Traditional uses of *Sauropus* spp

*Sauropus androgynus* is a medicinal herb with a long history of usage in Ayurvedic medicine. It was reported that the *Sauropus androgynus* leaf extract can increase the mother’s breast milk production without decreasing the quality of the breast milk (Kustifah, 1991). *Sauropus androgynus* is widely used as tonic, antioxidant and febrifuge. The leaves are used as antitussive, tonic and soothing lungs and to relieve internal fever. The dark green leaves provide a rich source of chlorophyll which is a valuable blood building element, cell rejuvenator and beneficial to the circulation (Ambasta, 1994).

Leaves of *S. androgynus* are used as vegetables (Gopalakrishna, 2003). It can also be useful as a dye in food colouring, a delicious hot weather green vegetable, widely considered to be nutritious, approximately 10% protein content, the roots and leaves are used as medicine (Stoepman, 2003). Young shoots, leaves, flowers and fruits can be eaten as a vegetable raw or cooked. The taste is sweet and very typical odour. They can also be added to soup. The dried crushed root is used medicinally in head ache it also acts against fever and urinary problem. *Sauropus androgynus* leaves can increase the quantity of milk production in mice (Saroni *et al.*, 2004; Fletcher, 2004). In traditional system of medicine, the leaves are used to treat various disorders like epistaxis, oriental sores, used as application for oral thrush in infants and the leaf paste is applied over nausal ulcers and yaws, erythema and measles. Apart from its traditional medicinal uses it is used by local folk healers to treat debility, anemia and locally it is called as ‘Multivitamin plant’. The leaves pounded with milk are applied topically for hair growth and decoction taken orally for hypertension (Chooi *et al.*, 2003).
2011). *Sauropsis bacciformis* (L.) Airy Shaw is a herb growing in seashore sandy tracts, especially in brackish clayey soil near sea level to below 100 m. *Sauropsis bacciformis* is commonly called Kuruvi Thengai, Thengai Keerai and it is used by the rural folk for medicinal purpose. The aerial parts of the plant is used against gastrointestinal problems. The plant paste is given with *Piper betel* orally (Muralidharan and Narasimhan, 2012). The plant is also used by the local people for skin diseases. They use the aerial parts as a green vegetable.

**Traditional uses of *Sesuvium portulacastrum***

*Sesuvium portulacastrum* is a herb commonly known as shoreline purslane or sea purslane and is distributed in the coastal areas throughout the world. It is used as a salad ingredient, vegetable, soup thickener, flour and pickle. The flowers are edible raw or cooked. It has omega 3 fatty acids, antioxidants, vitamins and minerals. According to the experts at the University of Texas, purslane contains 10-20 times more melatonin, an antioxidant than other vegetables tested (Correll and Johnston 1979). The mucilagenous sap comes in purslane can be used in salads and soups. The stem can be pickled. It has vitamin A, B, C and E six times more than spinach and betacarotene seven times more than carrot and it is a nutraceutical (Whitehouse, 1962).

**Pharmacognosy**

Pharmacognosy is the study of drugs of natural origin. The American society of pharmacognosy defines pharmacognosy as the study of physical, chemical, biochemical and biological properties of the drugs as well as search of new drugs from natural source. Plant based crude drugs whose botanical identity are not known are identified based on their morphological and anatomical characters. Organoleptical
characters play an important role in the identification of crude drugs. In this method, the color, taste and smell of the drugs are characterized. Shah and Khanna (1961) distinguished the fruits of *Embelia ribes* with its greyish black colour and warty surfaces with that of *E. robusta*, which has reddish, longitudinally wrinkled surface and more prominent calyx with five sepals. Satakopan and Thomas (1970) distinguished the leaves of *Adhatoda vasica* and its adulterant *Ailanthus excelsa* based on the palisade ratio and anatomical characters of leaf and petiole. Mitra *et al.* (1976) after careful pharmacognostical study stated that no difference was found in the macro and micro characters in rhizome of red and white varieties of *Nelumbo nucifera*. Patel and Satakopan (1979) distinguished *Saraca asoka* bark from its adulterants by the analysis of the powder and put fourth a key for the identification of the ‘Asoka’ bark powder.

Chakraborti *et al.* (1988) studied the stem barks of *Strychnos nux-vomica* and *S. potatorum* and distinguished the authenticity of ‘Nux-vomica’ bark from other barks. Srivastava and Srivastava (1988) indentified the adulterants of *Catharanthus roseus* by the analysis of powdered drug. The microscopic features of leaf, midrib, petiole, stem, root and the parameters such as leaf constituents were used for the identification of medicinal plants such as *Jatropha podagrica* (Kotian and Jolly 1991). Khatoon *et al.* (1993) used TLC finger printing technique and identified that the market samples ‘Ratanjot’ is derived from *Arnebia nobilis*. *Mucuna cochinchinensis* is the adulterant of the Unani drug ‘Karanj’ (*Pongamia pinnata*). Scanning electron microscopical (SEM) studies were also useful in the identification of crude drugs even at the variety level (Serrano *et al.*, 2010).

Kotnis *et al.* (2004) reported the pharmacognostic characteristics of *Hemidesmus indicus* var, *pubescens*. The data from efficacy study suggested that the
drug hold promising future for the treatment in kidney disorder. Adebowale and Adedire (2006) studied the chemical composition and insecticidal activity of seeds of *Jatropha curcas*, the results showed that the oil content was high (66.4%), triacylglycerol was the dominant lipid and linolenic acid was the dominant fatty acid. Physicochemical properties of the oil indicated that the acid value, free fatty acids, peroxide value and iodine value were high. The stem of *Sesuvium portulacastrum* increase in thickness by forming successive rings of cambia that formed concentric rings of xylem alternating with phloem. The cambium is semi-storied and exclusively composed of vertically elongated fusiform initials while cambial rays were absent in the fusiform cambial initials undergo further division and develop into vertically upright rays. Secondary xylem has vessel elements, fiber tracheids whereas secondary phloem consists of sieve tube elements, companion cells and parenchyma with no rays in the young stem (Rajput and Patil, 2008).

Arif et al. (2009) studied pharmacognostical characters of bark and trunk of *Spondias mangifera* and differentiated it from other species. Vikas Kumar et al. (2009) carried out pharmacognostical and phytochemical evaluation on the leaves of *Paederia foetida*. It has a simple leaf, petiolate, stipulate, glabrous and mostly ovate with entire margin and taste was indistinct. Microscopic analysis, phytochemical standardization parameters and preliminary identification of phytoconstituents were also determined.

Rajesh et al. (2010) studied the presence of various phytoconstituents in *Capparis sepiaria* such as glycosides, reducing sugars, flavonoids, saponins, starch and terpenoids. The extractive values, foaming index, moisture content and swellings index were also evaluated. Manjoosha et al. (2010) investigated the phytochemicals present in the leaf of *Jatropha curcas*. The physical parameters like oil content
(7.45%), pH 6, refractive index 1.4556nD (30.9°C); density (mg/ml), 0.8728, acid value and iodine value (111.5) were also determined. Macroscopical study of the rhizome of *Corallocarpus epigaeus* revealed that it was napiform, smooth with membranous peeling leaving a white surface. Transverse section showed presence of simple and compound starch grains. Physicochemical parameters were evaluated and the preliminary phytochemical studies showed the presence of carbohydrates, flavanoids, alkaloids, mucilages, proteins and aminoacids. Three alkaloids were identified in TLC analysis of methanolic extract (Nishashri *et al*., 2010).

Uthayakumari and Sumathy (2011) evaluated the macro and microscopic characters and physicochemical parameters of *Jatropha maheswarii* an endemic taxon of Tamil Nadu. The results showed that ash value was more for leaf and moisture content was more for stem. Greater extractive values were obtained in water followed by methanol. The phytochemicals present were flavonoids, alkaloids, phenols, glycosides, tannins, steroids and saponins. Khyade and Vaikos (2011) studied the pharmacognostical and phytochemical characters of *Jatropha gossypifolia*.

Kulkarni *et al*. (2011) investigated the presence of alkaloids, tannins, carbohydrates and steroids in *Persea macrantha*. Standardization of bark was established by the macro and microcopical parameters. Physicochemical parameters and TLC could be utilized for quick identification of the drug and were particularly useful in the case of powdered materials. Kannan and Babu (2011) differentiated *Balanophora fungosa* from *Scindapus officinalis* based on their pharmacognostical characters. Nwokocha *et al*. (2011) carried out phytochemical studies on the leaf, stem, root and seed of four species of *Jatropha* (*J. curcas, J. gossypifolia, J. multifida* and *J. podagrica*). Qualitative and quantitative analysis of five secondary metabolites (alkaloids, tannins, saponins, flavonoids and phenols) were undertaken. All secondary
metabolites analyzed were present in all tissues studied but at different concentrations. These studies confirmed the relatedness of these species and spotlight these important phytochemicals in the species. However, variations observed in their concentrations confer individuality of the species.

Sumitra et al. (2012) carried out physicochemical parameters along with histochemical studies, preliminary phytochemical screening and fluorescence analysis in Suaeda maritima. The transverse section of stem indicated the arrangement of various cells in cork, cortex, phelloderm and pith region. These studies would be helpful in developing standards for quality, purity and sample identification of this plant. The total ash value of pneumatophore of Avicennia marina was 10.24%. The extractive value of water was more than in the solvents investigated. Preliminary phytochemical screening of pneumatophore showed the presence of alkaloids, catachins, coumarins, flavonoids, phenols, steroids, tannins, terpenoids, xanthoproteins and sugars in the methanol and ethanol extracts (Paulpriya et al., 2012). Parmar et al. (2012) studied the pharmacognostic characteristics of leaf of Diospyros melanoxylon. The physical constants such as ash value, extractive value and loss on drying were determined. Kewatkar, (2012) studied the macroscopic and microscopic characters of the leaves of Cassia obtusifolia. The physicochemical analysis and preliminary phytochemical screening were also determined. The phytochemical tests showed the presence of the alkaloids, glycosides, flavonoids, saponins, steroids, triterpenoids, flavonoids and fixed oil.

Bisht et al. (2013) investigated the physicochemical parameters and phytochemicals present in the leaf of Acorus calamus and the results revealed the presence of various phytochemicals like carbohydrates, glycosides, phenolic compounds, tannins, amino acids, terpenoids and flavonoids. Zaman and Pathak
(2013) studied the pharmacognostical and phytochemical parameters of *Annona reticulata*. The results showed that ash value was more for leaf than stem. Greater extractive value was found in alcoholic extract. The phytochemicals present were fats and oils, terpenoids, tannins, phenolic compounds, alkaloids and steroids.

**Phytochemistry**

The medicinal effects of plants are due to metabolites or organic compounds synthesized by plant using enzyme mediated chemical reactions called metabolic pathways. Plant metabolites can be considered as specific to individual plant species. Many thousands of secondary metabolites (phytochemical) have been isolated from plants and many of them have powerful physiological effects in humans and are used as medicines. These are mostly alkaloids, glycosides, tannins, flavonoids, steroids, saponins and terpenes etc. Phytochemistry is important for the determination of active ingredients of medicinal plants, their quantification and analysis of the beneficial and harmful effect to human health. Techniques commonly used in the field of phytochemistry are extraction, isolation and structural elucidation (MS, ID and 2D NMR) of natural products and as well as various chromatographic techniques like MPLC, HPLC, LC-MS, HPTLC, GC-MS are also employed.

*Zygophyllum quaternense* contained harmine, a plant toxin and a CNS stimulant *Salsola barysma* and *Zygophyllum quaternense* had alkaloids, coumarins and sterols (Duke, 1988). Flavonoids are a group of naturally occurring polyphenolic compounds found universally in foods of plant origin and widely distributed in fruit, vegetables, nuts, seeds, herbs, spices, stems, flowers as well as tea and wine (Harborne, 1998). Commercial use of mangroves as source of timber, fuel had long been recognized in tropical coastal zones. Mangroves also provides many non-timber
products such as tannin, fish poison, medicine, food fodder etc. They had been used in traditional medicine in South Asian countries including India (Bandarnayake, 2002).

The water distilled essential oil of the leaves of *Coridothymus capitatus* was analysed by GC-MS and also by direct thermal desorption GC-MS. The essential oil was mainly of monoterpenes while oxygenated hydrocarbons were identified as 55.6% and non-oxygenated hydrocarbons as 43.6%. The major components found were carvacrol, p-cymene, thymol, gamma-terpinene, alpha-terpinene, beta-myrcene and alpha-thujene. The essential oil of *C. capitatus* showed strong antibacterial activity (Goren *et al.*, 2003).

Falodun *et al.* (2006) reported the occurrence of flavonoids, saponins, diterpenes and phorbol esters in the aqueous and methanol extracts of *Euphorbia heterophylla*. Raghavendra *et al.* (2006) examined the powdered leaf material of *Oxalis corniculata* in different solvents and reported the presence of phenols, glycosides, carbohydrates, phytosterols and tannins. Awoyinka *et al.* (2007) extracted eight bioactive compounds from the dried leaves of *Cindoscolus aconitifolius* using water and ethanol. Different extracts of *Semecarpus anacardium* were analysed by Mohanta *et al.* (2007) for its phytochemical properties. Onwnkaeme *et al.* (2007) detected reducing sugars, phenols, tannins and flavonoids in *Pycnanthus angolensis*. Sixty two compounds were identified in the fresh matured leaves of *Lantana camara* by GC-MS technique (Chowdhury *et al.*, 2007). Umadevi *et al.* (2007) carried out the phytochemical analysis in *Achyranthes bidentata*. The methanol and acetone extracts of 14 plants belonging to different families were evaluated for phytochemical analysis and this study revealed the presence of tannins, cardiac glycosides, steroids and saponins (Vaghasiya and Chanada, 2007).
Methanol leaf extract of *Pterocarpus santalinus* was evaluated by the HPTLC finger print analysis (Arokiyaraj et al., 2008). From the leaves of lemon balm (*Melissa officinalis*) Citronellal, Citral, thymol, and \( \beta \)-caryophyllene, were identified (Cosge et al., 2009). Delazar et al. (2009) investigated the aerial parts of *Ornithogalum procerum* and the main compounds identified were phenylacetaldehyde, hexahydrofarnesyl acetone, docosan and 5-methyl octadecane. The main components of the n–Hexane extract of the bulbs were Hexatriacontane and 5\( \beta \), 6\( \beta \)-Epoxycholest-7-en- 3\( \beta \)-ol. Parasuraman et al. (2009) analysed the phytoconstituents present in the *Cleistanthus collinus* leaves by quantitative GC-MS analysis. The dried and the fresh leaves had more or less similar phytoconstituents. 17 compounds were identified and the major phytoconstituents present in the fresh and dried leaves of aqueous extract were 3-0-methyl-d-glucose and benzenetriol. Teffo et al. (2009) delivered dichloromethane and acetone fractions from leaves of *Dodonea viscosa var. angustifolia* to isolate four kaempferol. The isolation and identification of two bioactive products from *Chrysanthemum myconis* were carried by Nadiet et al. (2009).

GC/MS analysis of ethyl acetate extract of *Goniothalamus umbrosus* revealed the existence of 1 - butyl-2 - cyclohexen - 1-ol, benzaldehyde and globulol (Abdelwahab et al., 2009). GC-MS analysis of *Jatropha curcas* leaves revealed the presence of 16 compounds. The four most abundant components were 22, 23-dihydrostigmasterol, alpha-tocopherol, beta amylin and dotriacon. The content of gamma tocopherol reached 2.88% and vitamin E reached 18.06% in the extract (Wang et al., 2009).

Sirohi et al. (2009) evaluated total sugar, protein, tannin and saponin content of aqueous, methanol and acetone extracts of twenty one different herbal plants and their
parts. Tannins saponins, phlobatanins, flavonoids, anthraquinones, terpenoids, steroids, alkaloids and glycosides distribution in four medicinal plants belonging to different families (Caricaceae, Lamiaeceae, Passifloraceae and Graminae) were investigated and compared (Victor Njoku and Chidi, 2009). Sazada et al. (2009) analyzed preliminary phytochemicals in some of the important medicinal and aromatic plants.

Khaled et al. (2010) isolated and identified twelve fatty acids in which linolic acid and palmitic acid were the main acids from the aerial parts of Beaumontia grandiflora. The leaves and fruits of Pedalium murex were experimented to evaluate the phytochemical components (Sermakani and Thangapandian, 2010). The phytochemicals, minerals and vitamins A and C composition of Spondias mombin leaves were determined by Igwe et al. (2010). Phytochemicals were identified from the leaf extract of Andrographis stenophylla using TLC and its hypoglycemic activity was also recorded by Parasuraman et al. (2010).

Phytochemical screening of extract of Acacia nilotica revealed the presence of tannins, carbohydrates and glycosides. This analysis exhibited the high antibacterial activity in the methanol extract of Acacia nilotica (Venkataswamy et al., 2010). Manjoosha et al. (2010) investigated the phytochemicals present in the leaf of Jatropha curcas and the results revealed the presence of various phytochemicals like alkaloids, anthraquinones, flavonoids, glycosides, phytosterol, saponins, steroids, tannins and triterpenoids. Screening of phytochemicals of Suaeda maritima showed presence of carbohydrates, protein, tannins, alkaloids and flavonoids in comparatively higher amount than other phytochemicals tested (Patra et al., 2011). Laitonjam et al. (2011) isolated and compared the chemical constituents taken from Cissus adnata
leaves and *Smilax lanceaefolia* roots and their free radical scavenging activities were also tested.

Ambikapathy *et al.* (2011) studied *Enicostemma littorale* whole plant methanol extract and found out the presence of the phytocompounds - Laminaribiitol, 12-hydroxy-9-octadecenoic acid, Myricetin, 3,3-Methylene-bis (4-hydroxycoumarin) and Catachin. *E. littorale* could be used as herbal alternative for the synthesis of antifungal agents. Ezhilan and Neelamegam (2011) determined bioactive compounds of *Polygonum glabrum* by GC-MS analysis. This study reported the compounds with antimicrobial property and plasticizer compound showed antifouling activity also. The results of this study offer a base of using *P. glabrum* as herbal alternative for the synthesis of antimicrobial drugs.

Gopalakrishnan (2011) investigated the ethanolic extract of *Mussaenda frondosa* by GC-MS analysis. Twenty chemical constituents had been identified. The major chemical constituents were (-)-Quinic acid, 4-((1E)-3-Hydroxy-1-propenyl)-2-methoxyphenol, Naphthalene, decahydro-2-methoxy- and 1, 2, 3-Benzenetriol. Devendran and Balasubramanian (2011) determined the possible chemical components of *Ocimum sanctum* leaves by GC-MS which leads to the identification of 10 compounds. This analysis revealed that *Ocimum sanctum* leaves contains mainly eugenol and caryophyllene.

Ganesh and Vennila (2011) carried out phytochemical analysis leaves of *Acanthus ilicifolius* and *Avicennia officinalis*. It showed the presence of protein, resin, steroids, tannins, reducing sugar, carbohydrates, saponins, sterols, terpenoids, phenols, cardioglycosides and catechol. In the GC-MS analysis, seven bioactive phytochemical compounds were identified in the methanol extract of *Acanthus*
*ilicifolius* leaves and three bioactive compounds in *Avicennia officinalis*. Yadav and Agarwala (2011) studied seven medicinal plants such as *Bryophyllum pinnatum, Ipomea aquatica, Oldenlandia corymbosa, Ricinus communis, Terminalia bellerica, Tinospora cordifolia, and Xanthium strumarium*. These results showed the presence of phytochemicals such as phenols, tannins, flavonoids, saponins, glycosides, steroids, terpenoids and alkaloids. It provided evidence that crude aqueous and organic solvent extracts of these tested plants contain medicinally important bioactive compounds and it justifies their use in the traditional medicines for the treatment of different diseases.

Dried leaves of *Melanthera scandens* was analysed for its proximate composition and the results obtained showed that, it had ash content (14.23%), moisture (7.35%) crude protein (25.13%), crude fibre (6.59%), fat (9.43%) and carbohydrate (37.40%). The results of the phytochemical screening showed the presence of tannins, alkaloids, saponins, flavonoids and cardiac glycosides. The leaves were also found to be rich in minerals and the amino acid composition showed correlation with some of the essential amino acids with respect to FAO/WHO provisional pattern. It was also indicated that the leaves of *Melanthera scandens* had nutritional qualities that could provide the users and consumers with additional nutrients and the presence of phytochemicals indicated that it was a potential source of drug (Omoyeni *et al.*, 2012). Al-Azzawi *et al.* (2012) carried out phytochemical screening of *Sesuvium portulacastrum*. The ethanolic extract of the leaves and stem showed the presence of steroids. While the aqueous extract was positive towards the presence of alkaloids, saponins, tannins and terpenoids. GC-MS analysis revealed the presence of 22, 23-dihydro stigmasterol, benzoic acid 3, 4, 5-trihydroxy- (gallic acid), (2R, 3R)-(-)-epicatechin and capsaicin. All of these compounds had shown to have antibacterial activity.
The preliminary phytochemical constituents, and HPTLC analysis of the whole plant ethanolic extract of *Cayratia trifolia* revealed the presence of alkaloid, flavonoids, tannins, saponins and phenolic compounds. The ethanolic extract of *Cayratia trifolia* possessed the free radical scavenging activities. The HPTLC analysis assessed that the ethanolic extract had five alkaloid compounds and one flavonoid compound (Perumal *et al.*, 2012). Abirami and Rajendran (2012) carried out GC-MS analysis of methanol extract of *Vernonia cinerea*. In the GC-MS chromatogram seven peaks were identified. The three major compounds identified were n-hexadecanoic acid (42.88%) 1, 2-Benzene di carboxylic acid, disoctyl ester (23.00%) and squalene (11.31%). Bharathy *et al*. (2012) studied the phytocomponents in the methanol extract of *Jatropha gossypifolia* leaves using GC-MS analysis. This study revealed the presence of eighteen compounds, of which lanosterol (34.47%), globulol (18.96%) and C-sitosterol (12.51%) were the main components. Vinodprabhu and Guruvayoorappan (2012) identified 60 different compounds in the methanolic extract of *Avicennia marina* by GC-MS and LC/MS analysis. Pentanoic acid, decanoic acid, diethylhydroxylamine, pyrrolidine, 4-Chlorophenyl, Octadecylisocyanate, thiazolidinones and arabinopyranoside (flavonoid) were the major compounds reported.

Musa and Abdul (2012) determined the chemical constituents in the leaf extract of *Avicennia marina* and found Phthalic acid, all trans squalene and 4-Ethyl glaiacol at concentration rates of 39.0%, 8.5% and 6.8% using GC-MS analysis. Alagammal *et al*. (2012a) studied the active constituents present in the whole plant ethanol extract of *Polygala rosmarinifolia* by GC-MS analysis. Twelve compounds were identified and 1, 5- anhydro-d-mannitol (73.35%) was the prevailing compound in ethanol extract, which was suggested to be an anticancer compound.
The active constituents present in the whole plant extract of *Rauwolfia densiflora* was investigated by Shunmugapriya and Uthayakumari (2012a). Seven compounds were identified in the ethanol extract by GC-MS analysis. The major components present were propanoic acid anhydride, 1, 10-Decanediol, Phytol and 3-Pentanol, 2, 4-dimethyl. Alagammaal *et al.* (2012b) evaluated the phytocomponents of *Polygala javana* whole plant methanol extract using GC-MS. It revealed that *P. javana* had Polygalitol (84.79%), 1H-Perimidine, 2,3-dihydro-2-(2,4,5-trimethoxyphenyl) (6.33%), 4H-1 Benzopyran - 4 - one, 5 - hydroxyl - 2-(4-hydroxyphenyl) - 3,7-dimethoxy (1.53%) and Ledene Oxide-(1) (1.43%).

Shunmugapriya and Uthayakumari (2012b) carried out chemical evaluation of tubers of *Stephania wightii*. Thirteen compounds were identified in the ethanol extract of tuber by GC-MS analysis. The major components presented in the tuber of *S. wightii* were (1H) Indolo (2,1-a) isoquinoline, 5, 6, 11, 12-tetrahydro-2,3,8,9-tetramethoxy (59.98%), 6H Dibenzo (a,g) quinolizine 5, 8, 13, 13a - tetrahydro-2, 3, 9, 10 -tetramethoxy-(n)-(34.86%) and 1, 3-propanediol, 2-(hydroxymethyl) -2 – nitro-(2.89%). The tubers were used as a medicine in the treatment of cancer. Daffodil *et al.* (2012) identified six phytocompounds in the ethanol extract of rhizome of *Curculigo orchioides*. The major compounds were Hexadecane, 5-butyl, Benzoic acid, 4-ethoxyethyl ester, Ethyl iso allocholate and Dodecane, 2, 6, 11-trimethyl.

Umadevi *et al.* (2012) investigated the physicochemical characters phytochemical screening and chromatographic finger print profile of *Aegle marmelos* leaf ethanolic extracts. It revealed the presence of tannins, flavonoids, alkaloids, betacyanins, quinones, phenols, coumarins, glycosides and steroids in large amount. HPTLC analysis showed the presence of ten compounds in the fraction and HPLC analysis showed the presence of rutin, ursolic acid, duercitin and marmesin.
Arisarum vulgare seed methanol water extract possessed strong antioxidative properties in vitro and they are confirmed by high polyphenols and flavonoids contents and corroborated by HPLC identifications (Kadri et al., 2013). The phytochemical constituents of Leucas aspera flower extract revealed the presence of alkaloids, flavonoids, steroids, cardiacglycosides, saponins and tannins. This may be responsible for various pharmacological actions of this plant part like antibacterial, antiulcer, anticancer, larvicidal and chemoprotective activities. The antioxidant activity of Leucas aspera extracts might be attributed alkaloids, phytosterols and flavonoid contents. (Latha et al., 2013).

Pharmacology

Antioxidant activity

Natural antioxidants or phytochemical antioxidants are the secondary metabolites of plants (Middleton and Kandaswami, 1993; Walton and Brown, 1999). Carotenoids, flavonoids, cinnamic acids, benzoic acids, folic acid, ascorbic acid, tocopherols, tocotrienols etc are some of the antioxidants produced by the plant. Beta-carotene, ascorbic acid and alphatocopherol are the widely used antioxidants (Call and Frei, 1999). Naturally occurring antioxidants can also be replaced by commercially available synthetic antioxidants such as butylated hydroxyanisole (BHA) and butylated hydroxytoluene (BHT) which are quite unsafe to use and is restricted due to their carcinogenic effects (Velioglu et al., 1998). The search for antioxidant principles from plants has been accelerated and many plants with potential antioxidant activities had been identified. Naturally occurring antioxidants can be used in foods and also for prevention and treatment of free radical related disorders Flavonoids display a remarkable array of biochemical and pharmacological actions viz., antiinflammatory, antioxidant, antiallergic, hepatoprotective, antithrombotic, antiviral and
anticarcinogenic activities. (Middleton et al., 2000; Tiwari, 2001). Flavonoids are important for human beings due to their antioxidative and radical scavenging effects as well as for their potential estrogenic and anticancer activities (Springob and Saito, 2002). Pourmored et al. (2006) carried out the relative antioxidant activity in the extracts of selected Iranian medicinal plant species. The antioxidant properties of 25 edible tropical plants were studied using Trolox equivalent antioxidant capacity, DPPH scavenging, reducing power, and total polyphenol contents.

Wong et al. (2006) carried out in vitro antioxidant activity in thirteen medicinal plants from Western Ghats of India using different models (Badami and Channabasavaraj, 2007). Sureshkumar et al. (2008) surveyed antioxidant activities of selected medicinal plants namely Albizia amara, Achyranthes aspera, Cassia fistula, C. auriculata and Datura stramonium. Agoramooorthy et al. (2008) evaluated five halophytes and eight mangroves for the total polyphenol content and antioxidant activity. They confirmed the potential free radical scavenging activities of Indian mangrove and halophytes. Narumon et al. (2008) determined antioxidant capacity, vitamin C, total phenolic content and nutritive value of Sauropus androgynus plants harvested during different periods of the year.

antioxidant activity assays. Souri et al. (2008) determined free radical scavenging activity of some medicinal plants by linolenic acid peroxidation and DPPH methods.

The antioxidant activity, total phenol and flavonoid contents of water, ethanol and methanol extracts of Hieracium pilosella were reported by Ljiljana et al. (2009). Antioxidant activity and total phenolics contents of Mentha piperita, Origanum vulgare and Capiscum annum were determined by Univer et al. (2009). 123 extracts were prepared from 59 plant samples, belong to 32 plant species to measure their ability of scavenging radicals (Rajendra and Shakti, 2009). Bushra et al. (2009) derived extracts from the leaves of Terminalia arjuna and Aloe barbadensis using four solvents by adopting two extraction techniques to observe their antioxidant activity. In vitro antioxidant activity (DPPH and reducing power assay) of methanol leaf and flower extracts of Lippia alba was determined by Naznin and Hasan (2009).

Aliyu et al. (2009) evaluated antioxidant potential by DPPH and reducing power assay on the methanolic extract of Bauhinia rufescens leaves. Similar studies showed that extracts of Stephania rotunda and Stephania hernandifolia strongly scavenged DPPH radicals (Gulcin et al., 2010; Patal et al., 2010). Different dried herbal parts of Cassis sophera were studied by Dheeraj et al. (2010) to assess their effects on antioxidant, antiinflammatory and analgesic activities. The antioxidant activity of aqueous and methanol extracts of Erythrina indica leaves were tested by DPPH, nitricoxide radical scavenging activity and inhibition of lipid peroxidation by thiobarbituric acid reactive substance under in vitro condition and quantitative analysis of total phenolics, flavonoids were also estimated by Sakat and Juvekar (2010). Shajiselvin and Kottaimuthu (2010) examined in vitro free radical scavenging potential by DPPH radical scavenging activity, superoxide anion scavenging activity and Iron chelating activity of various extracts of whole plant of Borreria hispida. In
vitro antioxidant activity in leaves and stem of *Aristolochia indica* were evaluated by Devi *et al.* (2010).


Free radicals are responsible for aging and causing various human diseases. According to the study of Thirunavukkarasu (2010) the antioxidant substances which scavenge free radicals played an important role in the prevention of free radical-induced diseases. In his study high SOD (Superoxide dismutase) radical scavenging value was found in *Sesuvium portulacastrum* and the highest phenolic content was found in *Suaeda maritima* extract and there was no positive correlation between evaluated antioxidant activities and the phenolic contents of the examined coastal plants.

Patra *et al.* (2011) investigated the *in vitro* antioxidant and antimicrobial activities along with phytochemical screening of organic and aqueous extracts of leaf and stem of *Suaeda maritime*, a mangrove associate from Bhitarkanika of Odisha. Paliwal *et al.* (2011) analysed the antioxidant properties of *Moringa oleifera* and the
M. Morris. Bonh., 1999) that showed the presence of tannins, flavonoids, W. D., 1989) that for the ethanolic extract of drumsticks on DMBA (7, 12-dimethylbenz (a) anthracene) induced renal carcinogenicity.

Morakinya et al. (2011) evaluated the in vitro antioxidant property of Zingiber officinale, a known food additive. It indicated that the extracts possessed potent antioxidant property as shown by significant scavenging of ABTS and SOD radicals. Similarly, MDA (Malondialdehyde) level (lipid peroxidation) was significantly reduced by the both extracts. The hexane and ethyl acetate extracts of Stephania dinklagei, showed the most pronounced DPPH scavenging activity (Udegbunam et al., 2012).

Shanmugapriya et al. (2012) investigated the antioxidant and antimicrobial activity of Avicennia marina and A. officinalis. The Avicennia marina samples had more effective antioxidant activity when compared to the Avicennia officinalis. At the test of antimicrobial activity by the well diffusion assay also clearly expressed that Avicennia marina had high concentration of active principles when compared to Avicennia officinalis. Jenecius et al. (2012) investigated the plant parts of Sauropus bacciformis and found that the highest amount of total phenolics and flavonoids were reported in the stem of Sauropus bacciformis. It also showed highest in vitro antioxidant activities.

Kumbhare et al. (2012) carried out phytochemical analysis and antioxidant activity of Moringa oleifera and it revealed the presence of tannins, flavonoids, steroids and alkaloids. The LC50 (Lethal concentration)values were obtained for extracts as 850 µg/ml for petroleum ether extract 800 µg/ml for chloroform extract and 900 µg/ml for methanol extract. Sreelatha et al. (2012) investigated the antioxidant capacity and the possible protective effects of Amaranthus paniculatus
leaves on the antioxidant defense system in Ehrilich’s ascites carcinoma (EAC) treated mice. Oral administration of the leaf extract at different doses caused a significant decrease in tumour volume, viable cell count and tumor weight and elevated the life span of EAC bearing mice. It also showed an improved antioxidant potential as evidenced by a significant increase in the cellular antioxidant defense system such as catalase, superoxide dismutase and reduced glutathione and also significantly reduced the levels of thiobarbituric acid substances (TBARS) in liver. The levels of RBC, a haemoglobin and lymphocyte count were altered in EAC bearing mice and were reverted back to near normal levels after the treatment with the leaf extracts.

Samuel et al. (2012) determined the antioxidant property of *Ageratum houstonianum* leaves and it was found that ethyl acetate extract could scavenge the oxidants at 500 µg/ml with high percentage inhibition (88.26 ± 0.35µg/ml) of DPPH and in the case of hydroxyl radicals the maximum percentage inhibition was (75.81±0.39µg/ml). Olabinri et al. (2013) investigated the *in vitro* antioxidant activity and nitric oxide scavenging capabilities in stem bark of *Jatropha gossypifolia*. The activity was significantly higher in dry season.

Plant extracts are a good source of antioxidant property containing phytoconstituents. The presence of flavanoids, tannins, steroids and saponins present in extracts may be responsible for antioxidant activity. All the plants studied (*Ficus bengalensis, Hemidesmus indica, Sida retusa, Ixora coccenia, Green tea and Terminalia chebula*) possessed marked antioxidant effect (Ansa et al., 2013).
Anticancerous activity

Cancer is one of the most life threatening diseases with more than 100 different types. Scientists all over the world are concentrating on one of the herbal medicines to boost immune cells of the body against cancer. Plants have been a long history of use in the treatment of cancer. There are several medicinal plants all over the world, including India, which are being used traditionally for the prevention and treatment of cancer. Hartwell, in his review on plants against cancer listed more than 3000 plant species that have been repeatedly used in the treatment of cancer. The search for anticancer agents from the plant source started in earnest in the 1950s with a discovery and development of Vinca alkaloids vincristine and vinblastine and isolation of cytotoxic podophyllotoxins. These discoveries promoted the United States National Cancer Institute (NCI) to initiate extensive plant collection program in 1960. This leads to the discovery of many novel chemotypes showing a range of cytotoxic activities including taxanes and camptothecins. The first clinically isolated drug from Catharanthus roseus of Apocynaceae i.e. vincristine and vinblastin.

Torrance et al. (1976) studied that the chloroform extract of Jatropha macrorhiza and it was found to contain triterpene acetylaleuritolic acid which possessed inhibitory activity towards the P-385 (3 PS) lymphocytic leukemia test system. Gunasekera et al. (1979) isolated spruceanol from Cunuria spruceana which was reported to have cytotoxic and antitumour activity. Aguye et al., (1986) carried out acute toxicological and histopathological investigations on the acetonitrile extract from Jatropha curcas in comparison to praziquantel, the known antischistosomal drug. Pharmaceutical companies have screened more than 25,000 plants for anticancer drugs (Saxe, 1987). Jatropha curcas containing tannins are known to be useful in the
treatment of ulcerated tissues any they have remarkable activity in cancer prevention and anticancer treatment (Lin et al., 2003).

Taxol is a diterpenoid compound isolated from *Taxus brevifolia* and these molecules called taxanes by the US Department of Agriculture (USDA) for the National Cancer Institute (NCI). The leaves of *T. canadiensis, T. baccata* are used in the traditional Asiatic Indian Ayurvedic medicine system in the treatment of cancer. Palitaxel, occurs in the leaves of various *Taxus* species has provided a major renewable natural sources of natural drugs. It is used in the treatment of breast, ovarian and non-small-cell lung cancer and has shown efficacy against *Kaposi sarcoma* (Cragg and Newman, 2006).

Another important addition to the anticancer drug armamentarium is the class of clinically active agents derived from camptothecin, which is isolated from the Chinese ornamental tree *Camptotheca acuminata* (Nyssaceae), known in China as the tree of joy. The derivatives of Camptothecin, Topotecin and Irinotecin, originally developed by Japanese company, YAKUH Honsha, are now in clinical use. These are used for the treatment of ovarian, lung and colorectal cancers. Several genera of the Apocynaceae family including *Bleekeria vitensis* have reputed anticancer properties (Cragg and Newman, 2006).

The two clinically active agents, etoposide and teniposide, which are semi synthetic derivatives of the natural product, epipodophyllotoxin (an isomer of podophyllotoxin), may be considered as being more closely linked to a plant, *Podophyllum* species used for the treatment of cancer. *Podophyllum peltatum* (American *Podophyllum*) and *P. emodii* from India (Indian *Podophyllum*) have a long history of medicinal use, including the treatment of skin cancer and warts. The major
active constituent of this plant is podophyllotoxin. With particular cancer, anticancer
drug discovery is now based on high throughput screening of compounds against a
range of such target (Cragg and Newman, 2006).

The ethanol, petroleum ether and dichloromethane extracts of *Thelesperma megarotamicum* Oxa *lis erythorrhiza* and *Larrea divaricata* showed high inhibitory
activity on MCF - 7 (cell line from human breast caner) cell line proliferation
(Bongiovanni *et al.*, 2006). Pradhan *et al.* (2008) studied the methanolic extracts of
*Foeniculum vulgare* and *Helicteres isora* against normal human blood lymphocytes
by micronucleus assay and antitumour activity against B16F10 melanoma cell line
trypan blue exclusion assay for cell viability. They stated that *Foeniculum vulgare*
and *Helicteres isora* could be considered as a normal resource of antitumour agents.

Romelilah (2009) studied the anticancer activity of hydrodistilled essential oils
obtained from flowers of *Matricaria chamomilla* and the dried leaves of *Marjorana
hortensis* against leukaemia HL- 60 and NB 4 cells were tested in-vitro. The essential
oils of above said plants could be used as a potential natural antioxidant and
anticancer agents.

Forty four extracts from plants used traditionally as anticancer agents were
evaluated in vitro for their antiproliferative activity against Hep-2, MCF-7 and Vero
cell lines. Among the tested extracts, methanol fractions of *Ononis hirta* (aerial parts)
and *Irula viscosa* (flowers) were the most active fractions against MCF-7 cells
(Talib and Mahasneh, 2010). Joseph *et al.* (2011) analysed bioactive compounds from
*Sidra cordifolia* and the antimicrobial, cytotoxic effect of HeLa cell lines by the
bioactive compound. Muangman *et al.* (2012) investigated the antimetastatic effects
of curcusone B, a diterpene from *Jatropha curcas* against human cancer cell lines.
Treatment with non-cytotoxic doses of curcuscine B resulted in a strong reduction of in vitro invasion, motility and secretion of matrix-metalloproteinases (MMP) of the cancer cells and it effectively suppressed the metastatic cancers.

Aditya et al. (2013) studied the anticancer properties of three plants, Rubia cordifolia, Plumbago zeylanica and Calophyllum inophyllum. Anticancer activities are assayed with standard MTT colorimetric procedure against MCF-7 (Breast cancer) and HT-29 (colon cancer) cell lines.

**Antidiabetic activity:**

Diabetes mellitus (DM) is caused by inherited or acquired deficiency in production of insulin by the pancreas, or by the ineffectiveness of the insulin produced. This insulin deficiency results in increased concentration of glucose in the blood. Increase in blood glucose damages many systems of the body in particular, the blood vessels and nerves. The hyperglycemia caused due to decreased insulin production is called Type-1 diabetes and hyperglycemia due to insufficient insulin utilization is called Type-2 diabetes. Out of these two types, Type-2 diabetes is a major problem of today and it account for nearly 95% of total diabetic population. The World Health Organization (WHO) reported that 300 million people would suffer from diabetes mellitus by the year 2025. The treatment with modern medicine is mostly associated with the side effects. Management of side effects has become the major task for the medical community. To overcome the toxic effects caused by these drugs an alternative system of treatment is required. There are many traditional medicinal plants reported to have hypoglyceamic properties and have gained importance in the treatment of diabetes.
Ghosh and Gupta, 1980 studied that ethanolic extracts of leaves and flowers of *Catharanthus roseus* lower blood glucose levels. Oral administration of the extract of *Astracantha longifolia* could significantly improve glucose tolerance in healthy human and diabetic patients (Fernando et al., 1991). *Achyranthes aspera* extract produced a significant dose-related hypoglycaemic effect in normoglycaemic and alloxan induced diabetic rabbits. The plant might act by providing certain necessary elements like calcium, zinc, magnesium, manganese and copper to the beta-cells (Akhtar and Iqbal, 1991)

S-allyl cysteine sulphoxide (SACS), a sulphur-containing amino acid of *Allium sativum* that is the precursor of allicin and garlic oil, had been found to show significant antidiabetic effects in alloxan diabetic rats. Administration of a dose of 200mg/kg significantly decreased the concentration of serum lipids, blood glucose and activities of serum enzymes like alkaline phophatase, acid phosphatase, lactate dehydrogenase and liver glucose 6-phosphatase. It significantly increased liver and intestinal HMG-CoA (3-hydroxy-3-methylglutaryl-coenzyme A) reductase activity and liver hexokinase activity (Sheela and Augusti, 1992). Saponin isolated from the leaves of *Acanthopanax senticosus* injected to mice decreased experimental hyperglycaemia induced by injection of adrenalin, glucose without affecting the levels of blood sugar in untreated mice (Sui et al., 1994)

The antihyperglycaemic effect of *Cuminum cyminum* was studied in healthy rabbits subjected to weekly subcutaneous glucose tolerance tests after gastric administration of water, tolbutamide or traditional preparation of the plant. The results showed that the *C. cyminum* significantly decreased the area under glucose tolerance curve and the hyperglycaemic peak (Ramos et al., 1995). Ten human subjects were treated with a preparation of the whole plant, *Phyllanthus amarus*
for ten days (6 subjects were hypertensive and four were diabetic). Glycaemia was reduced in the treated group (Srividya and Periwal, 1995).

Garg et al. (1997) reported that once daily administration of the juice of *Lantana camara* leaves given at different dose levels for 14 days in rats resulted in alterations in various haematological and biochemical parameters. A strong hypoglycaemic effect was seen with 1500 mg. Trans-dehydrocrotonin (t-DCTN), a 19-nor-clerodane diterpene isolated from the bark of *Croton cajucara* showed a significant hypoglycaemic activity in alloxan-induced diabetic rats but not in healthy rats at oral doses of 25 and 50 mg/kg body weight (Farias et al., 1997).

Tunali et al. (1998) found out that the administration of extracts obtained from *Beta vulgaris var. cicla* leaf inhibited the increase in the non enzymatic glycosylation of skin proteins and blood glucose. These results proved the ability of this plant in preventing or retard ing the development of some diabetic complications. An experimental study showed that the extracts of *Euphorbia prostrata* decreased the hyperglycaemic peak and the area under the glucose tolerance curve in hyperglycaemic rabbits (Aguilar et al., 1998). The extracts of the aerial and root parts of *Sida cordifolia* showed hypoglycaemic activity. Moreover, the methanol extract of root was found to possess significant hypoglycaemic activity. *Azadirachta indica* leaf extract significantly blocked the inhibitory effect of serotonin on insulin secretion mediated by glucose (Chattapadhyay, 1999).

Olayiwola et al. (2004) investigated the antidiabetic potential of *Jatropha tanjorensis* leaves and results showed that the hypoglycaemic effect of Et OH/H₂O (1:1) leaf extract in fasted and glucose loaded rats at the doses of 1 and 2g/kg *in vivo*. Only 2g/kg of the extract possessed significant glucose lowering activity in glucose
loaded rats while the insulin secretion ability in vitro was limited to the ethylacetate fraction. The methanol extract of Aegle marmelos decreased blood sugar in Alloxan diabetic rats by lowering its oxidative stress evidenced by reducing serum and liver lipid peroxidation, hydroperoxide levels, elevating catalase glutathione peroxidase, superoxide dismutase and reduced glutathione levels (Kesari et al., 2006).

Tailang et al. (2008) reported that the oral administration of ethanolic extract of Cinnamomum zeylanicum leaves in the doses of 100, 150, and 200 mg/kg body weight to white Wistar albino rats significantly reduced their blood sugar level in alloxan induced diabetic rats under acute and sub acute studies. Gymnema sylvestre had significant antidiabetic activity and a hypolipidemic activity in alloxan induced and normal fasting rats (Mall et al., 2009). There was an increase in glycosylated haemoglobin and decrease in total haemoglobin in alloxan induced diabetic rats. Administration of leaf ethanolic extract of Acacia catechu brought back the level to normal and this was due to the result of improved glycaemic control produced by the extract (Jarald et al., 2009). Ethanolic extract of Euphorbia hirta possessed significant antihyperglycaemic activity in streptozotocin induced diabetic mice (Kumar et al., 2010a).

Administration of Luminitzeracemosa leaf extract to diabetic rat reduced all the elevated parameters such as SGOT, SGPT, ALP, bilirubin and LDH levels (Ravikumar and Gnanadesigan, 2011). Hibiscus cannabinus leaf extract had significant antidiabetic activity, which lowered the fasting blood glucose level in streptozotocin induced diabetic rats (Sundarraj et al., 2011). Administration of the ethanolic and aqueous extracts of Adiantum philippense dried fronds in the doses of 250 and 500mg/kg body weight to alloxan induced diabetic rats had significant antihyperglycaemic potential as well as antioxidant potential (Paul et al., 2012).
Ethanolic extract of *Ginkgo biloba* possessed significant antihyperglycaemic, antioxidant and antihyperlipidemia activities in streptozotocin induced diabetes in rats (Cheng *et al.*, 2013). *Calamus erectus* fruit extract had significant antidiabetic potential and could improve lipid profile and oxidative stress efficiently during diabetic condition (Ghosal and Mandal, 2013). Oral administration of the hydroalcoholic extract of *Cestrum nocturnum* leaves in the doses of 200 and 400 mg/kg body weight to Wistar rats significantly reduced their blood glucose levels in streptozotocin induced diabetic rats (Kamboj *et al.*, 2013). Verma *et al.* (2013) studied that the extracts of *Clitoria ternatea* stimulated significant regeneration of β cells of pancreas and antihyperlipidemic activity. They found out that the flavonoid, flavonone and polyphenolic content were correlated with antidiabetic activity. They also concluded that the antidiabetic potential is due to decrease in oxidative stress, decrease in serum, lipid profile and increase in the level of SOD, GSH, and CAT enzyme activity.

**Hepatoprotective activity**

Liver diseases are one of the most severe ailments. They are mainly caused by toxic chemicals, excess consumption of alcohol, infections and autoimmune disorders. Most of the hepatotoxic chemicals damage liver cells mainly by inducing lipid peroxidation and other oxidative damage in the liver. They may be classified as acute or chronic hepatitis (inflammatory liver diseases), hepatosis (non-inflammatory diseases) and cirrhosis (degenerative disorder resulting in fibrosis of the liver). It has been reported that about 170 phytoconstituents isolated from 110 plants belonging to 55 families do possess hepatoprotective activity, therefore due importance has been given globally to develop plant based hepatoprotective drugs effective against a variety of liver disorders (Handa, 1991). Inspite of tremendous advances made in
allopathic medicine, management of liver diseases was still a challenge to modern medicine.

Plant drugs were known to play a vital role in the management of liver diseases (Satagopan, 2000). Numerous plants and polyherbal formulations reported to possess hepatoprotective activities (Malhotra et al., 2001). The modern medicine offers little for the alleviation of hepatic ailments, whereas the most important representatives are the phytoconstituents (Chandrasekhar et al., 2004). Mondal et al., (2005) reported that methanol extract of Diospyros malabarica bark had potent hepatoprotective activity against carbon tetrachloride induced liver damage in rats. Dash et al. (2007) reported that chloroform and methanol extracts of entire plant of Ichnocarpus frutescens were effective hepatoprotective agents against paracetamol induced liver damage in rats. Tandon et al. (2008) studied hepatoprotective activity of Vitex negundo leaf Ethanolic extract against hepatotoxicity. The result indicated that effect of V. negundo leaf Ethanolic extract was evident in the doses of 250 and 500 mg/kg body weight, as there was a significant decrease in TB, AST, ALT and ALP levels than control. Histology of the liver secretion of the animals treated also confirmed the hepatoprotective activity.

Manokaran et al. (2008) investigated the hepatoprotective activity of alcoholic extract of Aerva lanata against paracetamol induced liver damage in rats. The plant extract was effective in protecting the liver against the injury induced by paracetamol in rats. Aqueous extract from seeds of Areca catechu and nut galls of Quercus infectoria were investigated for their hepatoprotective potential against liver injury induced by carbon tetrachloride in rats (Pithayanukyl et al., 2009). Shyamal et al. (2010) reported that ethanol extracts of roots of Ixora coccinea, Rhinacanthus...
nasutus and whole plant of Spilanthes ciliata had potent hepatoprotective activity against aflatoxin B$_1$ intoxicated livers of albino male Wistar rats.

Ravi et al. (2010) studied the hepatoprotective activity of methanolic extract of flowers of Bombax ceiba against hepatotoxicity produced by administering a combination of two antitubercular drugs. Isoniazid and Rifampicin for 10 and 21 days by intraperitoneal route in rats. The hepatoprotective effect of leaf extract of Jatropha curcas was investigated against carbon tetrachloride induced acute hepatotoxicity in rats. The extracts showed protective effect by lowering serum levels of various biochemical parameters in the selected models (Imtiyaz, 2010).

Kumar et al. (2010b) studied the effect of diethyl ether extract of Coccinia indica leaves on hepatoprotective activity against carbon tetrachloride induced liver toxicity in rats. The hepatoprotective activity of Coccinia indica leaf extract at doses of 400 mg/kg body weight were comparable with standard treatment 125 mg/kg body weight of silymarin. Verma et al. (2010) investigated the hepatoprotective activity of alcoholic and aqueous extract of leaves of Anisochilus carnosus against Rifampicin induced hepatotoxicity. Hepatoprotective activity of alcoholic extract of Luffa acutangula against carbon tetrachloride and rifampicin-induced hepatotoxicity in rats was evaluated and probable mechanism of action was suggested (Jadhav et al., 2010).

Aghel et al. (2011) studied the hepatoprotective action of Ficus carica leaf ethanolic extract in animal model of hepatotoxicity induced by carbon tetrachloride. Levels of marker enzymes such as alanine aminotransferase (ALT) and aspartate aminotransferase (AST) increased significantly in CCl$_4$ treated mice. Pre-treatment with the extract resulted in less pronounced destruction of the liver with no fibrosis
and moderate inflammation observed. The treatment with *Ficus carica* leaf extract in dose of 200 mg/kg enhanced protection against CCl₄ induced hepatic damage.

*Zakaria et al.* (2011) investigated the hepatoprotective effect of virgin coconut oil, prepared by dried or fermented processed methods, using the paracetamol induced liver damage in rats. Lahon and Das (2011) investigated the hepatoprotective effect of Tulsi (*Ocimum sanctum*). The *Ocimum sanctum* alcoholic leaf extract showed significant hepatoprotective activity and synergism with sliymarin. Karthikeyan *et al.* (2011) investigated the hepatoprotective activity of ethanolic extract of *Spermacoce hispida* against carbon tetrachloride induced hepatotoxicity in rats. Liver functions were assessed by the determination of the SGOT, SGPT, ALP and bilirubin.

Pattanayak *et al.* (2011) investigated the hepatoprotective activity of crude flavonoid extract of *Cajanus scarabaeoides* in paracetamol intoxicated albino rats and it showed hepatoprotective activity. Gnanasekaran *et al.* (2012) evaluated the hepatoprotective activity of the ethanolic extract of whole plant *Indigofera tinctoria* on the Chang cell line (normal human liver cells).

Ravikumar *et al.* (2011) evaluated hepatoprotective effect of ethanolic extract of *Suaeda maritima* leaves using concanavalin- A induced liver injury model in Wistar rats. Rats in concanavalin- A administered group showed elevated levels of AST, ALT, ALP and bilirubin. Pretreatment of rats with ethanolic extract (300 mg/kg body weight) significantly reduced these serum parameters compared to concanavalin - A administered group. Histopathological examination of liver sections showed that, normal liver architecture was disturbed by hepatotoxin intoxication. The triterpenoids might be responsible for the hepatoprotective activity and this plant might be useful for the development of herbal medicine for the treatment of hepatitis.
Anitha et al. (2012) evaluated the hepatoprotective and antioxidant effect of ethanol extract of whole plant of *Cynoglossum zeylanicum* on CCL\textsubscript{4} induced hepatotoxicity in rats. The extract of *Cynoglossum zeylanicum* exhibited a significant hepatoprotective effect showing increasing levels of SOD, CAT, GPX, GSH and GRD by reducing malondialdehyde (MDA) levels.

Pattanaik et al., 2013 evaluated the hepatoprotective and lipid peroxidation study of *Crataeva magna*. The lipid peroxidation activity of the methanolic extract obtained from sequential method was analyzed which show significant result with IC\textsubscript{50}=0.176 mg/ml. This extract was found to be a source hepatoprotective effect probably acting by promoting the antioxidant defense system.

**Antiinflammatory activity**

Inflammation is the defense mechanism by which body tries to resists the entry of invading pathogen or help the body to remove the injurious stimuli and initiate the healing process. But unchecked inflammation is associated with a large number of pathological conditions like asthma, atherosclerosis, diabetes, obesity, rheumatoid arthritis, inflammatory bowel disease etc. Acute inflammation is the result of immediate response to tissue injury which result in vasodilation, vascular leakage (oedema) leukocyte migration and mucus production. Chronic inflammation results from tissue destruction by inflammatory cells (abuss formation) and attempts taken during repair with fibrosis and angiogenesis clinical signs of inflammation include heat (calor), pain (Dolor), redness (Rubor), swelling (tumour) and loss of function. Medicines from plant origin had been used as antiinflammatory agents since long time without any adverse effects.
Handa and Kapoor (1992) cited that species of 96 genera belonging to 56 families are ascribed antiinflammatory activity. The triterpenes, alpha-amyрин acetate, beta-amyрин acetate and Lupeol acetate of Alstonia boonei were evaluated for antiarthritic activities in rats (Okai and Carroll, 1993). Flavonone glycosides, diinsininol and diinsinin from rhizomes of Sarcophyto piriei showed prostaglandin synthesis inhibition and the inhibition of platelet-activating factor-induced exocytosis respectively. The dichloromethane extract of the aerial parts of Tanacetum microphyllum yielded two antiinflammatory flavonoids 5,7,3’-trihydroxy-3,6,4’-trimethoxy flavones (centaureidin and 5,3’-dihydroxy-4’-methoxy-7 carbomethoxy flavonol (Abad et al., 1993). Ammar et al. (1997) revealed the antiinflammatory activity of bioactive fractions isolated from the seeds of Trigonella foenumgraceum, roots of Glycyrrhiza glabra and fruits of Coriandrum sativum. Three flavonoids isolated from Inula viscosa dichloromethane extract were 7-O-methylaromadendrin, rhamnocitrin and 3-O-acetylpadmatin along with a sesquiterpene lactone inuvisolide; a sesquiterpene acid, ilicic acid and a diagalactosyl diacylglycerol, inugalacolipid A and shown to have 12-O-tetradecanoylphorbol-13-acetate induced ear oedema inhibitory activity in mice (Manez et al., 1999). The alcoholic extract of Clerodendron serratum root was evaluated for its antiinflammatory activity in animal models (Narayanan et al., 1999). The antiinflammatory activity of the aqueous extract of the stem bark of Bridelia ferruginea was evaluated using carrageenan induced paw oedema in rats and mice (Olajide et al., 1999) The antiinflammatory activity of the aqueous extract of roots of Rumex patientia was evaluated using carrageenan, histamine, dextrane, serotonin and formaldehyde-induced oedema tests (Suleyman et al., 1999).

Aqueous and alcoholic extracts of pods and flowers of Tecoma sambucifolia were analysed to determine their antiinflammatory activity using carrageenan-induced
Oedema test (Alguacil et al., 2000). Fangchinoline and tetrandrine, major alkaloids from *Stephania tetrandra* had been used traditionally to treat inflammatory diseases in Korea. Both fangchinoline and tetrandrine showed antiinflammatory effects on mouse (Choi et al., 2000). Quercetin belongs to the group of plant pigments called flavonoids that were largely responsible for the colours of many fruits, flowers and vegetables, Quercetin works as antiinflammatory, antioxidant, and anticancer agents (Lamson and Bringnale 2000). The compound Dicadalenol, Caryolane -1, 9 β-diol and quercetin were the most active substances tested and displayed dose dependent activities, isolated from aerial parts of *Heterotheca inuloides* (Delgado et al., 2001).

Hexane, chloroform and methanol extracts of seven herbal drugs (*Aristolochia trilobata*-leaves and bark, *Bursera simaruba*-bark, *Hamelia patens*-leaves, *Piper amalago*-leaves and *Syngonium podophyllum*-leaves and bark) were evaluated for their typical antiinflammatory activity (Sosa et al., 2002). The ethanol extract of the rhizomes of *Cistanche deserticola* were evaluated for its antiinflammatory activity (Lin et al., 2002). Methanol extract of dried leaves of *Alstonia macrophylla* and its fractions were investigated for its antiinflammatory activity in carrageenan-induced rat paw oedema (Arunachalam et al., 2002). Antiinflammatory activity of ethanolic extract from *Bouchea fluminensis* leaves had been demonstrated (Delaporte et al., 2002). *Satureja hortensis* is a medicinal plant used in Iranian folk medicine as muscle and bone pain reliever. In the hydro-alcoholic extract, polyphenolic fraction and essential oil of the aerial parts of the herb were prepared and evaluated for their antiinflammatory activity using carrageenan induced paw oedema in rats (Hajhashemi et al., 2002).

Aqueous, hexane and methanol extracts of 12 plant species traditionally used in Kenya were evaluated for their antiinflammatory activity (Matu and Staden, 2003).
The antiinflammatory activity of the alcoholic extract of stem of *Tabernaemontana pandacaqui* was evolved using carrageenan induced rat paw oedema (Taeotikul *et al.*, 2003). *Mitragyna ciliata* was widely used in traditional medicine to treat inflammation, hypertension, headache, rheumatism, gonorrhoea and broncho-pulmonary diseases. The antiinflammatory and analgesic properties of the hexane and methanolic extracts of the stem bark of *M. ciliata* had been investigated (Dongno *et al.*, 2003). The methanol -water extract of *Barleria prionitis* was evaluated for antiinflammatory and antiarthritic activities against different acute and chronic animal test models (Singh *et al.*, 2003). Pharmacological studies were conducted on the hexane extract of the dry stem of *Diospyros variegata* on experimental animals for evaluating its analgesic, antipyretic and antiinflammatory activities (Trongsakul *et al.*, 2003).

The methanolic extract from *Clerodendrum petasites* was assessed for antiinflammatory and antipyretic activities on experimental animals. It was found that the extract possessed moderate inhibitory activity on acute phase of inflammation (Panthong *et al.*, 2003). The antiinflammatory activities of *Piper cubeba* (fruit), *Physalis angulata* (flower) and *Rosa hybrid* (flower) using carrageenan induced paw oedema, arachidonic acid-induced ear edema and formaldehyde-induced arthritis in mice. The antiallergic and analgesic activities of these plants were studied by using 2, 4-dinitrofluorobenzene (DNFB) induced contact hypersensitivity reaction (type IV) and hot plate test in mice (Choi and Hwang, 2003). Antiinflammatory activity of ethanol extracts from 9 vine plants used in traditional Chinese medicine to treat inflammatory conditions were evaluated (Li *et al.*, 2004).

Mujumdar and Misar (2004) investigated the antiinflammatory activity *Jatropha curcas* root powder in paste form in the TPA (12-O-tetradecanoylphorbol
acetate) induced ear inflammation, in albino mice. Bagul et al. (2005) reported the antiinflammatory activity of two ayurvedic formulation containing ‘guggul’. Vale et al. (2006) studied that the raw extract of Jatropha gossypifolia aids the healing on the 3rd day post surgery, concerning the enhanced resistance of the gastrographies to pressure of rupture and on the 7th day, presenting better co-aption of the edges and reducing acute inflammatory reaction by microscopic analysis in male rats. The petroleum ether, ethyl acetate, ethanol and aqueous extracts of Sesbania sesban leaves were investigated for antiinflammatory activity in albino rats (Tatiya et al., 2007). The alcoholic and petroleum ether fractions of Mirabilis jalapa possessed good antiinflammatory property which may be attributed to the individual or combined action of phytoconstituents like alkaloids and steroids present in it (Nath et al., 2010).

Krishanamadhuri et al. (2011) carried out the vasoconstrictor activity of leaf extracts of Acalypha indica using different solvents like petroleum ether, chloroform, ethyl acetate and ethanol. The comparative study of the results indicated that the petroleum ether extract showed better vasoconstrictor activity against the blood vessels of frog comparable with the references standard drug adrenaline. Rahman et al. (2011) investigated the methanol extract of the dried leaves of Avicennia alba for its possible antidiarrhoeal and antinociceptive activities in animal models. The extract produced significant writhing inhibition in acetic acid-induced writhing in mice at the oral dose of 500 mg/kg body weight (P<0.001) comparable to the standard drug diclofenac sodium at the dose of 25 mg/kg of body weight.

Psychotria octosulcata had significant reduction in inflammation i.e. 67.94% (200 mg/kg body weight) in paw oedema method and 72.61% (200 mg/kg body weight) in cotton pellet method as compared to the standard drug, diclofenac which was 69.23% and 74.85% respectively (Mariyammal and Kavimani, 2013). The flower
extracts of *Ervatamia coronaria* exhibited significant analgesic and antiinflammatory activity, thereby justifying their use in traditional system of medicine (Joshi *et al.*, 2013).

**Other bioactivities**

*Salsola baryasma* possessed CNS depressant activity. *Zygophyllum simplex* is used as an antibiotic and a laxative (Saleh *et al.*, 1993; Oqlah and Abbas, 1994; Woo *et al.*, 1997). Okeke *et al.* (2001) stated that some of the phytochemical compound like glycosides, saponins, tannins, flavonoids, terpenoids, and alkaloids had variously been reported to have antimicrobial activity.

Goren *et al.* (2004) investigated the essential oil composition of *Satureja thymbra* by direct thermal desorber and head space GC-MS analysis methods. These essential oils were found to be active against the bacteria *Escherichia coli*, *Pseudomonas aeruginosa*, *Salmonella typhimurium*, *Shigella sonnei* and *Staphylococcus aureus* and the yeast *Candida albicans*.

Kilic (2006) analyzed the fresh and brine of leaves of *Thymbra spicata* var *spicata* by hydrodistillation, and head space GC-MS techniques. The main components were determined as carvacrol, p-cymene, beta-myrcene, gamma-terpinene, a-terpinene and trans-caryophyllene. The essential oil and carvacrol showed strong activity against all microorganisms.

Vadlapudi *et al.* (2009) studied the antimicrobial effect of the crude methanol extracts of mangrove plants *Tamarix aphylla*, *Sesuvium portulacastrum* and *Xylocarpus granatum*. They concluded that the crude methanol extracts possessed antimicrobial activity against *Acremonium strictum*, *Aspergillus niger*, *Candida*
albicans, Ervinia carotovara, Fusarium oxysporum, Pseudomonas marginalis, and Ustilago maydis.

Unlu et al. (2009) evaluated the essential oil from aerial parts of Thymbra spicata by GC-MS and its in vitro antimicrobial activity was examined. The in vitro efficacy of the essential oil against 21 bacteria and seven Candida species was examined. The essential oil demonstrated strong antimicrobial activity in a wide spectrum against most microorganisms, particularly the yeasts tested. Abdelwahab et al. (2009) evaluated the antibacterial activity and chemical composition of Goniothalamus umbrosus leaf extracts. The extracts demonstrated broad spectrum antibacterial effects against all tested bacteria.

Sivaperumal et al. (2010) screened the antibacterial activity of chloroform bioactive crude and column fractionated compounds from leaves of Exoecaria agallocha against 5 species of antibiotic resistant pathogens viz., Staphylococcus aureus, Staphylococcus epidermidis, Streptococcus pneumoniae, Pseudomonas aeruginosa and Klebsiella sp. The crude chloroform extracts had maximum activity (10mm) against Pseudomonas aeruginosa.

Jeeshna et al. (2011) screened the leaf extracts of Croton bonplandianum phytochemically. The methanol extracts of the leaf showed effective inhibition against the fungi and bacteria studied. Therefore the leaves of Croton bonplandianum could be considered to be the promising source of antimicrobial compounds. Cathrine and Prabavathi, (2011) evaluated the preliminary phytochemical analysis and antibacterial activity of leaf extracts of Vitex leucoxylon. Disc diffusion method revealed the high activity against Vibrio cholerae, Salmonella paratyphi, Enterobacter aerogenes and Escherichia coli a group of gram negative bacteria.
Paulpriya et al. (2012) investigated the pharmacochemical characterization and antibacterial activity of the pneumatophore extracts of *Avicennia marina* against gram positive and negative pathogenic bacteria. The pneumatophore extracts of *Avicennia marina* showed potent antibacterial activity. Nagababu and Uma (2012) studied the antibacterial activity and phytochemical analysis of mangrove plant *Avicennia alba*. The plant extracts in different solvents were screened for antibacterial activity. Of the six solvent extracts of *A. alba*, ethyl acetate and acetone extracts of leaf and stem showed relatively high antibacterial activity. *A. alba* leaf and stem extracts of different solvents showed good antibacterial activity against gram negative bacteria than the gram positive bacteria tested.

The ethnobotanical efficacy of *Avicennia marina*, *Caesalpinia pulcherrima* and *Melastoma malabathricum* were evaluated against gram positive (*Staphylococcus aureus*) and gram-negative (*Escherichia coli, Klebsiella pneumoniae, Pseudomonas aeruginosa*) bacteria. Among treatments, maximum in vitro inhibition was scored in the extract of the plant *Avicennia marina* followed by *Caesalpinia pulcherrima* and *Melastoma malabathricum*. All plant extracts showed significant zone of inhibition for *Staphylococcus aureus* than for other bacterial species taken for the study. Among the four solvents tested the methanol and ethyl acetate extracts were more potent in their antibacterial activity (Sheeladevi et al., 2012). Chollom et al. (2012) demonstrated that *Psidium guajava* leaf extract had nutritional value as well as great antiviral potential against NDV in vivo.

Ramanathan et al. (2012) studied that the extracts of *Casuarina equisetifolia* can be used as potent antimicrobial activity against *Bacillus proteus, Klebsiella pneumoniae, Bacillus megaterium, Bacillus subtilis, Shigella siga* and *Shigella sonnei*. Considerable antifungal activity was found against *Aspergillus fumigatus*,
Rhizopus sp, Aspergillus flavus, and Candida albicans. The condensed tannins extracted from C. equisetifolia showed considerable DPPH radical scavenging activity and ferric reducing antioxidant power.