 1995). Hanna et al. (1996) isolated alkaloids, flavonoids, phytosterols, terpenoids, tannins and fatty acids from Solanum elaegnifolium and S. nigrum.

Phytochemical screening of the methanolic extract of leaves of Solanum macrocarpum and S. torvum revealed the presence of alkaloids, tannins and steroids (Ajaiyeoba, 1999). Among petroleum ether, chloroform, ethanol and aqueous extracts of aerial parts of Rivea hypocrateriformis, the ethanolic extract showed positive result for alkaloids, glycosides, saponins, tannins and phenolic compounds (Shivalingappa et al., 2001). Badana variety of pomegranate was containing highest
quantity (1.17%) of tannins among the different varieties of apple, pear, peach and pomegranate studied. (Tabasum et al., 2001).

Ethanolic extract of 45 million medicinal plants were studied for its phyto constituents qualitatively by Ahmad and Beg (2001). The study inferred that all plants found to possess common phyto compounds including phenols, tannins and flavonoids as major active constituents.

The investigation of Evans et al. (2002) in Euphorbia hirta, Citrus aurantifolia, Cassia occidentalis and C. eucalyptus revealed the presence of alkaloids and saponins in all parts of C. aurantifolia and C. eucalyptus, respectively. The roots of E. hirta and C. occidentalis found to contain saponins in trace. The results of Lavanya and Hemalatha (2002) stated that the phytocompounds such as carotenoids, anthocyanins and flavonoids were present in Vinca rosea. Sekar (2002) isolated anthroquinones from the methanolic extract of Cassia obtusa roots. The leaves of Centella asiatica found to contain flavonoids, terpenoids and carotenoids (Malini and Hemalatha, 2002).

Preliminary phytochemical analysis of Eupatorium odoratum showed the presence of glycosides, flavonoids, steroids, saponins and tannins (Ramana et al., 2003). Plaza et al. (2003) isolated a new triterpene glycosides from the stem of Anomospermum grandifolium. The methanolic leaf extract of Asystasia gangetica exhibited the presence of carbohydrates, proteins, alkaloids, tannins, steroidal aglycones, saponins, flavonoids, reducing sugar and triterpenoids (Akah et al., 2003).

Methanol, petroleum ether and aqueous extracts of 67 medicinal plants of Ethiopia showed the presence of several secondary metabolites like polyphenols, alkaloids, tannins, sterols, saponins and glycosides (Geyid et al., 2005). Triterpenes, flavonoids, glycosides and steroids were presented in alcoholic extract of *Hemidesmus indicus* (Prashant et al., 2005). Edeoga et al. (2005) studied the qualitative screening of phyto constituents from 10 medicinal plants belonging to different families. All the plants were found to contain alkaloids, tannins and flavonoids except for the absence of tannins in *Sida acuta* and flavonoids in *Stachytarpheta cayennensis*, respectively. The results of 20 Bulgarian fruits showed the highest total phenolic content in blue berries (670.9 mg GAE 100 g⁻¹), dogwood berries (432.0 mg GAE 100 g⁻¹) and sore cherry (429.5 mg GAE 100 g⁻¹). The greatest total flavonoid content was revealed in blue berries (190.3 mg CE 100 g⁻¹). The lowest total phenolics and total flavonoids were established in peaches (50.9 mg GAE 100 g⁻¹ and 15.0 mg CE 100 g⁻¹, respectively) (Marinova et al., 2005).

Aqueous decoction of *Mangifera indica* flowers indicated the presence of steroids, triterpenes, phenolic compounds and flavonoids. On the whole, the extract indicated the presence of total phenolics as 53 % (Limi et al., 2006). Phytochemical screening of aqueous extract of *Ficus sycomorus* stem bark exhibited the presence of gallic acids, tannins, saponins, reducing sugar, alkaloids and aglycones (Sandabe et al., 2006).

The toxicology evaluation of *Calycopteris floribunda* revealed the presence of flavonoids, alkaloids, tannins and saponins (Sreekanth et al., 2006).

Gilani et al. (2007) reported that *Rhazya stricta* found to contain more than 100 alkaloids. Phytochemical profile of 8 common green leafy vegetables was performed by Onyeka and Nwambekwe (2007). The ethanolic extract of *Carpolobia lutea* leaves confirmed the presence of tannins, saponins, flavonoids, cardiac glycosides, anthroquinones and terpenes (Nwafor and Bassey, 2007). The leaves, roots and stem bark of *Annona senegalensis* showed the presence of tannins, phlobatannins and saponins (Ogbadoyi et al., 2007).

Kubmarawa et al. (2007) studied the preliminary phytochemical screening of 50 medicinal plants from Nigeria. Banso and Adeyemo (2007) reported the presence of tannins, terpenoids, alkaloids, flavonoids, phenols, steroids, glycosides, saponins and volatile oils in *Dichrostachyes cinerea*. Oladiji et al. (2007) studied the phytochemical constituents of *Sorgum bicolor* which
inferred the occurrence of alkaloids and saponins. Chemical screening of aqueous extract of Orthosiphon stamineus showed phenolic compounds and flavonoids (Sriplang et al., 2007). The phytochemical screening of ethanolic extract of Carica papaya leaves, Mangifera indica stem bark, Psidium guajava leaves and Vernonia amygdalina leaves showed the presence of flavonoids, terpenoids, saponins, tannins and reducing sugars. M. indica did not contain cardiac glycosides and alkaloids while P. guajava showed the absence of alkaloids and anthroquinones (Ayoola et al., 2008). Studies of Venkateshwara Rao et al. (2008) in Chloroxylon swietenia inferred that the chemical constituent of this plant was used for various ailments like anorexia, dryness of mouth and bladder disorder etc.

Siddiqui et al. (2009) screened the presence or absence of preliminary phytochemicals such as alkaloids, tannins, saponins, flavonoids, steroids, cardiac glycosides, phenols and terpenoids using different solvent extract in some important medicinal and aromatic plants. Qualitative analysis of 4 important medicinal plants to detect the presence or absence of several bioactive compounds viz. anthroquinones, alkaloids, catechols, flavonoids, phenolic compounds, saponins, steroids, tannins and triterpenoids was performed by Chitravadivu et al. (2009).

Studies of Doss (2009) inferred that the medicinal plants viz. Asteracantha longifolia and Passiflora edulis were found to contain phenols, cardiac glycosides, steroids, saponins and tannins except for the absence of flavonoids in A. longifolia and alkaloids in P. edulis, respectively. Phytochemical profile of methanolic extract of 4 medicinal plants revealed the presence of major phytocompounds like alkaloids, glycosides, phenolics and saponins (Zahin et al., 2009).

Results of Krishnaiah et al. (2009) indicated that 6 Malaysian medicinal plants are found to contain alkaloids, flavonoids, phenolic compounds, tannins, anthracine derivatives and essential oils as its phytoconstituents. Meghvansi et al. (2009) reported the presence of tannins, saponins, flavonoids, phenols, while alkaloids, steroids, cardiac glycosides and terpenoids were absent in some important medicinal and aromatic plants.

Preliminary phytochemical analysis of leaves and stem extracts of Achyranthes aspera showed the presence of flavonoids and saponins (Tullanithi et al., 2010).
A comparative phytochemical analysis of cocoa and green tea was performed by Subhashini et al. (2010). The study indicated the presence of phenols and flavonoids. Panda et al. (2010) reported the qualitative phytochemical analysis of *Chromolaena odorata* and this plant exhibited the presence of alkaloids, carbohydrates, tannins and phenolic compounds. Analysis of phytochemical constituents of some medicinal plants in Tamil Nadu was carried out by Manjamalai et al. (2010).

The phytochemical screening revealed the presence of carbohydrates, alkaloids, tannins, flavonoids, glycosides, steroids and saponins in *Anacardium occidentale* (Abulude et al., 2010). James and Friday (2010) studied the phytochemical composition of *Euphorbia heterophylla* leaf. The order of decreasing concentrations of phytochemical was as alkaloids > cyanides > tannins > flavonoids > saponins. The leaves, stem and flowers of *Ipomoea carnea* were analyzed for phenol and flavonoid content by Katiwora et al. (2010). The results revealed that the flowers contained the maximum (73 mg CE g\(^{-1}\)) and stem contained the minimum (30 mg CE g\(^{-1}\)) amount of phenolic compounds.

The flavonoid content of leaves, stem and flower were found ranging from 84 to 422 mg quercetin E g\(^{-1}\) of dry sample. The flavonoid content of the flowers was quit high compared to that of the leaves and stem.

Sathyaprabha et al. (2010) reported the presence of phytochemical constituents viz. tannin, phlobatannin, saponin, flavonoid, steroid, terpenoid and cardiac glycosides in *Aloe vera* and *Cissus quadrangularis*. Preliminary phytochemical analysis of *Eclipta alba* and *Morinda citrifolia* extracts showed the presence of different groups secondary metabolites viz. alkaloids, flavonoids, tannins, terpenoids and saponins which are of medically importance (Sharma and Sharma, 2010). Praveenkumar et al. (2010) carried out the identification of phytochemical evaluation of total phenols, total flavonoids in *Vitex negundo* leaves. The phenolic content was 27.72 mg 100g\(^{-1}\) of gallic acid equivalent (GE).

Qualitative phytochemical screening of 18 important medicinal plants confirmed the presence of various phytochemical like saponins, terpenoids, steroids, anthocyanines, coumarins, fatty acids, tannins, leucoanthocyanins and emodins (Savithramma et al., 2011). Studies of Yadav and Munin (2011) in 7 medicinal plants showed the occurrence of phytochemicals such as total phenolics
and flavonoids. The total phenolic content and flavonoid content ranged from 11.6 mg g\(^{-1}\) to 71.6 mg g\(^{-1}\) and 4.4 mg g\(^{-1}\) to 42.8 mg g\(^{-1}\), respectively.

Phytochemical analysis in the ethanolic leaf extract of *Centella asiatica* and *Tephrosia purpurea* showed the presence of flavonoids, tannins, saponins, while alkaloids was absent (Deshpande and Bhalsing, 2011). The screening and study of seven different plant seeds belonging to different families for phytochemical constituents viz. tannins, saponins, phlobatannins, terpenoids, flavonoids, cardiac glycosides, cartotenoids, steroids and alkaloids was performed by Ajayi *et al.* (2011 a).

Petroleum ether, acetone, methanol, ethanol and water extracts of leaf and stem of *Argyreia involucrata* showed the presence of carbohydrates, cardiac glycosides, phenols, flavonoids and saponins (Shaik, 2011). The phytochemical screening of ethanolic root extract of *Plumbago zeylanica* showed the presence of alkaloids, tannins, steroids, flavonoids, saponins, anthraquinones and phlobatannins (Ajayi *et al.*, 2011 b).

Meena *et al.* (2011) reported the phytochemical evidences of the Genus *Wedelia*. The results revealed the occurrence of alkaloids, steroids, tannins, cardiac glycosides, coumarins, anthoquinones, glucosides, sugars and proteins. Sulaiman *et al.* (2011) reported that about 4.36g GAE 100 g\(^{-1}\) of total phenolics occurred in selected raw vegetable.

Andarwulan *et al.* (2012) found that about 0.85 g GAE 100 g \(^{-1}\) of total phenolics presented in under utilized medicinal vegetables. The total flavonoid content of three herbs species namely *Majorana hortensis*, *Satureja hortensis* and *Thymus vulgaris* ranged from 2.36 to 4.10 g CE 100 g \(^{-1}\) dry weight of plant material (Vabkova and Neugebauerova, 2012). An attempt was made to survey the phytochemicals of the flowers of ten taxa namely *Cassia auriculata*, *Catharanthus roseus*, *Hibiscus rosa-sinensis*, *Lawsonia inermis*, *Michelia champaca*, *Mangifera indica*, *Mimusops elengi*, *Moringa oleifera*, *Nelumbo nucifera* and *Rosa indica* by Thiripura Sundari *et al.* (2012). The results inferred that all the ten flowers were found to contain flavonoids and phenols.

Phytochemical analysis of an under explored plant *Melothria perpusilla* indicated the occurrence of flavonoids, cardiac glycosides, triterpenes, steroids and tannins (Menaga *et al.*, 2012). Varadharajan *et al.* (2012) reported the phytochemical analysis in the ethanolic leaf extract of
Annona squamosa. Preliminary phytochemical screening of crude leaf extract of Clerodendrum philippinum was performed by Venkatanarasimman et al. (2012). Presence of sterol, sugar, alkaloids, phenolic compounds, flavonoids, tannins, saponins and amino acids were reported by Jeyasree and Dasarathan (2012) in Cinnamomum tamala.

Studies of Iqbal (2012) indicated the presence of active compounds like alkaloids, tannins, saponins, glycosides, phenols, flavonoids, anthroquinones, terpenoids and steroids in six native plants of Agra city. Phytochemical screening of secondary metabolites of Ziziphus mauritiana bark indicated the occurrence of all the main secondary metabolites viz. alkaloids, flavonoids, glycosides, phenols, lignins, saponins, sterols and tannins in various extracts namely petroleum ether, chloroform, methanol and distilled water. (Jain et al., 2012)

Quantitative analysis of phenolics, alkaloids, saponins and flavonoids had revealed that Mentha spicata possessed maximum phenolics (80.41%), Gmelina arborea had the highest alkaloids (5.66%) and flavonoids (22.80%) and Trigonella foenum-graecum had the highest saponins (50.12%) content (Soni and Sosa, 2013). Ai – Daihan et al. (2013) studied the phytochemical analysis of Zingiber officinale, Curcuma longa, Cumminphora molmol and Pimpinella anisum. The results inferred that alkaloids were found in Z. officinale and C. molmol whereas flavonoids in C. longa and P.anisum, steroids and tannins were found only in Z. officinale and C.longa, respectively. Studies of Wadood et al. (2013) in 10 different medicinal plants showed the presence of terpenoids, phlobatannins, reducing sugars, flavonoids and alkaloids. Leaves of Anacardium occidentale contained 19.78 % of total phenolics and 1.97 % of total flavonoids (Nugroho et al., 2013).

Quantitative analysis of seeds and fruits of Bennincasa hispida indicated the presence of alkaloids, cyanogenic glycosides, saponins, steroids, carbohydrates and amino acids (Mishra et al., 2014; Nadhiya et al., 2014). Various extracts of leaves, stem and roots of Uraria picta found to contain alkaloids, flavonoids, steroids, terpenoids, phenols, saponins, tannins and cardiac glycosides (Saxena et al., 2014). Jagtap et al. (2014) studied the phytochemical screening of Habenaria longicorniculata and inferred that plants are rich in a variety of primary secondary metabolites such as carbohydrates, glycosides, alkaloids, vitamin E & C, flavonoids, phenols and saponins.
Phytochemical composition of four Nigerian medicinal plants viz. *Memordica balsamina, Pavetta crassipes, Phyllanthus amarus* and *Aloe vera* showed the presence of cardiac glycosides, tannins, phenols, alkaloids, saponins, phlobatannins, steroids and flavonoids (Temitope and Ayodele, 2014). Nancy Immaculate Mary et al. (2014) analysed the phytoconstituents of *Vitex trifolia* leaf in various extracts. The result indicated the occurrence of alkaloids, flavonoids, phenols, saponins, steroids, tannins and terpenoids. The acetone extract found to contain high amount of flavonoids (0.432 mg) and tannins (0.521 mg) compared to the other extracts used in this study.

Six different extracts of a very rare medicinal plants, *Melodinus eugeniifolius* leaves and barks were screened for their phytochemical composition for the first time by Lu et al. (2014). The results inferred the presence of alkaloids, cardiac glycosides, sterols, steroids and flavonoids which are exploited in the management of various diseases like cancer, cardiovascular diseases and infection diseases. Investigation of Obouayeba et al. (2014) in *Hibiscus sabdariffa* petal extracts indicated that alkaloids, anthocyanines, flavonoids, saponins, steroids, sterols and tannins were the main phytochemical groups with biological activities. The results also inferred that anthocyanin seems to be the major compound (16.53 mg g$^{-1}$) followed by phenol (7.40 mg g$^{-1}$) and flavonoids (3.50 mg g$^{-1}$).

*Dolicandrone atrovirens* leaf and bark contain saponin (15.99 and 17.36 mg g$^{-1}$) total flavonoids (44.11 and 56.16 mg g$^{-1}$) and total phenols (71.95 and 93.51 mg g$^{-1}$) (Saminathan and Kavimani, 2015). Sowmya et al. (2015) quantified the phytochemicals like phenol (80.1 mg g$^{-1}$) tannin (98.3 mg g$^{-1}$) and alkaloids (277.2 mg g$^{-1}$) in *Cayratia trifolia*. The preliminary phytochemical screening indicated the presence of one or more phytoconstituents like steroids, terpenoids, alkaloids, tannins, cardiac glycosides, triterpenoids, flavonoids, saponins, phenols in *Adina cordifolia* (Prakash et al., 2015); *Anthocleista vogelli* (Nwali et al., 2015); *Coleus aromaticus, Hypitis suaveolens, Mentha arvensis* and *Ocimum basilicum* (Asha et al., 2015) and *Salix viminalis* (Zarger and Khatoon, 2015).

**GC-MS ANALYSIS**
Chromatography is the term used to describe a separation technique in which a mobile phase carrying mixture is caused to move in contact with the selectively absorbent stationary phase. It
also plays a fundamental role as an analytical technique for quality control and standardization of phyto therapeuticals (Andrew, 2007). The principle of gas chromatography is adsorption and partition. Gas chromatography has gained wide spread acceptance in numerous application areas such as process control in chemical plants, quality control in food industries, monitoring the sample composition in oil industries, environmental and Biomedical sciences. The first and main area of use is in the separation and analysis of multi component mixtures such as essential oil, hydrocarbons etc. It can quantitatively determine materials present at low concentrations. The second most important application area is in pollution studies, forensic work and general trace analysis. It is widely used for quantitative and qualitative analysis of mixtures and for the purification of compounds.

The combination of speed sensitivity and the high resolving power in gas chromatography provides a very adequate technique for the separation of complex samples. GC coupling to spectrometric methods such as mass spectrometry (MS) for different identification of unknown compound is easy to establish. Gas chromatography (GC-MS) is normally used for direct analysis of components existing in traditional medicines and medicinal plants. A knowledge of the chemical constituents of plants is desirable not only for the discovery therapeutic agents, but also because such information may be of great value in disclosing new sources of economic phyto compounds for the synthesis of complex chemical substances and for discovering the actual significance of folkloric remedies (Milne et al., 1993).

In recent years GC-MS studies have been increasingly applied for the analysis of medicinal plants as this technique has proved to be a valuable method for the analysis of non polar components, volatile essential oil, fatty acids, lipids, alkaloids, steroids etc (Betz et al., 1997; Hanbali et al., 2005; Chandra Mohan et al., 2012; Suryavathana and Rajan, 2012; Thiripura Salini and Shankar, 2014).

The alkaloid profile of *Cadaba fruticosa* and *C. rotundifolia* studied by Yousif et al., 1984) by GC – MS method. Tan et al. (2002) isolated three new homoisoflavonone glycosides from bulbs of *Ornithogalum caudatum* by GC – MS analysis.
The chemical composition of the volatile oil constituent from the roots of *Pulicaria odora* has been analysed by GC – MS. About twenty-seven components were identified and the main constituents such as thymol (47.83%) and isobutyrate (30.05%) exhibited a significant anti-bacterial activity (Hanbali *et al*., 2005). GC – MS analysis of the essential oils of the aerial parts of *Pimpinella aurora* was reported by Delazar *et al.* (2006 a). The seeds of *Croton tiglum* were subjected to GC – MS (Mangunwidjaja *et al*., 2006).

Lacikova *et al.* (2007) analysed four *Staphylea* plant species and identified four tocopherols, three sterols, amyrine, cyclourtenol, actinidiolide and linolenic acid by GS-MS method. GC-MS analysis of ethyl acetate extract of *Goniothalamus umbrosus* exhibited the presence of 1-butyl-2-cyclohexenol (46.84%), benzaldehyde (4.42%) and Globulol (4.07%) (Abdelwahab *et al*., 2009). In *Aloe vera* 26 bioactive compounds were identified by GC – MS method (Arunkumar and Muthuselvam, 2009).

A total of 20 compounds were identified from the essential oils of the aerial parts of *Ornithogalum procerum*. The identified compounds represented 70.27% of the total essential oils. The main components of the aerial parts were phenylacetaldehyde (7.57%), hexahydrofarnesylacetone (8.13%), docosan (5.52%) and 5 – methyl octadecane (4.63%) From the n – hexane and hydrolysed methanolic extracts of bulbs, 7 hydrocarbons representing 99.39% of the total extract and 4 polysterol type compounds representing 59.81% of the extract respectively, were detected. The GC – MS analysis revealed that the essential oils were mainly composed of oxygenated hydrocarbons, the n – hexane extract contained predominantly hydrocarbons and the hydrolysed methonolic extract comprised polysterol type compounds. (Delazar *et al*., 2009).

GC – MS study was performed in aerial parts of *Gmelina asiatica* (Merlin *et al*., 2009), leaves of *Gleistinthus collinus* (Parasuraman *et al*., 2009), leaves of *Euphorbia longum* and *Goniothalamus umbrosus* (Siddiq Ibraham *et al*., 2009) to support the presence of different phytochemical constituents.

GC-MS analysis of the volatile components of the aerial parts of *Macfadyena unguis-cati* revealed the presence of 52 compounds with major components namely n-decane (12.12%) and phytol.
GC – MS study of *Aspilla africana* leaf oil revealed the abundance of sesquiterpenes (57.5%) and α-cubebene (31.1%) as the major component. (Usman *et al.*, 2010). GC-MS analysis of *Aloe vera* and *Cissus quadrangularis* showed the presence of squalene, oleic acid and dodecanoic acid and eugenol, n-Hexadecanoic acid, 1,2 Benzene dicarboxylic acid, diiso octyl ester, phenol and 2,4 bis (1-phenyl ethyl) respectively (Sathyaprabha *et al.*, 2010). The GC-MS study was carried out in *Vitex negundo* showed the presence of phytochemicals like 4 H-pyran-4-one, 2, 3-dihydro-3, 5-dihydroxy-6 methyl – (RT : 6.17), phytol (RT : 19.67) and vitamin E (RT : 25.11) (Praveenkumar *et al.*, 2010). The GC – MS was conducted on various parts of the plants viz., *Lantana camera* (Maria Jancy Rani *et al.*, 2011), *Mimosa pudica* (Sridharan *et al.*, 2011) and *Indigofera trita* (Vinoth *et al.*, 2011).

In the GC – MS method, 19 bioactive phytochemical compounds were identified in the alcoholic extract of *Cadaba trifoliata*. The main important compounds in very high peak area were 1,2 – Benzenedicarboxylicacid,mono(2-ethylhexyl)ester(43.52%) and 1 – methyl – pyrrolidine – 2 – carboxylic acid (32.63%) (Velmurugan and Kamaraj, 2011). 47 bioactive compounds were identified by GC – MS method in the ethanolic extract of *Naringi crenulata*. The major constituents were hexadecanoic acid, lupeol, lup – 20 (30) –en – 3 – one, stigmast – 4 – EN – 3 – one etc apart from other major and minor constituents presented (Sampathkumar and Ramakrishnan, 2011). Investigation by Priya *et al.* (2011) represented the occurrence of compounds viz n – Hexadecanoic acid (44.23%) and oleic acid (21.08%) in the methanolic extract of *Caralluma fimbriata* as major constituents among 14 bioactive compounds identified.

A study was conducted in *Mussaenda frondosa* which showed the presence of about 20 different chemical constituents through GC-MS analysis (Gopalakrishnan and Vadivel, 2011). Rajeswari *et al.* (2011) indicated the presence of sesquiterpenoids, nitrogenous compounds, aldehydes, terpinolene and phenol constituents, which are considered to be responsible for the anti-microbial, anti-tumour and antioxidant properties. The results of Sarumathy *et al.* (2011) revealed the presence of phytochemicals namely 9,12,15 octadecatrienoic acid, methyl esters, 2,2,2-n hexadecanoic acid, 1,2-benzenedicarboxylic acid and di-iso-octyl esters in ethanolic extract of *Caesalpinia sappan*. The
ethanolic extract of *Murraya koenigii* by GC – MS method revealed the existence of 1-Methyl-pyrrolidine-2-carboxylic acid (69.00%), Ethyl-a-d-glucopyranoside (13.36%), Isolongifoline, 4,5-dehydro- (3.68%), Himachalene (2.88%), 1,2-ethanediol, monoacetate (2.79%), 1,2 benzene dicarboxylic acid, diiso octyl ester (2.55 %)(Hema *et al.*, 2011).

Methanolic extract of *Justicia wynaedensis* indicated the presence of 24 phytocompounds by GC – MS. Hexadecanoic acid (synonym : palmitic acid), 2H-1-Benzopyran-2-one, 3,4-dihydro (synonym: Dihydrocoumarin/melitol) and 3,7,11,15- Tetramethyl-2-hexadecan-1-1 (synonym: phytol) were found as the major components in the extract. Palmitic acid is reported as an antioxidant, in addition to nematicide as well as a pesticide and melitol, phytol are depicted to be an anti carcinogenic agents. Apart from these certain other antioxidants such as tetradecanoic acid, hexadecanoic acid, heptadecanoic acid, 2,6,10,14, 18, 22 – tetracosa hexane, 2,6,10, 15, 19, 23 – hexamethl (synonym: squalene), gamma tocopherol, vit E, Ergot-5-en-3, Beta-ol (synonym: Campesterol) and stigmasta – 5,22 – dien-3 beta-01 (3, beta, 22E) – (synonym: stigmasterol) were isolated. The occurrence of different antioxidants in *J. wynaedensis* emphasizes the high antioxidant property observed (Ponnamma and Manjunath, 2012).

The methanolic extract of *Eupatorium triplinerve* revealed the existence of ten compounds.Hexadecanoic acid (14.65%), 2,6,10-trimethyl, 14-ethylene – 14-pentadecane (9.84%), heptanes (2.38%), decanoic acid (3.86%), 1-undecanol (7.82%), 1-hexyl-1-nitrocyclohexane (2.09%), 1, 14-tetradecanediol (6.78%), octadecanoic acid (19.18%) and 2-hydroxy-3 [(9E) -9-octadecanoyl oxy] propyl (9E)-9 octadecanoate (8.79%) were identified as the major constituents.. The GC-MS method confirmed the occurrence of 10 major compounds with retention time 15.084, 15.75, 16.2, 16.40, 16.96, 17.15, 18.38, 19.986, 20.148 and 21.619, respectively. The major three compounds such as hexadecanoic acid, tetradecanoic acid and octadecanoic acid have been shown to have hypocholesterolemic activity, antioxidant and lubricative properties. The Anticancer as well as antiproliferative activities had been proved due to the presence of tetradecanoic acid and 2,6,10 – trimethyl-14-ethylene-14-pentadecane. The existence of 1-hexyl-1-nitro cyclohexane and 1,14- tetra decanediol had also depicted their antimicrobial and anti-inflammatory activities (Selvamangai and Anusha, 2012).
By GC-MS analysis about 13 bioactive phytochemical compounds were isolated in the ethanolic extract of *Cassia auriculata* by duly comparing their retention indices and mass spectra fragmentation patterns with those stored on the computer library of MS. The 3, 0-methyl d-glucose (59.71%), 2H- cyclopropa(a) naphthalene-2-one, 1, 1 a, 4, 5, 6, 7, 7 a, 7 b -octahydro-1, 1, 7, 7a-tetramethyl (11.57%) and azulene (10.80%) were identified as the major constituents. The other important constituents identified were phytol, squalene and1,2-Benzenedicarboxylic acid, diisoocyl ester (Senthilkumar and Vijayakumari, 2012 a).

Eight bioactive phytochemical compounds were isolated in the ethanolic extract of *Euphorbia hirta* through GC-MS analysis. The results revealed that the compounds such as 1, 6,10, 14 -Hexa decatetra en-3-ol, 3, 7, 11, 15 - tetra methyl - (E,E), Phytol and diazoprogesterone were major components (Suresh *et al.*, 2012 a). By GC-MS study nine bioactive constituents were found in the ethanolic extract of *Boerhaavia diffusa*, which confirm the occurrence of myo-inositol 4-c methyl, 1,14 Tetra decanediol phytol and vitamin E acetate as major constituents (Umamenaka *et al.*, 2012).

Abirami and Rajendran (2012), estimated the bioactive compounds from *Vernonia cinera* by applying GC-MS method. They found out n-hexadecanoic acid (42.88%) and 1, 2 benzene dicarboxylic acid diisoocyl ester (23%) as major constituents. The GC-MS study of ethanolic extract of whole plant of *Polygonum chinense* indicated the presence of squalene with anticancer and antioxidant properties by Bhagavathi and Neelamegam (2012). In *Calortropis procera* by applying GC-MS method Doshi *et al.* (2012) reported the presence of 9 phytochemicals. Of them, 2,6 dimethyl tetra-1,5-decaene and 3, 7,11 – Trimethyl – 2,6,10,12 – pentadecatrien-1-ol were the newly reported compounds from the latex.

The GC – MS investigation on *Tylophora indica* led to the identification of 10 compounds in which Phytol, Ethyl tridecanoate and Oleic acid found to be the major compounds (Gurav, 2012).

In the ethanolic extract of *Cardiospermum halicacabum* leaves by applying GC – MS method 15 different bioactive components were isolated. Of which 3-0 methyl d glucose, α- Amyrintrimethylsilyl ether, 1, 14 Tetradecanediol, vitamin E acetate and phytol were the major constituents followed by squalene and silane, 1, 4 phenylene bis (trimethyl) Senthilkumar and
Vijayakumari, 2012b). Suresh et al. (2012b) examined the ethanolic extract of Tephrosia purpurea by GC–MS method indicated the presence of myo-inositol 4-c methyl, squalene and phytol as major constituents. GC–MS analysis of Acalypha indica was performed by Chandra Mohan et al. (2012). Suryavathana and Rajan (2012) studied the chemical constituent of roots of Pseudathria viscida by GC – MS analysis.

The study was performed by Hemlal and Ravi (2012) to evaluate the chemical composition of the methanolic extract of Pseudathria viscida and Desmodium gangeticum. They have found out 43 compounds from P. viscida in which cis – Vaccenic acid (16.47%), γ – sitosterol (13.73%) and stigmasterol (6.24%) were estimated as the major constituents and 18 compounds from D. gangeticum of which 9,12 – Octadecadienoic acid (41.71%), n – Hexadecanoic acid (9.43%) and Octadecanoic acid (5.9%) were identified as unique constituents by applying GC – MS method. GC- MS analysis revealed the presence of 17 compounds in methanolic extract of Cassia italica leaf. The phytochemical components screened in this study were phytol, squalene, n-Hexadecanoic acid which may responsible for curing cancer, inflammation, arthritis etc (Sermakkani and Thangapandian, 2012).

In Wedelia chinensis leaf extract, Rehana Banu and Nagarajah (2013) reported the presence of 25 compounds of which the major compounds include 9, 12, 15 octadeca trienoic acid, methyl ester, (z,z,z) (13.68%) and pentadecanoic acid, methyl ester (10.04%). Shirsat et al. (2013) reported the presence of bioactive compounds viz., Tetradecane (20.51%), 1-butoxy, 2-ethyl hexane (13.91%), betulin(10.84%) and 2-methyl benzoic acid (10.13%) in aerial parts of Calotropis gigantea.

Phytochemical compounds such as 3-picoline-2-nitro, 1-acetyl beta carboline, Hydroxy citronellal, Trans decalone, Propionic acid-2-chloro,ethyl ester, Lavandulyl acetate and D-Glucoronic acid were identified by GC-MS study in Acacia nilotica and it is proved as an effective drug for various human diseases (Hemamalini et al., 2013). Investigation of Kalimuthu and Prabakaran (2013) showed the existence of 28 kinds of compounds with different chemical structures. The presence of various bioactive compounds confirms the application of Ceropegia pusilla for various ailments by traditional practitioners. Various phytoconstituents were isolated
by GC-MS analysis in *Calanthe triplicate* (Mythili et al., 2013); *Ficus religiosa* (Manorenjitha et al., 2013); *Ipomoea pes-caprae* (Kumar et al., 2014); *Cleome viscosa* (Manikandan et al., 2014) and *Cyperus rotundus* (Elezabeth et al., 2014).

The ethonalic extract of *Calanthis coromandelicum* leaves was analysed by GC-MS and 21 different compounds were identified. Among the 21 components squalene was found to be the major component available at RT 23.18 min. and 27.62% peak area and has several beneficial properties such as antioxidant, tumor protective, cardioprotective and preventive effect on breast cancer. (Thiripura Salini and Shankar, 2014).

GC-MS analysis revealed the presence of 23 phytoconstituents in *Hibiscus tiliaceus* (Nandagopalan et al., 2015) 47 compounds in *Salix viminalis* (Zarger and Khatoon, 2015) and 48 compounds in *Bruguiera cylindrica* (Revathi et al., 2015). GC-MS analysis of *Dolichandrone atrovirens* showed the presence of 12 compounds in leaf 11 compounds in bark extracts. Phytol in leaf and squalene in bark have phytopharmaceutical importance (Saminathan and Kavimani, 2015).

**HPTLC ANALYSIS**

Densitometric HPTLC has been widely used for the phytochemical evaluation of the herbal drugs, due to its simplicity and minimum sample clean up requirement. Finger print analysis by HPTLC has become an effective and powerful tool for linking the chemical constituent profile of the plants with botanical identity and for the estimation of chemical and biochemical markers (Dash et al., 2010; Patil et al., 2010a; Ramya et al., 2010). It also offers the better resolution and estimation of active constituents with reasonable accuracy in a shorter time. It has also been found to be rapid sensitivity, precise, accurate and applied for simultaneous quantification of phyto constituents.

Chromatographic finger print has been suggested to be practical and comprehensive approach for identifying authenticity and evaluating the quality, consistency and the stability of raw herbal materials as well as herbal extracts (Koll et al., 2003). HPTLC is a valuable tool for reliable identification of the medicinally important plants (Rakesh et al., 2009a,b; Sampathkumar and Ramakrishnan, 2011). This HPTLC profile also been used to distinguish the medicinally important plants from its adulterant.
β-Asarone content was quantified by Agarwal et al. (1994) in *Acorus calamus* by applying HPTLC method. Pharmacologically important three curcuminoids namely curcumin, demethoxy curcumin and bisdemethoxy curcumin were isolated from *Curcuma longa* by HPTLC method (Gupta et al., 1999).

The biologically active diterpenoids namely 14-deoxy-11,12-didehydroandrographolide, andrographolide, neandrographolide and andrographiside in *Andrographis paniculata* were isolated by HPTLC method (Saxena et al., 2000). Tripathi et al. (2006) quantified the phyllanthin and hypophyllanthin in *Phyllanthus* spp. through HPTLC.

Seven polyherbal formulations containing *Cassia angustifolia* leaves available in the Indian market for the treatment of constipation due to the occurrence of two unique hydroxyl anthracene glycosides viz sennosides A and B. Of which sennoside A and B were recovered as 95%, 97% respectively (Wasim Aktar et al., 2008). The occurrence of pharmacologically important curcuminoids such as curcumin, demethoxycurcumin and bis-demethoxycurcumin in *Curcuma longa* was reported by using HPTLC method (Paramasivam et al., 2008).

Three different polyphenols with Rf value of 0.52, 0.58 and 0.7 were identified by HPTLC method in *Pandanus odoratissimus* (Sasikumar et al., 2009). The HPTLC method provided a good resolution of quercetin with average recovery percentage of 99.33 from other constituents present in hydroalcoholic extract of dried flowers of *Nymphaea stellata* (Rakesh et al., 2009b).

Erasto and Mbwambo (2009) reported that ethyl acetate extract of *Lagenaria siceraria* was found to contain 7 compounds in fresh fruits and 9 compounds in dry fruits by utilizing HPTLC method.

Plumbagin, a 5 – hydroxyl – 2 methyl – 1,4 – napthoquinone an active chemical constituent of the root of *Plumbago zeylanica* was isolated by HPTLC analysis. This biomolecule has been proved as an anticarcinogenic, antiatherosclerotic and antimicrobial agent (Sasikumar et al., 2010). HPTLC profiling of leaves of *Ruellia tuberosa* and *Dipteracanthus patulus* (Manikandan and Victor Aroki Doss, 2010); *Crataeva tapia* (Patil et al., 2010a); *Adenanthera pavonina* (Dash et al., 2010) were reported.
Sajeeth et al. (2010) estimated the amount of gallic acid, rutin and quercetin in herbal plants and Rajkumar and Sinha (2010) identified a compound namely budmunchiamenis in Albizia amara by HPTLC. Ramya et al. (2010) conducted the phytochemical survey in certain selected flower extracts. HPTLC finger printing of the extracts marked the presence of three compounds in petroleum ether and nine components in aqueous extracts of Boswellia serrata (Zeeyauddin et al., 2011).

HPTLC has been applied for the quantification of reserpine in Rauwolfia serpentina by Lohani et al. (2011). The method proposed was highly precise, sensitive, specific and reproducible with an average recovery of 78%. By the way of applying HPTLC method in 3 species of Plumbago (Aryanathan and Rajamanickam, 2011); Naringi crenulata (Sampathkumar and Ramakrishnan, 2011) Aerva lanata (Johnson et al., 2011) different types of terpenoids, alkaloids, steroids and flavonoids of Aerva lanata (Yamuna Devi et al., 2011 a , b, c; 2012 a); Mangifera indica (Neelima et al., 2012) it has been concluded the presence of different kinds of bioactive molecules responsible for the pharmacological activities like anti-inflammatory, diuretic, hepatoprotective, antidiabetic, antihyperglycemic, antihyperlipidemic and anti microbial.

Investigation by HPTLC finger printing analysis of phytochemical compounds of crude leaf extract of Barleria cristata support the presence of alkaloids and phenolic compounds (Quercetin) in it (Narmadha and Devaki , 2012). The methanolic extract of stem, leaves, roots, flowers and seeds of Aerva lanata illustrated the presence of 24 different types of tannins with 24 different Rf values with a range between 0.01 and 0.93. Maximum number (10) of tannins were observed in flowers and seeds followed by leaves (9). The tannins with Rf value 0.01 was present commonly in the aerial parts of the plant. The tannins with Rf values 0.53, 0.67 and 0.80 showed their joined presence in stem and leaves and this study providing a valuable phytomarker for the identification and characterization of A.lanata (Yamua Devi et al., 2012 b).

By using HPTLC method stigmasterol was quantified from methanolic root extract of Pseudarthria viscida (105.15 µg ml⁻¹) and Desmodium gangeticum (20.9 µg ml⁻¹) by Hemlal and Ravi (2012). HPTLC of hydro-alcoholic extract of plant leaves Pentapetes phoenicea confirmed the presence
of seven components with different Rf values ranging from 0.02 to 0.78 under U.V.light 366λ (Sharma et al., 2014a).

A high performance thin layer chromatographic method was developed by Sheikh et al. (2014) for the qualitative finger printing analysis of Clerodendrum serratum, Fumaria officinalis and Eclipta alba. This investigation revealed the existence of different types of phytochemical elements with Rf value ranges from 0.37 to 0.96 in C. serratum (5 compounds) from 0.06 to 0.98 in F. officinalis (10 compounds) and from 0.08 to 0.96 in E. alba (6 compounds).

HPTLC fingerprinting of flavonoids revealed the occurrence of five polyvent phytoconstituents with Rf value ranges from 0.09 to 0.84 in petroleum ether extract while, the methanol extract showed 10 phytoconstituents with Rf value ranges from 0.07 to 0.84 in Pergularia daemia leaves (Sutar and Pal, 2015). Results of Sowmya et al. (2015) indicated the presence of six different tannin and four different phenolic compounds in Cayratia trifolia by HPTLC method. HPTLC fingerprints of flavonoids of Hyptis suaveolens, Coleus aromaticus and Ocimum basilicum showed the presence of gallic acid, ferulic acid, chlorogenic acid, quercetin and rutin (Asha et al., 2015).

FREE RADICALS AND THEIR MECHANISM OF ACTION

Free radical can be defined as a chemical compound, which contains an unpaired electron spinning on the peripheral layer around the nucleus. The free radicals are generated from the oxygen which is called ROS (Reactive Oxygen Species). It causes damage to other molecules by extracting electrons from them in order to attain stability. ROS are ions, atoms or molecules that have the ability to oxidize reduced molecules.

The ROS are different forms of activated oxygen, which include free radicals such as superoxide anion radicals (O₂⁻) and hydroxyl radicals (OH⁻), non-free radicals (H₂O₂) and singlet oxygen (¹O₂) (Halliwell, 1995). Superoxide anion radicals increase during stress conditions like heavy exercise, certain drugs, infection and various disease states. During normal metabolic processes, human body generates more than 2 Kg of O₂⁻ per year (Evans and Halliwell, 1999).

The free radicals are from two sources in the body namely endogenous sources, e.g. nutrient metabolism, ageing process etc and exogenous sources e.g. tobacco smoke, ionizing radiation, air pollutants, organic solvents, pesticides etc (Buykokuroglu et al., 2001).
Free radicals are chemical substances which can exist separately with one or more unpaired electrons. The propagation of free radicals can bring about thousands of reactions and may cause extensive tissue damage. Lipids, proteins and DNA are susceptible to attack by free radicals (Yu et al., 1992; Cotran et al., 1999). Most of the free radicals that occur in vivo originate either from ROS (Reactive Oxygen Species) or Reactive Nitrogen Species (RNS). Most of free radicals produced in vivo are oxidants, which are capable of oxidizing a range of biological molecules like carbohydrates, fatty acids, amino acids and nucleotides (Knoncke et al., 1995; Cooper et al., 2002).

Free radicals are generated in the body during drug metabolism, exposure to ionizing radiation, UV light, pollution etc which lead to a chain of reactions and may magnify the cell damage by several folds (Naik et al., 2005). Free radicals are very reactive and unstable and thereby damage the cells either by cell mutation or destruction (Nencini et al., 2007). The free radicals mediated cell damage may play an important role in occurrence of many disorders viz Diabetes, Coronary Heart Disease CHD and Cancer (Srividya et al., 2009).

**REACTIVE OXYGEN SPECIES (ROS)**

Reactive oxygen species are also called as Active Oxygen Species (AOS). In living organisms, various ROS are formed in different ways, including normal aerobic respiration, stimulated polymorph nuclear leucocytes, macrophages and peroxisomes. They constitute the main endogenous source of most of the oxidants produced by cells. Exogenous source of free radicals might be tobacco smoke, ionizing radiation, certain pollutants, organic solvents and pesticides (Naphade et al., 2009). The ROS may be ions, atoms or molecules. They have the ability to oxidize reduced molecules and are short lived entities that are continuously generated at low levels during the course of normal aerobic metabolism. ROS are of different forms of activated oxygen which include singlet oxygen (¹O₂), superoxide (O₂⁻), hydrogen peroxide (H₂O₂), hydroxyl radical (OH•) etc. (Bickers and Ather, 2006).
Reactive Oxygen Species (ROS) and Reactive Nitrogen Species (RNS) are together named as free radicals and other non-radical reactive derivatives are known as oxidants. Free radicals are lesser stable than non-radical species, although their reactivity is generally stronger. Free radicals are produced from molecules via the breakage of chemical bonds to give another radical and also via redox reaction (Bahorun et al., 2006). Hydroxyl (OH’), Superoxide (O2’), Nitric oxide (NO’), Nitrogen dioxide (NO2’), Peroxyl (ROO’) and lipid peroxy (LOO’) radicals are of free radicals whereas Hydrogen peroxide (H2O2), Ozone (O3), Singlet oxygen (1O2), Hypochlorous acid (HOCl), Nitrous acid (HNO2), Peroxynitrite (ONOO’), Dinitrogen trioxide (N2O3) and Lipid peroxide (LOOH) are not free radicals and are called as oxidants. However these oxidants may lead to free radical reactions in living organisms (Genestra, 2007).

Reactive oxygen species (ROS) plays an important role in physiological processes, however the excess ROS causes oxidative damage to molecules. Under physiological conditions, the production and detoxification of ROS are more or less balanced. In the thyroid, ROS and free...
radicals participate in physiological and pathological processes. For example, hydrogen peroxide (H$_2$O$_2$) is crucial for thyroid hormone biosynthesis, acting at different steps of the process. Moreover, H$_2$O$_2$ is believed to participate in the Wolff–Chaikoff’s effect, undergoing in conditions of iodide excess in the thyroid. Further evidences are available to indicate that oxidative stress is involved in pathogenesis of thyroid functions, eg. Graves’ disease, goitre formation or thyroid cancer (Karbownik and Lewinski, 2003).

When oxygen traps single electron, it becomes unstable and thus very reactive, since it produces harmful chain reactions against many biological molecules. The extreme toxicity of oxygen is related to its high capability of generating free radicals and in turn destroying many major biological molecules. They can attack lipids and proteins and destroy membranes. ROS can also damage DNA and lead to mutation and chromosomal damage. Oxidized cellular thiols abstract hydrogen atoms from unsaturated fatty acids to initiate the peroxidation of membrane lipids (Valko et al., 2006).

**BENEFICIAL ACTIVITIES OF FREE RADICALS AND OXIDANTS**

At low or moderate concentrations, ROS and RNS are needed for maturation process of cellular structures and act as weapons for the host defence system. Indeed, phagocytes like neutrophils, macrophages and monocytes release free radicals to destroy invading pathogenic microbes as part of the body’s defence mechanism against infectious disease (Young and Woodside, 2001; Droge, 2002). At low or moderate concentration, certain free radicals play beneficial physiological role in vivo which include energy production, cell growth, function in different cellular signalling systems and induction of mitogenic response (Poli et al., 2004).

At high concentrations, ROS behave as an important mediator to damage cell structures, nucleic acids, lipids and proteins (Valko et al., 2006; 2007). Superoxide radical (O$_2^{-}$) is responsible for lipid peroxidation and has the capability to decrease the activity of other antioxidant defence system of enzymes like catalase (CAT) and glutathione peroxidase (GP$_X$). It damages the ribonucleotides, which are involved in DNA synthesis. The protonated form of (O$_2^{-}$) is HO$_2^{-}$, which is more reactive and able to cross the membrane and tissue damage. OH$^-$ radical is the most reactive chemical entity and potent cytotoxic agent which able to attack almost every
molecule present in living tissue. H$_2$O$_2$ is not a radical, but produces toxicity to cells by causing DNA damage, membrane disruption and release calcium ions within cells, resulting in activation of calcium dependent photolytic enzymes. Metal induced generation of ROS attacks DNA and other cellular components involving poly unsaturated fatty acid residues of phospholipids, which are extremely sensitive to oxidation (Siems et al., 1995).

**ANTIOXIDANTS AND THEIR FREE RADICAL SCAVENGING ACTIVITY**

Antioxidants are micronutrients which have attracted prime importance nowadays due to their ability to neutralize free radicals or their actions (Vadlapudi and Naidu, 2010). Antioxidant, a known free radical scavenger by offering easy electron targets to the free radicals. In absorbing a free radical, antioxidants stabilize the lone free radical electron and make it stable enough to be transported to an enzyme, which combines two stabilized free radicals together to neutralize. Hence, compounds that inhibit or scavenge the ROS / RNS are of great interest as possible protective agent to help human body from the oxidative damage (Kuriakose and Kurup, 2010).

![Figure II](image)

Antioxidants have been detected in plenty of agricultural and food products including cereals, fruits, vegetables and oil seeds. Antioxidants are increasingly being recommended because they
act directly on oxidative processes and may be useful in preventing diseases and health problems related to ageing (Aguire and Borneo, 2010).

Nowadays a growing interest in searching natural antioxidants is for three main reasons

i. The consumption of fruits and vegetables rich in antioxidants is associated with reduced risk of developing chronic diseases such as cancer, cardiovascular disorders and diabetes supported by numerous clinical and epidemiological studies.

ii. Safety consideration with regard to harmful effects due to prolonged consumption of artificial antioxidants like butyl hydroxyl anisole and butyl hydroxyl toluene in preserved foods and beverages.

iii. Awareness of the publics that natural and dietary antioxidants are safer than synthetic analogues. Therefore, the food industry is making a great effort to find out new sources of safe and inexpensive antioxidants of plant origin (Rechc Cho et al., 2011).

An antioxidant is any substance that retards or prevents deterioration, damage or destruction by oxidation (Dekkers et al., 1996). At a time one antioxidant molecule can react with single free radicals and is capable to neutralize free radicals by giving one of its own electrons ending the carbon stealing reaction. Antioxidants protect cell and tissue damage against excessive free radicals by their repair mechanisms.

**Figure III**

**Neutralization of Free Radicals**

A variety of components acts against free radicals to neutralize them from both endogenous and exogenous origin. They include
Endogenous enzymatic antioxidants
Non – enzymatic, metabolic and nutrient antioxidants
Metal binding proteins like ferritin, lactoferrin, albumin and ceruloplasmin.
Phytoconstituents and phytonutrients (Jacob, 1995).

**TABLE I**

Various ROS and corresponding neutralizing antioxidants

<table>
<thead>
<tr>
<th>S. No</th>
<th>ROS</th>
<th>Neutralizing antioxidants</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Hydroxyl radical</td>
<td>Vitamin C, Glutathione, Flavonoids, Lipoic acid</td>
</tr>
<tr>
<td>2</td>
<td>Superoxide radical</td>
<td>Vitamin C, Glutathione, Flavonoids, SOD</td>
</tr>
<tr>
<td>3</td>
<td>Hydrogen peroxide</td>
<td>Vitamin C, Glutathione, β-Carotene, Vitamin E, CoQ_{10}, Flavonoids, Lipoid acid</td>
</tr>
<tr>
<td>4</td>
<td>Lipid peroxides</td>
<td>β-carotene, Vitamin E, Ubiquinone, Flavonoids, Glutathione peroxidase</td>
</tr>
</tbody>
</table>

**NATURAL ANTIOXIDANTS**

Plants are the rich source of natural antioxidants. The secondary metabolites of plants like flavonoids, tocopherols, folic acid, carotenoids, ascorbic acid, cinnamic acid, benzoic acid, tocotrienols etc., are some of the natural antioxidants produced by the plant for their sustenance. β-carotene, ascorbic acid and alpha tocopherol are the mostly utilized antioxidants (McCall and Frei, 1999). Plant antioxidants have been reported to prevent the occurrence of diabetes, cancer and ageing. It can interfere with the oxidation process by reacting with free radicals, catalytic metals and also by acting as oxygen scavengers (Buyukokuroglu et al., 2001).

Many synthetic antioxidants such as Butylated Hydroxyl Anisole (BHA) and Butylated Hydroxy Toluene (BHT) have been used to suspend the oxidation process. However the application of synthetic antioxidants must be under strict regulation because of their potential health hazards (Park et al., 2001). The main disadvantage of the synthetic antioxidants include their side effects like carcinogenicity when taken in vivo (Chen et al., 1992).

Hence the search for natural antioxidants is an alternative source which is of great interest among researchers. Plants are enriched with free radical scavenging molecules like vitamins, terpenoids,
phenolics, lignins, tannins, flavonoids, quinones, coumarins, alkaloids, amines and other metabolites, which are abundant in antioxidant activity (Zheng and Wang, 2001; Cai et al., 2003). Studies have emphasized that many of these antioxidant compounds possess anti-inflammatory, anti-atherosclerotic, anti-tumour, anti-mutagenic, anti-carcinogenic, anti-diabetic, anti-bacterial and anti-viral activities (Rice – Evans et al., 1995; Sala et al., 2002).

Flavonoids, the most common group of polyphenolic compounds that are found ubiquitously in plants. These are widely distributed in plants fulfilling many functions. Flavonoids and other plant phenolics are common in leaves, flowering tissues and woody parts such as stems and barks (Kahkonen et al., 1999).

Presently there is a growing interest in the therapeutic potentials of medicinal plants as antioxidants in reducing free radical induced tissue damages. Besides, well known and traditionally used natural antioxidants from tea, wine fruits, vegetables, spices and many other plant species have been investigated in the search for novel antioxidants from plant origin (Koleva et al., 2002). Twenty two Nigerian medicinal plants were extracted and screened for antioxidant activity using the 2, 2, diphenyl picryl hydrazyl radical (Oke and Hamburger, 2002).

Flavones, flavonols and pro anthocyanidins are popular compounds associated with antioxidant activity in plants (Skerget et al., 2005). Phenolics can be divided into two groups viz polyphenolics and simple phenols which contain phenolic acids.

The antioxidant properties in plants are due to the presence of polyphenol, phenolic acid, flavonoid and vitamin C (Marinova et al., 2005).

Flavonoids have pigmented functions which are responsible for the colour of flowers, fruits and sometimes leaves. Other functions of flavonoids include antioxidant and antimutagenic activities, role on plant growth regulation and on resistance to plant diseases. Flavonoids protect the plants from UV-damaging effects too (Gurib-Fakim, 2006).

Flavonoids have gained recent attention due to their pharmacological activities. Flavonoids have been reported to exert multiple biological properties including anti-microbial, cytotoxicity, anti-inflammatory as well as anti-tumour activities. Of which the most important property of flavonoids is their capacity to serve as powerful antioxidant which can protect the human body from free radicals.
and ROS, depends upon their molecular structure. The position of hydroxyl groups and other features in the chemical structure of flavonoids are important for their antioxidant and free radical scavenging activities. On the other hand, flavonoids such as luteolin and catechins are better antioxidants than the nutrient antioxidants such as vitamin C, vitamin E and β-carotene (Tapas et al., 2008).

Gallium aparine, a Rubiaceae member contains tannins, phenolic acids, flavonoids and iridoid glycosides in leaves and stems (Vanwyk and Wink, 2004). Flavonoids, phenols, tannins and terpenoids in the plants exhibit antioxidant activity (Rice Evans, 2004; Aderogba et al., 2005; Basile et al., 2005). The epidemiologic data on the health effects of polyphenols, focusing on the flavonoid subclasses of flavonols, flavones and catechins and on lignans, showed that both flavonoids and lignans have beneficial effects on cardiovascular diseases but not on cancer with the possible exception of lung cancer. Flavonoids constitute a group of natural compounds that occur in fruits, vegetables, wine, tea, chocolate and other cocoa products (Sies et al., 2005).

Kim and Lee (2005) identified a new compound namely Dicaffeoylquinic acid in Chrysanthemum morifolium which is having the antioxidant property. Aqil et al. (2006) investigated on 12 traditionally used Indian medicinal plants and stated that they are having antioxidant characters since they possess phytochemical substances.

Li et al. (2006) reported that the polyphenols is one of the most numerous groups of substances in plant kingdom ranging from simple molecules, such as phenolic acids to complex compounds such as tannins. In addition, it has a capacity to trap and scavenge free radicals due to their antioxidant properties.

Thangaraj et al. (2007) studied the antioxidant property of Emblica officinalis during restrain –stress in albino rats. Administration of E. officinalis (500 mg kg⁻¹ body weight for 30 days) significantly prevents the restrain – stress induced oxidative stress and elevation in LPO and corticosterone levels which may be due to its strong antioxidant property.

There are records that phenolic compounds and their derivatives are effectively correlated with antioxidant activities (Maisuthisakul et al., 2007) and plants with high antioxidant activities also have high total phenolics and flavonoid contents. Vaijanathappa et al. (2008) reported the in vitro antioxidant activity in Enicostemma axillare. All the four extracts of E. axillare showed
potent antioxidant activity with IC₅₀ values ranging from 13.26 to 24.36 µg ml⁻¹. The chloroform extract has shown potent antioxidant activity in H₂O₂, nitric oxide and hydroxyl radical using the deoxyribose and lipid peroxidation methods, with IC₅₀ values of 16.99 ±0.38, 60.66 ±0.30, 25.06 ±0.12 and 94.66 ±2.40 µg/ml, respectively.

Concentrations of the plant extracts required for 50% inhibition of DPPH radical scavenging effect (IC₅₀) were recorded as 0.04 mg ml⁻¹, 0.313 mg ml⁻¹, 0.58 mg ml⁻¹, 2.30 mg ml⁻¹ and 0.054 mg ml⁻¹ for Psidium guajava, Mangifera indica, Carica papaya, Vernonia amygdalina and vitamin C, respectively (Ayoola et al., 2008). Kumar et al. (2008) reported the antioxidant activity of selected medicinal plants namely Albizia amara, Achyranthes aspera, Cassia fistula, Cassia auriculata and Datura stramonium determined by inhibition of lipid peroxidation technique revealed that the highest inhibition of lipid peroxidation activity was observed in A. amara (96%) followed by C. fistula (89%) and C. auriculata (89%). The potency of protective effect of A. amara was about 4 times greater than the synthetic antioxidant, BHT which indicated that the antioxidant activity of A. amara could be harnessed as a drug formulation.

Ethanolic extract of Ficus racemosa exhibited significantly higher antioxidant activity than the water extract. Ethanolic extract of F. racemosa exhibited concentration dependent DPPH, ABTS - hydroxyl radical and superoxide radical scavenging and inhibition of lipid peroxidation with IC₅₀ comparable with tested standard compounds (Veerapur et al., 2009). The radical scavenging activity of methanolic extract of four Indian medicinal plants viz. Plumbago zeylanica (Root), Acorus calamus (Rhizome), Hemidesmus indicus (Stem) and Holarrhena antidysenterica (Bark) indicated that the percentage decrease of 1, 1-diphenyl -2-picryl hydrazyl radical (DPPH) standard solution was recorded maximum for H. indicus (77.0%) followed by P. zeylanica (73.41%), A. calamus (20.88%) and H. antidysenterica (20.06%) extracts at a concentration of 100 µg ml⁻¹ (Zahin et al., 2009). Antioxidant level was higher in ethyl acetate extract compare to the other extracts viz. hexane, chloroform, acetone and methanol in Cassia auriculata (Anushia et al., 2009).

The antioxidant activity of methanolic extract of stem bark of Gmelina arbora was investigated by Patil et al. (2009) and found that it possesses significant free radical scavenging properties and a
clear correlation was observed between the antioxidant activity and phenolic content. The antioxidant effect of fresh and dried fruits of *Lagenaria siceraria* was evaluated by Erasto and Mbwambo (2009) and the results indicated that ethyl acetate extract of the fresh fruits exhibited higher DPPH radical scavenging activities than other samples. Different extracts of *Ficus religiosa* (Kirana *et al.*, 2009; Pandit *et al.*, 2010; Krishanti *et al.*, 2010) exhibited free radical scavenging activities.

Antioxidant activity was measured by DPPH method and the leaves of *V. negundo* showed 23.21 mg /100 g of Ascorbic acid Equivalent Antioxidant Capacity (AEAC) (Praveenkumar *et al.*, 2010). In a comparative study by Patel *et al.* (2010) it was stated that high radical scavenging activity was observed with the stem extract of *Kigelia* followed by leaf of *Hibiscus, Kigelia* and *Gemelia*. These observations clearly showed a cross linkage between phenolics and antioxidant activity. A high correlation between total phenolic content and antioxidant capacity was found in all the cultivars and fruit tissues of *Malus domestica* analysed, except in the pulp (Henriquez *et al.*, 2010).

Free radical scavenging activity of different extracts of *Aegle marmelos* was evaluated by DPPH method and the results inferred that the leaves extracts had 10 times greater radical scavenging activity than synthetic antioxidant BHT due to the presence of high phenolic compounds (Siddique *et al.*, 2010).

The investigation of Chew *et al.* (2011) in 9 Leguminosae medicinal plants in Peninsular Malaysia revealed that *Bauhinia kockiana* flowers and *Caesalpinia pulcherrima* leaves possess strong DPPH radical scavenging activity with IC$_{50}$ of 27.0 µg ml$^{-1}$ and 50.0 µg ml$^{-1}$ respectively. The extracts of *Euphorbia hirta* (Basma *et al.*, 2011) *Oxalis corniculata* (Patil *et al.*, 2011a) and *Cassia fistula* (Subramanion *et al.*, 2011) exhibited antioxidant activity in scavenging DPPH, SOD and CAT.

Ethanolic extract of *Cassia auriculata* leaves found to have IC$_{50}$ value for DPPH, nitric oxide, superoxide and hydroxyl radical scavenging activity of 49.45,125.31, 247.52 and 142.04 respectively (Senthilkumar and Vijayakumari, 2012c). Rupeshkumar *et al.* (2012) reported that the flavonone (5 and 10 mg kg$^{-1}$ p.o) of *Cardiospermum halicacabum* showed a remarkable antioxidant activity as judged from the antioxidant levels in liver tissues of rats.
Alcoholic extract of stem bark of *Tamarindus indica* and *Cassia fistula* showed significant antioxidant activity in DPPH, nitric oxide and hydroxyl radical induced *in vitro* assay methods (Agnihotri and Singh, 2013). Soni and Sosa (2013) studied the antioxidant activity of methanolic extract of dried leaves of four medicinally important herbs namely *Ocimum sanctum*, *Mentha spicata*, *Trigonella foenum-graecum* and *Spinacia olerace*. The study revealed that the IC\textsubscript{50} value obtained by DPPH activity for *Mentha spicata* crude extract was found to be 170 µg ml\textsuperscript{-1} and reducing power was found to be maximum (1.92) at 1 mg ml\textsuperscript{-1} concentration. The results recommended that *Mentha spicata* had been promising antioxidant activity and could serve as a potential source of natural antioxidants.

Ethanolic extract of 8 medicinal plants from Bangladesh for antioxidant potential with DPPH method was assessed by Asadujjaman *et al.* (2013). Among these plants *Ammannia multiflora*, *Caesalpinia pulcherrima*, *Dendrophthoe falcate* and *Syzygium cumini* exhibited strong DPPH free radical scavenging action with IC\textsubscript{50} value of 6.25µg ml\textsuperscript{-1}, 7.46 µg ml\textsuperscript{-1} and 6.08 µg ml\textsuperscript{-1}. Antioxidant activity of methanolic root extract of *Imperata cylindrica* using various *in vitro* models showed IC\textsubscript{50} value for NO scavenging activity as 400.15 µg ml\textsuperscript{-1} due to the presence of tannins and phenolic compounds (Padma *et al*., 2013). An attempt has been made to identify 18 major medicinal plants with antioxidant activities (Rashed, 2014). Jeyaseelan *et al.* (2014) reported that *Corallocarpus epigaeus* plant extracted with petroleum ether, chloroform, ethyl acetate, methanol and water having DPPH, hydroxyl, NO and superoxide radical scavenging activity in dose depend manner. Antioxidant effects of silver nano particles of *Canthium coromandelicum* leaves extracts was performed by Chandra Mohan *et al.* (2014).

The higest value for DPPH assay was recorded in *Mentha arvensis* (37.01%) followed by *Hyptis suaveolens* (35.76%) (Asha *et al*., 2015). Hossain *et al.* (2015) observed a significant linear correlation between the amount of total phenolic content and antioxidant activity in *Adina cordifolia*.

The various parts of following plants were reported to have antioxidant properties namely *Eucommia ulmoides* (Yen and Hsieh, 2000); Olive (Mc Donald *et al*., 2001); *Hemidesmus indicus* (Ravishankara *et al*., 2002; Mary *et al*., 2003); *Caesalpinia sappan* (Badami *et al*., 2003).
2003); Plumes (Kim et al., 2003); Ocimum spp. (Javamardi et al., 2003); Rosmarinus officinalis (Eva et al., 2003; del Bano et al., 2004); Rubus, Ribes and Aromia spp. (Benvenuti et al., 2004); Plumbago zeylanica (Tilak et al., 2004); Pilostigma reticulatum (Aderogba et al., 2005); Berberis vulgaris (Motalleb et al., 2005); Triticum aestivum (Lyliyana – Pathirana and Shahidi, 2005); Acacia mangium and A. auriculiformis (Mihara et al., 2005); Rhizophora mangle(Sanchez and Melchor, 2006); Diospyros malabarica (Mondal and Chakraborty, 2006); Ligustrum vulgare, L. delvayanum (Nagy and Sersen, 2006); Decalepis hamiltonil (Murthy and Rajasekaran, 2006); Sechium edule (Ordon et al., 2006); Hyphaene thebaica (Hsu et al., 2006); Draba nemorosa (Rahman and Moon, 2007); Acacia arabica (Sundaram and Mitra, 2007) Asparagus racemosus (Velavan et al., 2007); Psidium guajava (Edwin et al., 2007); Vernonia amygdalina (Erasto et al., 2007); Commelina bengalensis (Hasan et al., 2008); Desmodium gangeticum (Niranjani and Tiwari, 2008); Malus domestica (Vieira et al., 2009 a, b); Tilia argentea, Crataegi folium, Polygonum bistorta (Demiray et al., 2009); Pandanus odoratissimus (Sasikumar et al., 2009); Hyoscyamus squarrosu (Ebrahimzadeh et al., 2009); Blechnum orientale (Lai et al., 2010); Pseudarthria viscidia (Mathew and Sasikumar, 2007; Vijayabaskaran and Venkiteswaramurthy, 2010; Hemlal et al., 2011); Boerhaavia erecta (Rajeswari and Krishnakumari, 2010); Helichrysum longifolium (Aiyegoro and Okoh, 2010); Calendula officinalis (Mukesh et al., 2011); Majorana hortensis (Radha and Padma, 2011); Cymbopogon citrates (Vanisha and Hema, 2012); Thymus vulgaris (Zeghad and Merghem, 2013); Canthium coromandelicum (Shankar and Thiripura Salini, 2014); Carica papaya (Panzarini et al., 2014); Dolichandrone atroviens (Kavimani et al., 2014); Adina cordifolia (Prakash et al., 2015) and Azadirachta indica (Patel et al., 2015).

From the above literature, it has been inferred that the antioxidant properties of aforesaid plants are due to the presence of phytochemical constituents such as phenols and flavonoids on a dose dependant manner.

ANTIMICROBIAL ACTIVITIES IN MEDICINAL PLANTS

Medicinal plants are local heritage with global importance and help in alleviating in human sufferings. They play an important role in lives of rural people, particularly in remote parts of developing countries with few health facilities (Prajapathi et al., 1996). The field of
ethanobotanical research has expanded greatly in recent years as the value of this type of research has come to be more widely recognized. Plant derived antimicrobial have received considerable attention recently (Sivasakthi et al., 2014).

Plants produce a wide range of selective antibacterial, antifungal, antiparasitic, antihelminthic, antiviral either in a constitutive or an inducible manner. Plants are known to offer excellent perspectives for the discovery of new therapeutic products. For commercial success of plant based products it is imperative that sustained supply of plant materials required for the catering to the needs of pharmaceutical industries. Medicinal plants form a numerically large group of economically important plants, which provide the basic raw materials for the indigenous pharmaceutical industry and help the nation earn foreign exchange as well (Vivekanandhan and Devatha, 2002; Kapoor et al., 2013 a,b; Kapoor and Bansal 2013; Kapoor and Purohit, 2013; Saranraj and Sivsakthi, 2014; Salam et al., 2015).

The antimicrobial activity of 10 different plant extracts was evaluated with antibiotic susceptible and resistant microorganisms. The highest antimicrobial potentials were observed for the extracts of *Caryophyllus aromaticus* and *Syzygium joabolanum* which inhibited 64.2 and 57.1% of the tested microorganisms respectively with higher activity against antibiotic resistant bacteria (83.3%) (Nascimento et al., 2000).

About 110 plant species of medicinal value were identified by Rao et al. (2000). Various solvent extract of dried leaves, stem and fresh fruits of *Jatropha gossypifolia* were tested for antimicrobial activity against microorganisms (Madhumathi et al., 2000). Methanol extracts from 19 medicinal plants of Togo were analyzed for antiviral and antibiotic activities. Ten of them showed antiviral activity and two displayed antibiotic activity (Ananil et al., 2000). Ahmad et al. (2000) determined antimicrobial potency in terms of MIC against several pathogenic microorganism in the alcoholic extracts of *Emblica officinalis*, *Terminalia chebula*, *T. bellarica*, *Plumbago zeylanica* and *Holarrhoea antidysenterica*.

Sharma and Singh (2001) reported that the plants used for the treatment of wounds by Tribes of Dadra, Nagar Haveli and Daman. Results revealed that 30 plant species used for treatment of wounds. Ebi (2001) reported that some fractions of methanolic extract of *Alchornea cordifolia*
leaves that contain phenolics and terpenoids exhibited significant activity against *Pseudomonas aeruginosa*, *Bacillus subtilis* and *Escherichia coli*. Antibacterial activity of black tea (*Camellia sinensis*) extract against *Salmonella* species was reported by Ciraj *et al.* (2001). Strong antiviral and antimicrobial activities were detected in methanolic extract of 24 plants used medicinally in the treatment of skin infections in four different regions of Colombia (Lopez *et al.*, 2001).

Erodemoglu and Sener (2001) reported that the ethanolic extracts of *Taxus baccata* heartwood showed significant activity against selected Gram-negative bacteria and against five out of nine tested fungi. Antimicrobial activity of ethanolic extract of 45 Indian medicinal plants were tested against certain drug – resistant bacteria and a yeast. Results indicate that 40 plant extracts showed antimicrobial activity against one or more bacteria. Anticandidal activity was detected in 24 plants extracts (Ahmad and Beg, 2001). Khan *et al.* (2001) reported that methanolic exteract of *Castanopsis acuminatissima* showed broad spectrum antibacterial activity and none was tested against moulds. Among 50 medicinal plants used in folk medicine, 72% showed antimicrobial activity. About 22 plants showed activity against Gram positive and Gram negative bacteria, fourteen plants did not show activity against any of the bacteria tested (Srinivasan *et al.*, 2001).

Akinpelu (2001) reported that 60% methanolic extract of *Anacardium occidentale* bark exhibited antimicrobial activity against 13 out of 15 bacterial isolates at a concentration of 20 mg/ml.

According to Elegami *et al.* (2001) the methanol extract of *Pilosepalus acaciae* leaves showed highest activity against tested microorganisms than chloroform and aqueous extracts. Islam *et al.* (2001) reported that petroleum ether, chloroform and methanolic extracts of leaves and barks of *Zanthoxylum budrunga* have been evaluated for their antibacterial, antifungal and cytotoxic properties. The petroleum ether and ethyl acetate extracts of *Rhynchosia beddomei* leaves showed inhibiting activity against some bacterial and fungal species at different concentration (Bakshu and Venkataraju, 2001). Battinelli *et al.* (2001) reported that the ethanolic extracts of *Epilobium* sp. showed antibacterial activity against Gram positive and Gram negative bacteria. Penna *et al.* (2001) recorded that different extracts of argentine plants showed antimicrobial activity against some microorganisms. Two antimicrobial compounds methylgallate and protocatechuic acid were isolated apart from quercetin, kaempferol, quercitrin and gallic acid.
Ly et al. (2001) reported the cytotoxic and antimicrobial activity of *Calycotom villosa* leaves. The Fraction of methanolic extract showed strong cytotoxicity and acid extract showed lower cytotoxicity. The antibacterial and antifungal activities along with a phytotoxicity test of the newly isolated diterpene bondenolide of a methanol extract of *Caesalpinia bonduc* was reported by Simin et al. (2001). Chattopadhyaya et al. (2001) reorted that the methanolic crude and methanol aqueous extract of *Alstonia macrophylla* leaves and n – butanol part of the crude extract showed antimicrobial activity against various strains of microorganisms.

Ramesh et al. (2001) isolated friedelin, epitridedlinol, beta – amyrin, beta – sitosterol, 3 – beta – D – glucopyranosides and naringin from the dried rhizome of *Dryaria quercifolia*. The methanol extract showed broad and concentration dependent antibacterial activity. Udhayakumar and Hazeena Beegum (2001) reported that 80% ethanolic extract of *Achyranthes aspera*, *Ficus glomerata*, *Leucas aspara*, *Thespesia populanea* and *Zizphus jujuba* exhibit antimicrobial activities against *Escherichia coli*, *Klebsiella pneumoniae* and *Salmonella typhi*.

Extracts of 13 Brazilian medicinal plants were screened for antimicrobial activity against bacteria and yeasts. Results indicated that 10 plant extracts showed varied levels of antimicrobial activity and 9 plants showed anticandidal activity (Hoetez et al., 2002). Three extracts of *Pulicaria dysenterica* were examined for antibacterial activity using the agar disc diffusion method against six bacterial strains. Some extracts were found to be active against some bacterial strains. All extracts were active against *Vibrio cholerae* (Nickovar et al., 2002). Five of seven collected plants in the eastern part of the Republic of Congo exhibited antiplasmodial activity (Tshibangu et al., 2002).

Guarino (2002) reported that the antimicrobial activity of crude ethanolic extract of 16 Siberian medicinal plants were tested against five species of microorganisms. Results indicate that 12 showed antimicrobial activity against one or more species of microorganisms. Methanol, ethyl acetate and hexane extracts of *Bridelia ferruginea* leaves exhibited significant activity against *Pseudomonas fluorescens*, *Bacillus subtilis*, *Escherichia coli*, *Staphylococcus aureus* and *Streptococcus faecalis* (Talla et al., 2002).
Okoli et al. (2002) analysed that the aqueous leaf extracts of *Harungana madagascariensis* phytochemically evaluated its antimicrobial activity against strains of *Bacillus subtilis*, *Salmonella typhi* and *Escherichia coli*. Glycosides, tannins, saponins, flavonoids and alkaloids were detected in the plant material. Atindehou et al. (2002) reported that 148 crude ethanol extracts of 115 plant species from the Ivory Coast were tested *in vitro* against Gram-positive and Gram-negative strains. *Moringa indica* leaf extracts was screened against various pathogenic bacteria. Among the organisms tested *Salmonella* was found to be highly sensitive (Shyamala and Hemalatha, 2002). Alkaloids from leaf extract of *Euphorbia hirta* showed 20 mm inhibition zone towards *Bacillus* and *Salmonella* than *Streptococcus* and *Escherichia coli* (Vallimayil and Hemalatha, 2002). The antibacterial activities of methanol extracts of some medicinal plants of Iran were determined by agar diffusion method against *Pseudomonas aeruginosa*, *P. fluorescens*, *Bacillus subtilis*, *B. cereus* and *B. pulmis* at 20 mg/ml (Bonjar et al., 2003). Morales et al. (2003) reported that the antibacterial activity of four medicinal plants viz., *Artemisia copa*, *Acantholippia punensis*, *Ephedra andina* and *Haplopappus rigidus*. Garg and Rakesh Kumar (2003) reported that essential oil from the rhizomes of turmeric exhibited good to moderate activity against *B. subtilis*, *S. aureus*, *A. niger*, *A. fumigatus*, *C. lunata* and *C. diphtheria* using paper disc agar diffusion technique.

The antimicrobial activity of crude ethanolic extracts of 10 medicinal plants used in traditional Chinese medicine was tested against five species of microorganisms. Results indicated that five plants showed antimicrobial activity against one or more species of microorganism (Janovska et al., 2003). Chowdhury et al. (2003) reported that the extracts of two Bangladesh medicinal plants, *Toona ciliate* and *Amoora rohituka*, along with siderin, a major coumarin from *T. ciliata*, exhibited significant *in vitro* antibacterial activity. Essential oils of some herbs were found to possess the strongest antimicrobial properties (Nalemba and Kunicka, 2003).

The results of a preliminary antimicrobial screening of the methanolic extracts of *Aframomum melegueta*, *Piper guineese*, *Xylopia aethiopica* and *Zingiber officinale* medicinal plants of Ghana were reported (Norming et al., 2004). Wiart et al. (2004) screened 72 extracts obtained from the...
leaves, barks and roots of 50 plant species used in the traditional medicine of Perak, Peninsular Malaysia for antibacterial and antifungal activities. Of which *Eclipta prostrata*, *Solanum torvum*, *Celosia argentea*, *Polyalthia prostrata*, *Peristrophe tinctoria*, *Dillenia suffruticosa*, *Piper stylosum* and *Rafflesia hasseltii* displayed the broadest spectrum of activity. Antibacterial activity of new stable aqueous extract of Allicin, a main antibacterial agent from garlic showed inhibitory activity against methicillin-resistant *Staphylococcus aureus* (Cutler and Wilson, 2004).

Acetone extract of *Esenbeckia yaaxhokob* showed antimicrobial activity against 4 Gram-positive and 4 Gram-negative bacteria (Aguilar and Rios, 2004). The methanolic extract of 39 native plant species from Northern Argentina were screened for antimicrobial activity via micro plate assay with an oxidation-reduction dye. Results indicated that all the extracts were able to inhibit bacterial growth (Salvat *et al.*, 2004).

39 methanol and water extracts from different parts of 27 indigenous plant species in Lebanon were tested for their antimicrobial efficacy using single disc diffusion method. Results indicated that the antimicrobial activities were more apparent in methanol rather than water extracts (Barbour *et al.*, 2004).

Among the 27 selected plants of 19 families from different localities in Island, Sequotra showed antibacterial activity against Gram – positive bacteria including multi resistant *Staphylococcus* strains. Methanolic extract of *Buxus hildebrandtii* displayed significant antifungal activity (Mothana and Lindequist, 2005). Tshikalange *et al.* (2005) analyzed the extracts of six medicinal plants for antibacterial activity using agar diffusion method. Phytochemical studies on *Senna petersiana* resulted in the isolation of Luteolin, which showed antimicrobial activity. Ethanolic extract of *Allium sativum* and *Zingiber officinale* against *Escherichia coli* and *Salmonella typhi* have been studied by Ekwenye and Elegalam (2005). The aqueous extract of garlic had no inhibitory effect on the two tested organisms. But the aqueous extract of ginger inhibited *Salmonella typhi* showing 8.0 mm diameter zone of inhibition.

Muhammed and Muhammed (2005) investigated the effect of water and chloroform extracts of *Lawsonia inermis* leaves against *Staphylococcus aureus* and *Pseudomonas aeruginosa* by in vitro agar incorporation method and well diffusion method.
The water extract of *Bidens pilosa*, *Jacaranda mimosifolia* and *Piper pulchrum* showed a higher activity against *Bacillus cereus* and *Escherichia coli* than gentamycin sulphate. Similarly the ethanol extract of all the species were active against *Staphylococcus aureus* except for *Justicia secunda* (Rojas et al., 2006). Among the 5 solvents tested methanol and ethanol extracts showed significant antibacterial activity in *Oxalis corniculata* (Raghavendra et al., 2006).

Kalavathi (2007) screened the aqueous extract of *Lawsonia inermis* leaves which showed the antibacterial activity against *Streptococcus pneumoniae* and *Bacillus subtilis*. The hexane, ethyl acetate, ethanol and water extract of aerial parts of *Eclipta prostrata* have been tested for their antibacterial activities against *Escherichia coli*, *Klebsiella pneumoniae*, *Shigella dysenteriae*, *Salmonella typhi*, *Pseudomonas aeruginosa*, *Bacillus subtilis* and *Staphylococcus aureus* (Karthikumar et al., 2007). The antibacterial activity against *Streptococcus aureus*, *Staphylococcus aureus*, *Pseudomonas* spp., *Escherichia coli* and *Aspergillus niger* were observed in *Cassia auriculata* (Narayanasamy and Mary Violet Christi, 2007).

The extract of *Rhododendron setosum* and the essential oil of *Eucalyptus globulus* were most effective against *Escherichia coli* and *Staphylococcus aureus* respectively.

But the extracts of *Azadiracta indica* and *Elsholtzia fructicosa* were found to be most effective against *Klebsiella* spp. (Chhetri et al., 2008). Girish and Satish (2008) evaluated the antibacterial screening of aqueous and methanol extract of 5 different plants in vitro.

It has been showed that the methanolic extracts had wide range of activity on the tested organisms than the aqueous extracts which indicate the methanolic extract of all selected plants may contain the active components.

The methanol leaf extract of *Acacia nilotica*, *Sida cordifolia*, *Tinospora cordifolia*, *Withania somnifera* and *Ziziphus mauritiana* showed significant antibacterial activity against *Bacillus subtilis*, *Escherichia coli*, *Pseudomonas fluorescens*, *Staphylococcus aureus* and *Xanthomonas axonopodis* pv. *malvacearum* and antifungal activity against *Aspergillus flavus*, *Dreschlera turcica* and *Fusarium verticillioides* when compared to root/bark extracts (Mahesh and Satish, 2008). In vitro antibacterial studies on ethanolic leaf extract of *Tabebuia rosea* were carried out on 10 medically important bacterial strains revealed that the extract showed good inhibitory
activity against all the tested pathogens compared with standard antibiotics like streptomycin and penicillin in a dose dependent manner (Sathiya and Muthuchelian, 2008).

The antibacterial properties of the *Cassia auriculata* were tested against 10 human pathogens by using five different solvents namely hexane, chloroform, ethyl acetate, acetone and methanol. The maximum antibacterial activity recorded against *Vibrio cholerae* and *Staphylococcus aureus* (Anushia *et al.*, 2009). Methanolic extract from the root, stem and leaf of *Datura stramonium* was screened against 4 bacterial strains namely *Escherichia coli*, *Pseudomonas aeruginosa*, *Staphylococcus epidermidis* and *Bacillus subtilis* (Iranbakhsh *et al.*, 2010).

Bharathi *et al.* (2010) reported the antimicrobial activity of ethyl acetate and methanol extract of *Datura metel* by agar disc and well diffusion method against HIV associated opportunistic infections causing bacterial pathogens. The plant extract showed better inhibitory activity against *Pseudomonas aeruginosa* followed by *Klebsiella pneumoniae*, *Escherichia coli*, *Staphylococcus aureus* and *Salmonella typhi*.

*Ficus religiosa*, *Leucas aspera*, *Holarrhena antidysenterica* and *Psidium guajava* were selected for the antimicrobial study by Preethi *et al.* (2010). The results indicated that methanol extraction of *P. guajava* showed high antibacterial activity against the food borne pathogens like *Salmonella typhi*, *Pseudomonas spp.* and *Bacillus subtilis*. Whereas in case of antifungal activity of *H. antidysenterica* showed more activity with maximum of 23 mm inhibition zone against *Aspergillus* spp. The crude extract from leaf and stem of *Cardiospermum halicacabum* in different solvents namely acetone, alcohol, benzene, chloroform and aqueous extracts were used for screening the antimicrobial activity. Acetone and chloroform extracts of leaf had higher inhibitory action against *Salmonella typhi* and *Streptococcus aureus*, respectively (Viji and Murugesan, 2010).

The leaf extracts of *Vitex negundo* solvented by ethanol showed the high spectrum of inhibition on *Salmonella paratyphi*. Most of the bacterial pathogens like *Klebsiella pneumoniae*, *Vibrio cholerae*, *Streptococcus mutans* and *Escherichia coli* were found to be susceptible in the leaf extract (Merlin Ross and Cathrine, 2011). Antimicrobial bio assay of five medicinal plants, *Lepidium sativum*, *Nerium oleander*, *Ranunculus repens*, *Tecoma stans* and *Urtica dioca* inferred
that all the five species showed no significant antimicrobial activity without any specificity (Hussain et al., 2011). The leaf, stem and root powder extracts of Ricinus communis were tested against three different bacteria by disc diffusion method and found that acetone and hexane extracts possess good zone of inhibition whereas ethanolic extract having antibacterial activity only on higher concentration (Mary Kensa and Syhed Yasmin, 2011).

Cardiospermum halicacabum extracts and seed oil exhibited antibacterial activities with the zone of inhibition ranging from 7 mm to 14 mm for ethanolic, ethyl acetate extracts and seed oil from 7mm to 10 mm for butanolic and 7mm to 9mm for aqueous extracts against the gram positive and gram negative bacterial strains. The crude ethanol, aqueous extracts and seed oil exhibited appreciable fungal activity against Candida albicans while Aspergillus niger was only active against ethanolic extract with significant zone of inhibition (18 mm) (Shareef et al., 2012).

Antimicrobial activity of Gymnema sylvestre leaf extract was studied by Wani et al. (2012). Aqueous and methanolic leaf extracts were studied against Escherichia coli, Serratia marcescens, Staphylococcus aureus and Candida albicans for their antimicrobial efficacy. The methanolic extract of the leaves were showing activity against all the four tested microorganisms while aqueous leaf extracts found to be non effective.

Kapoor and Sunil Kumar (2014) reported the antimicrobial screening of ethylether and alcoholic extract of leaves of three medicinal plant species viz. Clerodendrum phlomoides, Lycium babarum and Sida cordifolia which showed the positive reactions against bacterial pathogens like Staphylococcus aureus, E. coli and a fungal pathogen, Candida albicans.

Allium sativum have shown good activity against both Arthrobacter oxydans and Pseudomonas fluorescens (Marinkova et al., 2015). The ethanolic extract of Adina cordifolia exhibited most active antibacterial activity against Bacillus subtilis, Staphylococcus aureus, Escherichia coli and Klebsiella pneumoniae compared to methanol, petroleum ether, benzene, chloroform and aqueous extracts (Prakash et al., 2015). Root extract of Ruta graveolens gave 8 and 7 mm inhibition zone against Escherichia coli and Pseudomonas aeruginosa, respectively. Latex of Ficus carica showed good inhibition zone against Candida albicans (5.0mm) (Al- Sokari and El- Sheika, 2015).
The extracts of the following plants exhibited both antibacterial and antifungal activities evaluated by various researchers. *Caesalpinia pulcherrima, Euphorbia hirta and Asystasia gangeticum* (Sudhakar et al., 2006); *Oxalis corniculata* (Raghavendra et al., 2006); *Anogeissus latifolia* (Govindarajan et al., 2006); *Withania somnifera* (Girish et al., 2006); *Vitis vinifera* and *Cyperus rotundus* (Parekh and Chanda, 2006); *Mimosa pudica, Aegle marmelos* and *Sida cordifolia* (Balakrishnan et al., 2006); *Ficus religiosa* (Nair and Chanda, 2007; Uma et al., 2009); *Mucuna pruriens* (Salau and Odeleye, 2007); *Passiflora foetida* (Mohanasundari et al., 2007); *Enantia chlorantha* (Adesokan et al., 2007); *Origanum majorana* (Ravikumar et al., 2007); *Mentha piperita* (Bupesh et al., 2007); *Nyctanthes arboristis* (Padmalatha et al., 2007); *Zapoteca portoricensis* (Nwodo and Uzochukwu, 2008); *Aloe ferox* (Kambizi and Afolayan, 2008); *Cissus quadrangularis* (Ayyanan and Ignacimuthu, 2008); *Cassia tora* (Roopashree et al., 2008); *Coccinia grandis* (Umbreen et al., 2008); *Nauclea latifolia* (EI – Mahmood et al., 2008); *Vitex negundo* (Mahmud et al., 2009); *Acorus calamus* (Asha Devi and Ganjewala, 2009); *Solanum trilobatum* (Doss et al., 2009); *Operculina turpethum* (Sharef et al., 2010); *Solanum tomentosum* (Akinjogunla et al., 2010); *Acalypha indica* (Saranraj et al., 2010; Murugan and Saranraj, 2011); *Camptotheca acuminata* (Wang et al., 2011); *Datura metel* (Sivasakthi et al., 2011); *Phyllanthus amarus* (Saranraj and Sivasakthivelan, 2012; Sekar et al., 2012); *Mangifera indica* (Saranraj et al., 2012); *Salix viminalis* (Zarger and Khatoon, 2015) and *Saraca asoca* (Rajesh et al., 2015).

**ANTI INFLAMMATORY ACTIVITY**

Inflammation is considered as a primary physiologic defensive mechanism that helps body to protect itself against infection by bacteria, fungi, parasites and viruses, burns, toxic chemicals, allergens or other noxious environmental stimuli. Though it is a defensive mechanism, inflammatory mediators involved in aggravate or maintain greater number of diseases (Sosa et al., 2002). An uncontrolled and persistent inflammation may act as an etiologic factor for many of these chronic illnesses like redness (increase in blood flow), swelling (increased vascular permeability) pain (sensitization of primary afferent nerve fibres), RA, asthma etc. (Levine and Reichling, 1999).
Due to the increasing frequency of intake of NSAID’s and their severe side effects there is a need to focus on the scientific exploration of herbal drugs having fewer side effects. So, there is a continuous search for indigenous drug which can provide relieve to inflammation. Natural products, including those derived from higher plants have contributed greatly to the development of modern therapeutic drugs. Most of the plant derived secondary metabolites are known to interfere directly or indirectly with the mechanism or molecules like arachidonic acid, cytokines, prostaglandins, leukotrienes, cyclooxygenase (COX – 2), lipooxygenase etc. (Calixto et al., 2003). Hence the plant derived compounds with anti-inflammatory actions represent a very active area of recent research (Agnihotri et al., 2010; Shaikh, 2011; Hur et al., 2012; Ravichandran and Panneerselvam, 2012; Sharma et al., 2014b; Jeyaseelan et al., 2014).

Costa et al. (1992) reported the presence of methylsalicylate, an anti-inflammatory constituent with prostaglandin inhibitory activity in roots of S. longipendunculata. Jayasekara et al. (2002) revealed that about 90% of volatile material in the root extract of the same plant is constituted by methylsalicylate. Seeds of Ocimum sanctum contains 16.63% of linolenic acid which possesses significant anti-inflammatory property without any noticeable toxicity (Godhwani et al., 1987; Singh and Majumdar,1997;1999a; Singh et al.,1996). Ahmad et al. (1992) reported that plant extracts of Lactuca scariola and Artemisia absinthium exhibit anti inflammatory property.

Ammar et al. (1997) have revealed the anti-inflammatory activity of bioactive fraction isolated from seeds of Trigonella foenum- gracum, roots of Glycirhiza glabra and fruits of Coriandrum sativum.

Ursolic acid extracted from Plantago major have found to possess anti – inflammatory activity by inhibiting COX – 2 enzyme (Ringbom et al., 1998; Subbaramaiah et al., 2000). Avicins a family of triterpenoid saponins isolated from Acacia victoria possesses anti – inflammatory activity by inhibiting the expression of COX -2 through inhibition of NF – KB (Sailer et al., 1996; Haridas et al., 2001). Sala et al. (2001) isolated a new acetophenone glucosides from Helichrysum italicum with anti – inflammatory activity. Platycodin D isolated from the roots of Platycodon grandiflorum exhibited anti – inflammatory activity by inhibiting prostaglandin E 2 production, (Kim et al.,
Diphyllin acetylpioside isolated from *Haplophyllum hispanicum* exhibited topical anti-inflammatory activity through inhibition of 5–lipoxygenase (Prieto *et al*., 2002).

Bagul *et al.* (2005) have reported the two ayurvedic formulation containing guggul possess anti-inflammatory property. Methanolic extract of *Stepenia glabra* exhibited the anti-inflammatory potential. Pharmacological screening of root bark extracts of *Securidaca longipedunculata* has revealed that the root bark possesses potent anti-inflammatory effect in the topical and systemic models of acute inflammation by inhibiting the release of pro-inflammatory mediators of acute inflammation such as histamine and prostaglandin (Okoli *et al*., 2005). Arul *et al.* (2005) revealed the presence of anti-inflammatory property in the aerial parts of *Coldenia procumbens* by inhibiting the carrageenan induced rat paw edema.

The fixed oils containing α-linolenic acid from *Linum usitatissimum*, *Glycine max* and * Ocimum sanctum* exhibited anti-inflammatory effect in the high dose (3ml/kg) in carrageenan, leukotriene and arachidonic acid induced paw edema models in rats may be achieved by altering the eicosanoid precursor (Singh *et al*., 2008). The ethanolic extract of male flowers of *Borassus flabellifer* showed the anti-inflammatory property in rodents (Paschapur *et al*., 2008). *Dalbergia sissoo* bark ethanolic extract at 1000 mg/kg showed the most potent anti-inflammatory activity compared to the other groups (300 and 500 mg/kg), through out the observation period in carrageenan induced model (Mohammad Asif and Arunkumar, 2009). The extract of bark of *Albizia lebbeck* at 400 mg/kg level showed 36.68% inhibition of edema volume at the end of 4 h was reported by Saha and Ahmed (2009).

The total alcoholic extract of *Mirabilis jalapa* at 300mg/kg p.o and successive petroleum ether fraction at the dose of 200mg/kg exhibited significant anti-inflammatory activity in carrageenan induced paw edema model (Nath *et al*., 2010). Studies of Debranjan and Tara (2010) indicated that *Trigonella foenum-gracum* at 200mg/kg b.w.showed significant anti-inflammatory effect up to 4h. Hakim *et al.* (2010) evaluated the anti-inflammatory activity in the pods of *Astragalus hamosus*. The ethanolic stem extract of *Rubia cardifolia* at high dose (40mg/kg) was endowed with anti-inflammatory property (Chandra Shekhar *et al*., 2010).
The water soluble fraction of ethanolic extract of *Nyctanthes arbor-tristis* at a dose level of 250 and 500mg/kg showed activity against the inflammation induced by a foreign body (Tripathi et al., 2011). Results of Patel et al. (2011) indicated that aqueous extract of both pericarp and seeds showed anti-inflammatory activity but pericarp showed more potent action than seed in *Trapa natans*. Saha et al. (2011) isolated a bioactive triterpene saponin from leaves of *Bauhinia variegata* found to possess more pronounced anti-inflammatory activity in the petroleum ether fraction than ethanol. Studies of Yadav et al. (2011) showed that ethanolic extract of *Callicarpa macrophylla* leaves have better anti-inflammatory profile than the aqueous extract and may be the choice to be used as anti-inflammatory drug.

The hydrogel containing hydro-alcoholic extract of *Pterocarpus marsupium* showed significant anti-inflammatory activity (43.70%) when compared with the standard (17.03%) at the end of 8h and was more significant as that of marketed formulation (Patil et al., 2012). The anti-inflammatory activity was highest in the presence of 200 μg/ml *Euphorbia hirta* extract and nitric oxide production was decreased significantly (Sharma et al., 2014b). The ethanolic extract of rhizome of *Corallocarpus epigaeus* given at a different doses such as 200 and 400 mg/kg b.w.exhibited significant anti-inflammatory activity (Jayaseelan et al., 2014).

The administration of ethanolic extract of *Aerva javanica* significantly reduced the edema thickness in a time and dose dependent manner in carrageenan induced paw oedema in rats (Elsaeed et al., 2015).

The following plants were found to have anti-inflammatory activity due to the presence of their bioactive compounds like flavonoids, saponins, terpenoids, alkaloids, glycosides etc. as reported by various investigators. *Mikania cordata* (Bhattacharya et al.,1992); *Rubia cardifolia* (Antarkar et al., 1994); *Ambrosia artemisiaefolia* (Perez et al., 1996) *Turnera ulmifolia* (Brito and Antonio 1998); some Jordanian medicinal plant extracts (Atta and Alkohafi, 1998); *Euphorbia royleana* (Bani et al., 2000); *Culcasia scandens* (Okoli and Akah, 2000); *Aerva lanata* (Vetrichelvan et al., 2000) *Heterotheca inuloides* (Segura et al., 2000); *Inula viscose* (Hernandez et al., 2001); *Eupatorium buniifolium* (Muschietti et al., 2001); *Atractylodes lancea* (Resch et al., 2001); *Dalbergia sissoo* (Hajare et al., 2001); *Scoparia dulcis* (Ahmed et al., 2001); *Rubia cardifolia*
(Kasture et al., 2001); Curcuma zedoaria (Hong et al., 2002); Vitex peduncularis (Suksamrarn et al., 2002); Lourteigia balloteafolia (Rosas- Romero et al., 2002); Sideritis anariensis (Hernandez and Rabanal Gallego, 2002); Lavandula angustifolia (Hajhashmi et al., 2003); Aristolochia bracteata (Shirwaikar and Somashekar, 2003); Bauhinia variegata (Yadava and Reddy, 2003; Mohamed et al., 2009); Hedera colchica (Gepdiremen et al., 2004); Aeolanthus suaveolens (Leticia et al., 2004); Tilia argentea (Toker et al., 2004); Pterocarpus marsupium and Coccinia indica hydrogel (Salunkhe et al., 2005); Daucus carota (Vasudevan et al., 2006); Plumeria acuminata (Gupta et al., 2006); Zizyphus lotus (Borgi et al., 2007); Ficus religiosa (Sree lekshmi et al., 2007); Hedychium coronarium (Shrotriya et al., 2007); Stachys sehtschegleevii (Nazemiyeh et al., 2007) Aspilia africana (Okoli et al., 2007); Phyllanthus reticulatus (Saha et al., 2007); P. amarus (Mahat and Patil, 2007); Symplocos cochinchnensis (Rajendran and Lakshmi, 2008); Faidherbia albida (Tijani et al., 2008); Solanum trilobatum (Pandurangan et al. 2009); Barleria cristata (Gambhire et al., 2009); Bauhinia purpurea (Shreedhara et al., 2009); Sophora flavescens (Hong et al., 2009); Cardiospermum halicacabum (Shabi et al., 2009); Euphorbia hirta (Shih et al., 2010); Pseudarthrica viscida (Saravanan et al., 2010); Tecomella undulate (Goyal et al., 2010); Acacia catechu (Patil et al., 2010b); Russula virescens (Hur et al., 2012); Delonix elata (Ravichandran and Panneerselvam, 2012) and Burkea africana (Dzoyem and Eloff, 2015).

ANTI ULCER ACTIVITY

Peptic ulcer disease is a common health problem worldwide nowadays. It is a group of disorders characterised by the presence of ulcers in any portion of gastrointestinal tract (GIT) exposed to acid in sufficient quantities and duration. An ulcer is a crater like lesion of gastric or duodenal mucosa. Development of ulcer in GIT area exposed to acidic gastric juice are called peptic ulcers (Tortora and Derrickson, 2006).

It is formed or produced due to exposure of stomach and duodenum to pepsin and gastric acid. It is caused by an imbalance between the protective (mucus., bicarbonate, NO and PG’s) and the aggressive mechanism of the mucosa or association of several endogenous factors like
hydrochloric acid and pepsin and exogenous factors such as tobacco, alcohol NSAID’s and *Helicobacter pylori* infection (Rakesh Pahwa *et al.*, 2010).

**FIGURE IV**

Peptic ulcer disease

![Peptic Ulcer Disease](image)

A number of drugs are available for the treatment of peptic ulcer but its clinical evaluation shows the incidence of relapses, side effects and drug interaction. This emphasizes the development of new anti ulcer drug and search for novel molecules. The treatment of peptic ulcers with novel molecule from plant products used in folk medicine and the protection of induced gastric ulcer in experimental animals using medicinal plants received more attention (Rajeshkumar *et al.*, 2001; Gupta *et al.*, 2005; Muralidharan and Srikanth, 2009; Rakesh Pahwa *et al.*, 2010; Patil *et al.*, 2011a; Panda and Sonkamble, 2012; Kaur *et al.*, 2012b; Amandeep *et al.*, 2012; Vimala and Gricilda Shoba, 2014; Ifeanyi and Sunday, 2014).

Ethanol extract of *Terminalia pallida* was evaluated for its anti ulcer activity against various models of ulcers by Gupta *et al.* (2005). The results revealed that doses of 250 and 500 mg/kg p.o. exhibited significant protection against ulcers produced by indomethacin and histamine. The extract of *Morinda citrifolia* fruits administrated at the dose of 200 and 400 mg/kg possesses a
markable anti ulcer property which could be due to cytoprotective action of the drug or strengthening of gastric and duodenal mucosa with enhancement of mucosal defence. (Muralidharan and Srikanth, 2009).

Ethanol extract of leaves of *Sesbania grandiflora* at the dose of 400 mg/kg produced a notable reduction in the ulcer index due to anti secretory and cytoprotective mechanisms (Bhalke *et al.*, 2010). Studies of Moraes de Carvalho *et al.* (2010) in *Encholirium spectabile* ethanol extract exhibited anti ulcer activity due to the existence of prostaglandins, antioxidant compounds and nitric oxide synthase activity. The phytochemical results observed by Ukwe *et al.* (2010) on the root extract of *Zapoteca portoricensis* revealed the presence of alkaloids, terpenoids, glycosides and flavonoids which are responsible for its anti ulcer activity. Anti ulcer activity was evaluated by measuring ulcer index and percentage of ulcer healing by Zeeyauddin *et al.* (2011) in *Boswellia serrata* bark. The results revealed that the petroleum ether (250mg/kg) and aqueous extracts (250mg/kg) showed significant anti ulcer activity and further confirmed by histopathological measures also. Srinavas Reddy *et al.* (2011) evaluated the anti ulcer activity of *Paederia foedita* root extracts in aspirin induced ulceration in rats. The anti ulcer activity may be due to anticipated inhibition of hydrogen receptors resulting in inhibition of gastric acid secretion elicited by histamine and gastrin.

The evaluation on the ethanolic extract of stem bark of *Ficus religiosa* by Khan *et al.* (2011a) providing preliminary data on the anti ulcer potential of *Ficus religiosa* and support the traditional uses of the plant for the treatment of gastric ulcer. The anti ulcer effect of aqueous extract of *Murraya koenigii* was studied by Patidar (2011) in Pylorus ligation and NSAID’s induced ulcer model in albino rats. The extract at the dose of 200 and 400mg/kg produced significant inhibition of gastric lesion by reducing ulcerative lesion, gastric volume, free and total acidity. Study performed to evaluate the anti ulcer activity of aqueous and ethanolic extract of *Oxalis corniculata* leaves by Patil *et al.* (2011a) and confirmed its anti ulcer property. The stem bark of *Schleichera oleosa* have been extracted by ethanol and evaluated for the anti ulcer activity by aspirin induced and pylorus ligation of rats. The extract significantly decreased the gastric secretion, free acidity as well as gastric ulcers (Srinivas and Celestin Baboo, 2011).
The studies of Panda and Sonkamble (2012) in *Ipomoea batatas* tubers revealed the presence of ample amounts of antioxidants which are having ulcer healing properties and the plant has been recommended for peptic ulcer treatment. Kumar *et al.* (2013) determined anti ulcer activity of ethanol extract of the stem bark of *Careya arborea* on albino rats. The EECA has shown significant activity at both 300 and 600mg/kg dose level in a dose dependent manner. Phytoconstituents like tannins and saponins may be responsible for anti ulcer activity of EECA. Oloyede *et al.* (2015) reported that pretreatment with aqueous extract of *Carica papaya* seed exhibited anti ulcerogenic activity which may be due to the enhanced antioxidant enzymes. Ethanolic and aqueous extracts of roots of *Acacia catechu* found to possess anti ulcer activity and also observed that activity increases as the dose of extracts increases (Alambayan *et al.*, 2015).

The various plant parts of following plants namely *Terminalia pallida* (Gunasekhar *et al.*,1993);*Cissampelos mucronata* (Akah and Nwafor, 1999); *Ocimum sanctum* (Singh and Majumdar, 1999b); *Bidens pilosa* (Alvarez *et al.*, 1999; Tan *et al.*, 2000); *Emblica officinalis* (Rajeshkumar *et al.*, 2001; Sairam *et al.*, 2002); *Cassia nigricans* (Nwafor and Okwuasaba, 2001); *Amomum subulatum* (Jafri *et al.*, 2001); *Musa sapientum, Asparagus racemosus, Zingiber officinale* (Goyal and Sairam, 2002); *Hippocrates excelsa* (Navarrete *et al.*, 2002); *Cassia occidentalis* (Jacob *et al.*, 2002); *Bambusa arundinacea* (Muniappan and Sundararaj, 2003); *Tephrosia purpurea* (Deshpande *et al.*, 2003); *Utleria salicifolia* (Rao *et al.*, 2004, Radhakrishnan *et al.*, 2004); *Sygonanthus arthrotichus* (Batista *et al.*, 2004); *Kielmeyera coriacea* (Goulart *et al.*, 2005); *Cyanodon dactylon* (Patil *et al.*, 2005); *Byrsonima crassa* (Sannomiya *et al.*, 2005); *Securidaca longipedunculata* (Okoli *et al.*, 2005); *Rhizophora mangle* (Berenguer *et al.*, 2006); *Anogeissus latifolia* (Govindarajan *et al.*, 2006); *Cardiospermum halicacabum* (Sheeba and Asha, 2006, Muthumani *et al.*, 2010); *Toona ciliate* (Malairajan *et al.*, 2007); *Psidium guajava* (Edwin *et al.*, 2007; Umana Uduak *et al.*, 2012); *Cyperus rotundus* (Dandagi *et al.*, 2007); *Datura alba* (Gopalakrishna, 2007); *Anisochilus carnosus* (Mohammed *et al.*, 2008); *Gossypium arboreum* (Patil *et al.*, 2008); *Eupatorium cannabinum* (Mohanty *et al.*, 2008); *Calotropis gigantea* (Dandagi *et al.*, 2008); *Hemidesmus indicus* var. *indicus* (Anoop and Jagadeesan,
2008); Terminalia chebula (Raju et al., 2009); Phyllanthus niruri (Okoli et al., 2009); Aspilia africana (Ubaka et al., 2010); Acacia catechu (Patil et al., 2010b); Morus alba (Hojage et al., 2010); Symlocos racemosa and Asarum europaeum (Khalid et al., 2010); Sesbania grandiflora (Bhalke et al., 2010); Garcinia indica (Deore et al., 2011); Ficus religiosa (Khan et al., 2011a); Tamarindus indica (Kumar et al., 2011); Solanum nigrum (Kavithashree et al., 2012); Rhus coriaria (Ahmad et al., 2013); Shorea robusta (Sathishkumar et al., 2013) and Rhus coriaria (Ahmad et al., 2015) found to possess anti ulcer activity.

The above literature revealed that the anti ulcer property of various plant parts like bark, stem, leaves, roots, tubers, fruits, rhizome, wood, flowers might be due to the presence of antioxidants, tannins, saponins, fixed oils, terpenoids, ellagic acid, gallic acid, prostaglandins etc., by reducing gastric lesion, gastric volume, total and free acidity and enhancing the mucosal defence.

ANTI ARTHRITIC ACTIVITY
Rheumatoid arthritis (RA) is a chronic progressive auto immune disease of unknown cause which means the body’s immune system mistakenly attack on healthy tissues instead of protecting the joints by duly producing the substances that attack the joints by the immune system. About 1% of the world’s population is afflicted by this disorder and it is two to three times more common in women than men. The rheumatoid arthritis due to the presence of pro-inflammatory markers, cytokines and leukotrienes. The primary inflammatory markers are IL-1, TNF-α, IL-6, IL-15. IL-16. IL-17, IL-18, IFN-γ and granulocyte macrophage – colony stimulating factor, chemokines such as IL-8, macrophage inflammatory protein -1 and monocyte chemo attractant protin -1 which are responsible for the pain, joint swelling and joint damages.

FIGURE V Types of Arthritis
As illustrated in the above figure V in normal person, the joint lining is very thin and it has very few blood vessels whereas in the rheumatoid arthritis joints the lining is very thick and crowded with the white blood cells.

RA is characterised by persistent synovitis, systemic inflammation that primarily affects the peripheral joints (Scott et al., 2010). Pathogenesis of RA involves multiple factors including both genetic and environmental influences. Proliferation of cells in the synovial layer of the joint, together with infiltration by various cell populations as orchestrated by cytokines, chemokines, growth factors and hormones, produces locally invasive pannus that is capable of invading and ultimately destroying cartilage, bone and surrounding soft tissues.

RA presents as a symmetrical poly arthritis affecting the small joints of the hands and feet. This disease affects symmetrically many extra articular tissues includes skin, blood vessels, heart, lungs and muscles. Drug therapy for RA is based on two principle approaches viz. symptomatic treatment with NSAID’s drugs and disease modifying anti rheumatic drugs. Most of the currently available drugs are having lesser effect on immune-inflammatory path way and with side effects. Hence herbal plants constitute an important resource and are being used widely as medicine around the decades for treatment of arthritic disease (Long and Li, 2004; Amresh et al., 2007, Sammugapriya et al., 2010; Vishwabhan et al., 2011; Paval et al., 2011; Puratchikody et al., 2011; Singh et al., 2011; Kaur et al., 2012a; Sheik and Chandrashekar, 2013; Jaya Sankar Reddy et al., 2014; Bhagyasri et al., 2015).

Mayo (1988) reported that tannin, salicylic acid, isoflavones and 27-deoxyacetin in Actaea racemosa which are used in the treatment of arthritics. The studies on Uncaria tomentosa by Sandoval et al. (2002) revealed the presence of antiarthritic substances like alkaloids, tannins, rutin and stigmasterols. Colchicum luteum (Javed et al., 2005) and Foniculum vulgare (Ozbek, 2005) have been found to be effective in reducing carrageenan induced paw edema.

Daily ip administration of the low dose of purified curcuminoids (4mg total curcuminoids/kg/d), a natural compound present in the rhizomes of Curcuma longa inhibited joint inflammation in both the acute and chronic phases of arthritis (Kohli et al., 2005; Funk et al., 2006; Vaidya, 2006). The ethanolic extract of Cleome gynandra administrated at the dose of 150mg/kg b.w. for 30 days to the
FCA induced arthritic rats showed antiarthritic effect due to the presence of the chemical constituents such as tannins, triterpenes, anthroquinones, flavonoids, saponins and steroids (Narendhirakannan et al., 2005; 2007).

The resin of *Boswellia serrata* contains β- boswellic acid which has an anti arthritic activity by duly switching off the pro-inflammatory cytokines and mediators in terms of reducing the breakdown of glycosaminoglycan synthesis (Kokate, 2007).

The extract of *Strychnos potatorum* seeds at a dose of 200mg/kg p.o. showed reduction in the paw volume in Freud’s adjuvant induced arthritic rats (Mallikharjuna et al., 2007; Ekambaram et al., 2010). The potent anti-arthritic effect of *Aristolochia bracteata* chloroform extract may be through maintenance of synovial membrane and vascular permeability, thereby inhibiting cytokines and leukotriene infiltration inhibition as evidenced in paw edema volume and xylene induced ear edema (Chitme and Patel, 2009). The extract of *Borassus flabellifer* at doses of 200mg/kg b.w.; 400mg/kg b.w showed significant anti-inflammatory and anti-arthritic activities (Mahesh et al., 2009).

Piperine, an alkaloid isolated from *Piper nigrum* administrated orally at a dose of 20 and 100mg/kg/day for 8 days caused decrease in the arthritic symptoms in carrageenan induced acute paw arthritis (Bang et al., 2009). The leaves of *Abutilon indicum* (Deshpande et al., 2009), *Anisomeles malabarica* (Lavanya et al., 2010), *Physalis angulata* (Shravan et al., 2011), *Arissaema rhizomatum* (Chen et al., 2011), *Colchicum luteum* (Nair et al., 2011) and *Centella asiatica* (Seema and Meena, 2011) exhibited anti-arthritic activity. Oral administration of *Withania somnifera* root powder showed the anti-arthritic effect in adjuvant induced arthritic rats due to the presence of alkaloids and steroidal lactones (Mirjalili et al., 2009; Patwardhan et al., 2010). The anti-arthritic properties of *Aloe vera* is due to the presence of anthroquinone compound namely anthracene, cinnamic acid and anthranilic acid as revealed by Joseph and Raj (2010). The epigallocatechin, a potent antioxidant from the leaves of *Camellia sinensis* reduced collagen induced arthritis by the inhibition of inflammatory mediators namely COX-2, INFγ and TNFα in arthritic joints of mice (Chopade et al., 2008; Akroum et al., 2009; Ahmed, 2010).
Mangiferin extracted from *Mangifera indica* showed anti-inflammatory activity (Garrido *et al.*, 2001; 2004; Barbera *et al.*, 2010). Studies of Tripathy *et al.* (2010) reported that the alcoholic extract of *Ammania baccifera* found to possess anti-arthritic property.

The petroleum ether extract of *Vitex negundo* caused inhibition of paw edema in 4 h. in a dose dependent manner in carrageenan induced hind paw edema due to the presence of glycosidic iridoids and alkaloids (Subramani *et al.*, 2009; Vishwanathan *et al.*, 2010). Long term treatment with *Premna corymbosa* leaves significantly suppressed the development of chronic arthritics in FCA induced arthritis (Karthikeyan and Deepa, 2010).

*Leucas aspera* contains triterpenoids, oleanolic acid, ursolic acid, b- sitosterol, diterpenes which showed anti-rheumatic effect in FCA induced arthritis (Prajapathi *et al.*, 2010; Kripa *et al.*, 2010). The ethanolic extract of *Premna serratifoli* consists of alkaloids, flavonoids, tannins, glycoside, steroids and phenolic compounds which exhibited anti-arthritic activity in rat paw edema (Rajendran, 2010). Oral administration of 200mg/kg of the ethanolic extract of *Cleome rutidosperma* inhibited FCA induced rat paw edema by 44% after 21 days (Chakraborty and Roy, 2010). Otari *et al.* (2010) inferred that the ethanolic extract of seeds of *Vernonia antihelmintica* had produced significant effect of antiarthritic property.

The ethanolic root extract of *Cissampelos pareira* had significant protective effect against FCA induced arthritis in dose dependent manner (Amresh *et al.*, 2007; Singh *et al.*, 2010; Ariya *et al.*, 2011). The aqueous extract of *Terminalia paniculata* bark at a dose of 200mg/kg exhibits anti-rheumatic activity (Talwar *et al.*, 2011). Anti- rheumatic activity of the methanolic extract of bark of *Ficus bengalensis* were studied using various arthritic induced models (Patil and Patil, 2010; Joseph and Raj, 2011; Manocha *et al.*, 2011).

The results indicated the presence of flavonoids, tannins, saponins and steroids may attribute to its anti-rheumatic activity as well as modifying the auto immune system.

The active constituent responsible for anti-arhritic activity seems to be bartogenic acid in *Barringtonia racemosa* as reported by Sun *et al.* (2006), Behbahani *et al.* (2007) and Patil *et al.* (2011b). The bitter principle viz. tinosporine, tinosporide, cordifolide, columbin and b- sitosterol in *Tinospora cordifolia* used in the treatment of RA at the dose of 100mg/kg/ showed reduction of paw
volume in collagen induced arthritic rats (Jana et al., 1999; Singh et al., 2003; Rawal et al., 2009; Paval et al., 2011). *Saussurea lappa* root extracts are endowed with effective anti-arthritic activity as reported by Uma Chandur et al. (2011).

Extract of *Tripterygium wilfordii* caused decrease in arthritic joint counts, arthritic severity scores and anticollagen antibody titers in type II collagen induced arthritis in mice due to the presence of triptolide (Kimura et al., 2011). Methanolic extract of *Saraca asoca* reduced the paw thickness in adjuvant induced arthritic rats by its phyto constituents (Saravananan et al., 2011). The anti-arthritic activity of *Glycyrrizha glabra* and *Boswellia serrata* were assessed by significant reduction of paw edema volume and its capacity to stabilize lysosomal enzyme activity such as ACP significantly (Mishra et al., 2011).

The results of Khan et al. (2011b) inferred that the herbal drug, arthritin derived from 7 herbs is more effective than the commercially available drug Methotrexate in the treatment of RA.

Sesquiterpene Lactones from *Zingiber officinale* found to be anti-arthritic compound (Rehman et al., 2011; Zakeri et al., 2011; Feng et al., 2011). Roots of *Calotropis procera* at a dose of 180mg/kg showed anti-inflammatory activity (Babu and Karki, 2011). Nyctanic acid, b-amyrin and b-sitosterol present in leaves of *Nyctanthes arbor-tristis* were responsible for anti-arthritic property (Bhalerao et al., 2011; Sandhar et al., 2011). The chemical analysis of aerial parts of *Justicia gendarussa* showed the presence of β−sitosterol, aromadendrin, flavonoid and vitexin in ethanolic extract which are having significant anti-arthritic activity (Paval et al., 2009a,b; Bachheti et al., 2011; Correa et al., 2012).

**RESULTS AND DISCUSSION:**

On oral treatment of 8 days with ethanolic extract of *Hemidesmus indicus* reduced the paw volume and paw thickness more than Diclofenac sodium due to the presence of coumarin, tannic acid, triterpenoid and saponins (Rajan et al., 2011; Shaikh, 2011; Mehta et al., 2012). Hydroalcoholic extract of *Terminalia chebula* exhibits anti-arthritic activity due to its modulatory effect on proinflammatory cytokine expression in the synovium (Nair et al., 2010; Singh and Sharma, 2010; Chang and Lin, 2012). The anti-arthritic activity of
hydroalcoholic extract of *Coriandrum sativum* may be attributed to the modulation of proinflammatory cytokines in the synovium (Nair *et al*., 2012).

CFA rats were treated daily with oral administration of different doses of methanolic extract of *Randia dumetorum* reduced paw swelling and arthritic index which makes this plant as a strong candidate for further research on RA (Patel *et al*., 2012). Leaves of *Cocculus hirsutus* (Tirkey and Tiwari, 2012), *Barleria lupulina* (Mazumder *et al*., 2012), *Barringtonia acutangula* (Thirumal and Vijaya, 2013), *Tribulus terrestris* (Mishra and Biswal, 2013) and roots of *Litsea cubeba* (Lu Pin Qin and Hong Zhang, 2013) were found to possess anti arthritic property.

The petroleum ether, chloroform, alcohol and aqueous extract of *Euphorbia thymifolia* were screened for anti-arthritic activities using FCA induced arthritic in albino rats and the results suggested that the plant possesses anti-arthritic activity (Mamatha *et al*., 2014). Astragaloside IV (AST) a saponin from *Astragalus membranaceus* exerts anti arthritic effect by inhibiting macrophages and chondrocytes there by preventing the synthesis of inflammatory mediators (Wang, 2014).

Ethanolic extract of *Caesalpinia pulcherima* at two different dose (200 and 400 mg kg⁻¹) has shown anti arthritic activity with the significant decrease in paw volume which may be due to the presence of flavonoids, steroids and phenols by inhibiting the 5-Lipoxygenase path way together with the COX-2 path way in FCA induced arthritic rat model (Rajaram *et al*., 2015).

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