The concept of Ethnomedicine is evolved from the necessity for studies in the light of modern sciences on the drugs used in the traditional medicines. It is defined as the interdisciplinary science of biologically active agents traditionally observed by man. India has vast ethnobotanical knowledge since ancient times. Origin of all such knowledge in India is from the great tradition of Ayurveda. Many plant-derived drugs used in modern medicine are developed through ethnobotanical approach which leads to subsequent ethnopharmacological studies. Scientific studies available on a good number of medicinal plants indicate that promising bioactive constituents can be developed to solve many problems pertaining to health.

**Traditional uses of *Jatropha spp.***

*Jatropha* is a medicinal taxon whose leaf, stem, bark, latex of probably of all the species are used in ethnomedicine for long time. Seed oil of *Jatropha gossypifolia* is used in rheumatism and paralytic affections (Annon 1965). *Jatropha gossypifolia* is used in different countries in many ways. It possesses significant anticancer, hepatoprotective and pesticidal activity (Hartwell, 1969; Chatterjee *et al.*, 1980). The stem sap stops bleeding and itching of cuts and scratches (Morton, 1980). In West Africa, the leaves of *J. curcas* are utilized extensively in different forms to treat various ailments like fever, mouth infections, jaundice, guinea-worm, sores, and joint rheumatism. The root decoction is used as a mouthwash for bleeding gums, toothache, eczema, ringworm, and scabies and to treat dysentery and venereal diseases (Oliver-Bever, 1986).

In south Nigeria, the fresh *Jatropha gossypifolia* leaf extract is applied with crushed leaf by herbalists and local people to stop bleeding from skin and nose
The tree exudates of *Jatropha gaumeri* is used to alleviate skin rashes and mouth blisters, as well as fever and bone fractures. (Comerford, 1996). The leaves and fruits of *Jatropha variegata* is used as antiseptic for wounds and haemostatic. (Al-Tubai and Khulaid, 1996).

The sap and leaves of *Jatropha curcas* are used to control parasites (Fagbenro-Beyioku et al., 1998). In traditional medicine *Jatropha nana* is used as antiirritant in ophthalmia (Das and Venkataiah 2000). In ayurvedic literature, *J. glandulifera* seeds, leaves, bark and roots were reported for its analgesic properties, and used in inflammation, asthma and bronchitis (Das and Venkataiah 2000). In Latin America and the Carribbean, the leaves of *J. gossypifolia* are boiled and the decoction is used for washing wounds. The stem sap is used to stop bleeding and itching of cuts and scratches. The leaf bath is used for sores, sprains, and rashes (Lans et al., 2001). The red sap of *Jatropha unicostata* is used as a haemostatic in human and live stock infection. It is also used to treat the skin, tender glands, eye infection, chest pain, stomach pain, itching and as a vermifuge (Miller et al., 2004).

*Jatropha tanjorensis* leaves are consumed in Nigeria as soups and as a tonic with the claim that it increases blood volume. The leaves are also employed traditionally in the treatment of anaemia, diabetes and cardiovascular diseases (Iwalewa et al., 2005). Seed oil of *Jatropha glandulifera* is used in chronic ulceration, foul wound ring worm, rheumatism and paralysis. Plant juice is used to remove film from the eyes. Water extract of root is given to children suffering from abdominal enlargement (Senthil kumar et al., 2006). The local people of Alagoinha, Perambuco and northeast Brazil use the latex from *Jatropha curcas* and *Jatropha mollissima* for external application and internal consumption of latex by diluting it with water has been claimed to treat snake poisoning (Albuquerque, 2006).
*Jatropha curcas* and *Jatropha gossypifolia* leaf extracts have been used to clean sores in Trinidad and Tobago (Lans, 2007) and to treat skin rashes and oral candidiasis in Tanzania (Kisangau *et al.*, 2007). The roots, stems, leaves, seeds, and fruits of the plant have been used in traditional folk medicine. The young stem of *Jatropha gossypifolia* is used as tooth brush as well as to clean the tongue (Ogundare, 2007).

Ethnobotanical uses of *Jatropha gossypifolia* reported for cancer, diarrhoea, dysentery, skin diseases (leprosy), arthritis, ulcer, gum infections and wound healing (Rajesh *et al.*, 2007). In Malaysia and Indonesia the leaves of *Jatropha gossypifolia* are boiled with coconut oil, heated over open fire and applied over the abdomen to help relieve abdominal colic due to constipation. To relieve the constipation the seeds are burnt and pulverized and this is taken orally (Khare, 2007). Dabur *et al.* (2007) reported that root of *Jatropha gossypifolia* traditionaly used in diarrhoea and dysentery. The oil is used as the purgative and locally applied in skin disease and arthritis. Latex and leaf juice are used to treat ulcer, skin disease and gum infections. *Jatropha zeyheri*, indigenously known as “Sefapabadia” amongst Sotho tribe, root is used by traditional medicine practitioners in the treatment of sexually transmitted infections and urinary tract infections. It is also used to treat menstrual pains, irregular periods, and to ensure a strong foetus during pregnancy (Van Wyk and Gericke, 2007).

Three drops of latex of *Jatropha curcas* with a glass of water taken orally for three days to cure mouth ulcer (Karuppusamy, 2007). *Jatropha pandurifolia* is used as purgative styptic and emetic, and is also used in the treatment of warts, tumour, rheumatism, herpes, pruritis, tooth ache, scabies, eczema and ring worm (Pertino *et al.*, 2007). Jothi *et al.* (2008) listed the ethnobotanical uses of *Jatropha glandulifera*, stem being used to arrest bleeding from wounds, cuts and ulcers and
leaves and seeds of *Jatropha gossypifolia* are used to cure stomach disorders and fever. Seed oil useful in body pain, root used in kidney troubles, liver bladder diseases, diabetes and against leprosy.

The latex of *Jatropha* contain alkaloids including Jatrophine, Jatropham and curcin with anticancerous properties. It also used externally against skin diseases, piles and sores among the domestic livestock. The roots are known to contain an antidote against snake venom. The root extract also helps to check bleeding from gums. (Thomas *et al.*, 2008). In Africa, the plant *Jatropha tanjorensis* plays an important role in the traditional methods of malaria treatment by providing good sources for the detection of novel antiplasmodial compounds. (Chukwujekwe *et al.*, 2009). The stem sticks of *Jatropha gossypifolia* are used as tooth brushes and are said to strengthen the gums and to cure spongy gums and gum boils. (Panda, 2010)

The roots of *Jatropha glandulifera* are boiled and taken to treat diabetics. It is one among 29 species to treat diabetics and related complications by the traditional healers and the tribal inhabitants of Nalamankadai, Chitteri Reserve Forest, Dharmapuri India (Kadhirvel *et al.*, 2010). 2-3 tsp of fresh latex from *Jatropha gossypifolia* and equal amount of Mohari (*Brassica compestris*) seed oil mixed well and the mixture is applied topically on skin twice a day up to 6-8 days to clear pimples, scars and warts on faces of elder girls and boys (Salave and Reddy 2011(a)). An extract from a handful of seeds of *Jatropha podagrica* in water is mixed with 2-3 tsp of Kanda (*Allium cepa*) bulb extract and applied externally on face of elder girls once daily at night for 12-15 days to clear pimples, scars and warts (Salave *et al.*, 2011(b)).
Pharmacognosy

Pharmacognosy is the study of drugs of natural origin. The American Society of Pharmacognosy defines pharmacognosy as "the study of the physical, chemical, biochemical and biological properties of drugs, drug substances or potential drugs or drug substances of natural origin as well as the search for new drugs from natural sources". In the standardization of a drug macroscopical, physicochemical, phytochemical (qualitative, quantitative) and chromatographical methods are used.

Stem of Jatropha is with well developed secondary growth. The transverse section consists of distinct periderm, wide cortex, continuous hollow cylinder of xylem and phloem and wide pith. Circular, thick walled laticifers are abundant in cortex. Gelatinous fibres occur as ring. Calcium oxalate crystals are of druses type and found in abundant in leaf and stem (Metcalfé, 1979). Dehgan (1982) studied the anatomical features in several species of Jatropha. This study was the evidence in support of infrageneric relationships. A trilacunar 3 trace nodal pattern is typical for this genus. The number of vascular bundles ranges from 11 though 9, 7, 5 and 3 occur in a ring, as free traces, a medullated cylinder or as “U” shaped free traces. Reduction in number of petiolar traces is followed in the evolutionary advancement in various taxa. This reduction in traces corresponds with South-North distribution of species and consequential anatomical adaptation to colder and more arid climates in Central America and Africa.

Srivastava and Srivastava (1988) identified 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. Jatropha podagrica (Kotian and jolly, 1991). The
anatomical investigation of the stem was carried out in the soft woody, semi arid plant *Calotropis procera*. The stem and leaves of this plant has an abundance of caustic latex which is vesicant, irritant and rubefacient. The characters observed in the stem can be used to identify the drug from the plant in entire or powder form (Ogund, 1993). Amerjothi (2002) studied the crystal character of medicinal plants and the application of crystallography in the identification of important medicinal plants and in detecting adulterant.

Kotnis *et al.* (2003) reported the pharmacognostic characteristics of *Hemidesmus indicus* var. *pubescens*. Also, the data from efficacy study suggested that the drug holds promising future for the treatment in kidney disorder. Kuijt and Dong (2005) reported difference between the rhizome and stem of *Balanophora* and he noted the presence of regular vascular bundles in a ring in rhizome, which is absent in stem. Kemal (2006) studied a comparative examination of seed, calyx and petal characters as well as pollen characteristics of 7 *Silene* species (*Silene sipylea*, *S. fabaria*, *S. tenuiflora*, *S. lydia*, *S. discolor*, *S. colorata* and *S. apetala*).

Liu *et al.* (2007) studied the microsporogenesis and male gametogenesis in *Jatropha curcas*, and showed that the male flowers had 10 stamens, which had four microsporangia and the development of anther wall being dictyledonous type. The cytokinensis following microsporogenesis was simultaneous, producing tetrahedral tetrads. Mature pollen grains are two-celled at anthesis, with a spindle shaped generative cell.

Kaviani (2008) investigated morphological, micromorphological and anatomical features of *Lilium ledebourii* an endemic, rare and very attractive ornamental species in Iran. This study revealed that there were some particular,
unique properties in this species. Arif et al. (2009) utilized pharmacognostical characteristics, phytochemical parameters, TLC fingerprint profiles and microscopic characters, for the identification of *Spondias mangifera* trunk and bark and differentiated it from other species.

Abdulrahman et al. (2010) made anatomical studies of *Jatropha gossypifolia* and associated microflora under different watering conditions. Nayak and Patel (2010) made a detailed pharmacognostic study of *Jatropha curcas* leaf which had a single layer of epidermis, covered by cuticle, on both sides. Trichomes and anomocytic stomata were present in leaves. Lamina showed the presence of palisade cells and midrib has 5-7 layered, thick walled closely packed collenchyma on both surface, spongy mesophyll and vascular bundles. The phytoconstitutents present were alkaloids, flavonoids, glycosides, saponins, tannins, phenolic compounds, steroids, terpenoids, carbohydrates and amino acids. Pharmacognostical evaluation of leaves of *Momordica tuberosa* could be used to distinguish it from other species of *Momordica* (Pramod 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. The physical parameters like oil content (7.45%), pH 6, refractive index 1.4556nD (30.9°C); density(mg/ml), 0.8728; acid value (mg KOH/gm, 4.21); Iodine value (111.5) were also determined. Dibinlal et al. (2010) carried out pharmacognostical studies on the bark of *Artocarpus hirsutus*. All these pharmacognostical and phytochemical studies can be used as a diagnostic tool for the correct identification of the plant and also to test adulteration.
Kulkarni *et al.* (2011) studied the systematic pharmacognostical evaluation of bark of the plant *Persea macrantha*. The results obtained from standardization of bark established the macro and microscopical parameters, physicochemical parameters and TLC profiles. These parameters can be utilized for quick identification of the drug and are particularly useful in the case of powdered materials.

Khyade and Vaikos (2011) studied the pharmacognostical and phytochemical evaluation of *Jatropha gossypifolia*. Macromorphology, microscopic studies of transverse section, histochemical colour reactions, quantitative microscopy and phytochemical components were determined. Different compounds such as anthraquinones, flavonoids, phlobatannin, phenolics, saponins, tannins and terpenoids were detected. The physicochemical characters such as moisture content, total ash, acid insoluble ash and extractive values were also evaluated.

Kannan and Babu (2011) differentiated the *Balanophora fungosa* from *Scindapus officinalis* based on their pharmacognostical character. Vivekanand *et al.*, (2012) investigated the pharmacognostical and physicochemical characteristics of *Martynia annua*. Various parameters established in this study will help in controlling the standards and quality of the raw material of *Martynia annua*. Bothara and Singh (2012) carried out pharmacognostical studies of seeds on some plants belonging Chattisgarh. This pharmacognostical and preliminary phytochemical studies will be beneficial for proper identification and authentification of seeds of *Diospyros melonoxylon* and *Manilkara sapota*.

Parmar *et al.* (2012) studied the pharmacognostic characteristics of leaf of *Diospyros melonoxylon*. The physical contents such as ash value, extractive value and loss on drying were determined and also preliminary phytochemical investigation of
all extracts were carried out. The preliminary phytochemical screening showed the presence of steroids and triterpenoids in petroleum ether extract, flavonoids, tannins and phenolic compounds, sterols and triterpenoids in ethyl acetate extract, flavonoids, tannins, phenols and steroids in alcoholic extract, carbohydrates, proteins, amino acids, flavonoids and tannins in aqueous extract.

Kewatkar, (2012) studied the macroscopic and microscopic characters of the leaves of *Cassia obtusifoila*. The physiochemical analysis and preliminary phytochemical screening were also determined. The phytochemical test showed the presence of the alkaloids, glycosides, flavonoids, saponin, steroids, triterpenoids, flavonoids and fixed oil.

Bisht *et al*. (2013) investigated the phytochemicals present in the leaf of *Acorus calamus* and the results revealed the presence of various phytochemicals like glycosides, phenolic compounds, tannins, amino acids, terpenoids and flavonoids. The physical parameters like moisture content (8.06%), total ash (9.4%), acid insoluble ash (0.65%), hexane soluble extractive values (2.5%), alcohol soluble extractive values (3.5%), and water soluble extractive values (30.5), total starch content (2.46%), total sugar content (0.80%), total tannins (1.09%), total phenolics (0.41%), total flavonoids (0.2%), total flavanols content (0.4%), total proanthocyanadines content (0.65%) and total volatile content (2%), were also determined.

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 plants. Plant metabolites can be considered as specific to individual plant species. Many thousands of secondary metabolites (Phytochemicals) 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. 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.

Banerji et al. (1984) isolated Gadain, a new lignin from Jatropha gossypifolia, the structure and stereochemistry of the compound was determined by spectral analysis, partial synthesis from Jatrophan and from transformation reaction. Kang et al. (1985) identified various alkaloids and flavonoids in Ricinus communis leaves. The dried leaves of Ricinus communis afforded two alkaloids, ricinine and N-demethylricinine and five flavonol glycosides: kaempferol-3-0-D-xylopyranoside, kaempferol-3-0-D-glucopyranoside, quercetin-3-0-D-xylopyranoside, quercetin-3-0-D glucopyranoside kaempferol-3-0-rutinoside and quercetin -3-0-rutinoside. The structure of withaminimin, a new ergostane-type steroid from Physalis minima, was established by spectral analysis (1H and 13C NMR-MS) (Hugo et al., 1987).

Seven phenolic acids, p-hydroxybenzoic acid, p-coumaric acid, caffeicacid, vanillic acid, gentisic acid, ferulic acid and syryngic acid were identified by thin layer chromatography, paper chromatography and UV spectrometry from Strobilanthes
crispus by Soedira et al. (1987). Jakupovic et al. (1988) isolated two pairs of rhamnolofane derivatives from the root bark of Jatropha grossidentata. The structures are elucidated by high field NMR spectroscopy. Das and Benerji (1988) isolated 2,3 – Bis -(hydroxymethyl) -6,7- methylenedioxy-1-(3,4 - dimethoxyphenyl) - napthalane from Jatropha gossypifolia. This was the first report of the isolation of arylnaphthalene lignin from a natural source.

The physicochemical properties of the seed and seed oil of Jatropha gossypifolia were assessed by standard methods. The seed contains 35.8% crude oil of iodine value 107.25, 13.40% protein, 9.25% fibre, 30.32% carbohydrate and 6.0g/kg saponins. The fatty acid composition of the seed oil was determined by GC-MS. Caprylic, myristic, palmitoleic, palmitic, oleic, stearic, linoleic, vernolic, arachidic, and lignoceric acids were found. (Ogbobe and Akano, 1993). Misra et al. (1993) isolated and characterized two aliphatic ketols, 28- hydroxypentatriacontan-7-one and 7-hydroxydotriacontan-2-one, together with 5 acetox ytriacontane and β-sitosterol from the shoots of Leucas aspera. A novel non-cyanogenic cyanoglucoside, 1-cyano-3-Beta-d-glucopyranosyloxy-(z)-1-methyl -1-propane, was isolated from the latex of Jatropha multifida. (Berg et al., 1995)

Horsten et al. (1996) isolated a novel cyclic heptapeptide cyclogossine from the latex of Jatropha gossypifolia. A combination of amino acid analysis, FAB mass spectrometry and two dimensional IH-NMR spectroscopy was used to determine the primary structure. Elizabeth et al. (1996) determined oleander glycosides in gastrointestinal contents by High Performance Liquid Chromatography (HPLC), Fluorescence method. This method provided an evidence of the presence of Oleandrin, which is one of the most active cardiac glycoside which produces higher level of toxicity in the Nerium oleander. Guette et al. (1997) isolated the new cyclic
octapeptide, cyclogossine B together with the known cyclic heptapeptide cyclogossine A from ethyl acetate extract of *Jatropha gossypifolia*.

Das and Kashinathan (1997) isolated four compounds, tetradecyl (E)-ferulate, Jatropholone-B, ferulic acid and fraxetin (7,8-di hydroxy l-6-methoxycoumarin) from the roots of *Jatropha gossypifolia*. Tetradecyl(E)-ferulate was isolated as colourless crystals. 3-Acetylaeleuritic acid, sitosterol and a novel lathyrane diterpene, Jatrowedione, had been isolated from the roots of *Jatropha weddelliana* (Brum *et al.*, 1998).

Faizi and Ali (1999) isolated shamimin (a new flavonol C-glycoside) as a pale yellow powder from the ethanolic extract of fresh, undried leaves of *Bombax ceiba*. Its structure has been elucidated as 2- (2, 4, 5-trihydroxyphenyl)-3, 5, 7- trihydroxy-6- C- glucopyranosyloxy- 4H-1-benzopyran-4-one through extensive spectroscopic methods. Guette *et al.* (1999) isolated two cyclic heptapeptides pohliani ns A and B and one cyclic octapeptide, pohlianin C from ethyl acetate extract of the latex of *Jatropha pohliana* by multi-step chromatography procedure, including HPLC. A cyclic heptapeptide-Mahafacyclin A was isolated from the latex of *Jatropha mahafalensis* and its structure was elucidated (Baraguey *et al.*, 2000). Baraguey *et al.* (2001) isolated a cyclic heptapeptide-Mahafacyclin B from the latex of *Jatropha mahafalensis*.

Kotoky *et al.* (2001) carried out phytochemical analysis for seed oils of *Garcinia xanthochymus, Phoebe attenuata, Polyalthia jenkensii* and *Pyrus pashia* and reported that these contained 5 to 23% fatty oil content. Gas liquid chromatography analysis of methyl esters of fatty acids indicated that oleic acid was predominant ranging from 39 to 71%. Roy *et al.* (2002) carried out phytochemical studies on roots
of *Hemidesmus indicus* and isolated a acyclic triterpenic acid, acyclic diterpenic ester and monocyclic sesquiterpene ester and elucidated their structures based on spectral and chemical data. Arjunaphthanoloside – a novel naphthanol glycoside was isolated from the stem bark of *Terminalia arjuna* and its structure was established as 2, 3, 6, 7, 8, 9 - hexa hydroxyl naphthalene-2-O- a - L (-) rhamnose by means of spectroscopical and chemical methods (Ali *et al.*, 2003).

Ravindranath *et al.* (2003) isolated a novel macrocyclic diterpene, Jatrophenone, from the whole plant of *Jatropha gossypifolia*. The structure of the compound was established by detailed studies of its one and two dimensional (ID and 2D) NMR spectra. The compound possesses significant antibacterial activity. Two new triterpenoid saponins, monepaloside K and monepaloside L together with a known saponin, mazusaponin I, were isolated from the water-soluble part of the whole plant of *Morina nepalensis* (Teng *et al.*, 2003).

The phytochemical constituents studied from *Jatropha maheswarii* stem extract were Friedlin (0.16%), epi-friedelinol 90.12%, n-octacosanol (0.11%), B-sitosterol (0.2%) and B-sistosterol-3-B-D-glucopyranoside (10.24%). Methanol extract of stem exhibited maximum activity against *Staphylococcus aureus* provides scientific evidence for use in skin diseases and tooth aches (Viswanathan *et al.*, 2004). Ravindranath *et al.* (2004) isolated twenty constituents from *Jatropha curcas*. The structures of the new compounds were established by extensive studies of their ID- and 2D-NMR spectra. The chemical composition of the essential oils from leaves and wood of *Ocotea brenesii* growing wild in Costa Rica was determined by capillary GC/FID and GC-MS. From the leaves, 64 compounds were identified, corresponding to 85.9% of the oil, and from the wood 57 compounds were identified corresponding to 69.0% of the oil (Carlos and José, 2005).
Sadhu et al. (2006) isolated four new diterpenes, leucasperones A and B and leucasperols A and B, and three new isopimarane glycosides, leucasposides A, B, and C, together with the known compounds asperphenamate, maslinic acid, (−)-isololiolide, and linifolioside from *Leucas aspera*. Two new long chain compounds, heptatriacontan-12, 13-diol and dotetracont-15-en-9-ol were isolated from the leaves of *Bauhinia variegata*. (Singh et al., 2006(a)). The chemical compositions of the essential oils of *Ocimum basilicum* L. cv. purple and *Ocimum basilicum* L. cv. green cultivated in Iran were investigated by GC-MS (Seyed, 2006).

Two new cyclic heptapeptides integrrimides A and B, were isolated from the latex of *Jatropha integerrima* (Mongkolvisut et al., 2006). The GC-MS analysis of *Strobilanthes crispus* oil revealed the presence of 28 components. The main constituents were found to be phytol, α-cadinol, Megastigmatrienone, 2,3-dihydrobenzofuran and eugenol (Asmah et al., 2006). Santos et al. (2006) isolated and identified twenty-three components in volatile oils of *Cordia leucomalloides* and *C. curassavica*. The major sesquiterpenes reported in *Cordia leucomalloides* include δ-cadinene, (E)- caryophyllene, bicyclogermacrene and germacrene D. The predominant compounds present in the oil of *C. curassavica* include monoterpenes and sesquiterpenes among which α-pinene, β-pinene, (E)- caryophyllene and bicyclogermacrene are predominant.

A HPTLC method for the determination of alpha-amyrin in a methanol extract of powdered bark of *Mallotus philippensis* had been developed (Kapil et al., 2007). Chemical investigation on the stems of *Jatropha multifida* yielded two diterpenoids, multifolone and Jatrogrossidentadione acetate along with five known diterpenoids, a flavone and a coumarino-ligan (Das et al., 2008). *Jatropha gossypifolia* and *Hevea brasiliensis* seed oils were found to contain 18.0% of 12-hydroxyoctadec-cis-9-enoic
acid (ricinoleic acid) (Hosamani and Katagi, 2008). A new aliphatic acid named japodic acid with germ–dimethyl cyclopropane ring was isolated from the roots of *Jatropha podagrica* (Aiyelaagbe and Gloer, 2008).

GC-MS analysis of *Jatropha curcas* leaves revealed the presence of 16 compounds. The four most abundant components were 22, 23-dihydro-stigmasterol (16.14%) alpha-tocopherol (15.18%), beta amylin (7.73%) and dotriacontanol (7.02%) The content of gamma tocopherol reached 2.88% and Vitamin E reached 18.06% in the extract (Wang *et al.*, 2009). Ebuehi and Okorie (2009) studied the flavonoid contents of the leaf extract of *Jatropha curcas*. Flavonoids like anthocyanidins, glycosides, flavonols and flavones were detected from *Jatropha gossypifolia* by thin layer chromatography (TLC) and spectroscopic method. (Narwade *et al.*, 2010). Sharma *et al.* (2010(a)) investigated two new compounds viz. 4-oxo octyl-2 hydroxyundecanoate and heptacosane-3-enyl-5-hydroxy-hexanoate from the stem of the *Nerium oleander*

A HPTLC method had been developed and validated for the analysis and to quantify the β-sitosterol in leaves, root and seed oil of eight *Jatropha* species. This method was found to be faster and reliable (Bhagat *et al.*, 2010). The alkaloid atherospermidine and a steroid stigmasterol were isolated from the ethyl acetate extract of the stem bark of *Jatropha curcas*. The structure of these compounds were determined by spectroscopic analysis. (Gupta *et al.*, 2011). Spectrophotometric and HPLC analysis were carried out in methanolic kernel meal extract of *Jatropha curcas*. Spectrophotometric analysis showed the presence of phenolics, flavonoids and saponins with values of 3.9, 0.4 and 19.0 mg/g DM respectively. HPLC analysis showed the presence of gallic acid and pyrogallol (phenolics), rutin and myricetin (flavonoid) and daidzein (isoflavonoid) (Oskoueian *et al.*, 2011(a)).
Two new macrocyclic diterpenoids, multifidanol and multifidenol along with several known compounds were isolated from the stem of *Jatropha multifida* (Kanth *et al.*, 2011). Rejila *et al.* (2012) identified four different types of phenolic compounds, kaempferol compounds, coumarin, catechin and quercetin from methanolic extract of the *Jatropha curcas* leaf by HPTLC analysis. Deo *et al.*, Anupama (2012) carried out comparative study of 1-phenynapthalene type with arylnapthalene lignin in *J.gossypifolia* by HPLC method. The ethyl acetate extract from *Jatropha multifida* (Euphorbiaceae) leaves yielded two C-glycosyl flavones. The structure of the two flavonoids were determined as Vitexin andIsovitexin (Beatriz *et al.*, 2012).

The HPTLC studies on the seeds of *Jatropha curcas* showed the presence of protocatechuic acid and gallic acid. *Jatropha curcas* seed extract showed significant in *vitro* antioxidant activity, 50% hydroalcoholic extract showed the most potent activity. Quantification of protocatechuic and gallic acid in 50% hydroalcoholic extract of *Jatropha curcas* had been performed and was found to be 0.146% and 0.092% respectively (Verma *et al.*, 2012). A novel anticancer diterpenoid compound abiodone was isolated from the root bark of *Jatropha gossypifolia*. (Falodun *et al.*, 2012). Yang *et al.* (2013) isolated two new sesquiterpenoids, (1s, 2R)-dihydroxycycyloax-4(15)-ene (1), 14-dehydroxyl daucucarotol(2), and one new rhamnofalane diterpenoid, 2-hydroxy-3dehydroxycaniojane(3), together with two known compounds, curcusone D (4) and C(5) from the roots of *Jatropha curcas*. Chetan and Parameswaran (2013) isolated a new alkaloid from the chloroform extract of the stem of *Jatropha curcas*. The alkaloid was found to have good antibacterial activity.
Antioxidant activity

Antioxidants act as free radical scavengers and alleviate free radical mediated cellular damage in the body. (Halliwell and Gutteridge, 1989). Antioxidant compounds in food play an important role as a health protecting factor. Primary sources of naturally occurring antioxidants are whole grains, fruits and vegetables. Natural 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 effect (Velioglu et al., 1998). Natural antioxidants or phytochemical antioxidants are the secondary metabolites of plants (Walton and Brown, 1999). Carotenoids, flavonoids, cinnamic acids, folic acid, ascorbic acid, tocopherols, tocotrienols etc., are some of the antioxidants produced by this plant for their sustenance. Beta-carotene, ascorbic acid and alpha tocopherol are the widely used as antioxidants (McCall and Frei, 1999). Antioxidant activity gives rise to anticarcinogenicity, antiimmunogenicity and antiaging activity. Hence, compounds, especially from natural sources, capable of protecting against ROS mediated damage and may have potential application in the prevention and/or curing of diseases.

Calotropis species reported to have very high antioxidant activity (Mueen et al., 2003). Piao et al. (2004) reported that the DPPH radical-scavenging activity in furano coumarins and its correlation with the number of phenolic hydroxyl groups present in their structures. The extracts of Withania somnifera increased the action of antioxidants CAT, SOD and GPx (Kaur et al., 2004). Aglaia roxburghiana extracts increased the level of antioxidants by scavenging oxide free radicals (Chakrabarty et al., 2004). Can-Ake et al. (2004) carried out experiments on the methanolic extracts of roots and leaves of Jatropha gaumeri showed antimicrobial and antioxidant
activity. β-sitosterol and the triterpenes α-amyrin, β-amyrin and taraxasterol are the metabolites responsible for the antioxidant activity. *Andrographis paniculata* plant extracts activated antioxidant enzymes thereby protecting the tissues from free radicals. Leaf extracts of *Aloe vera, Allium sativum, Azadirachta indica, Emblica officinalis* and *Tinospora cordifolia* were some other plants which have been reported to have antioxidant activity (Govindarajan *et al.*, 2005).

Iwalewa *et al.* (2005) studied the pro and antioxidant effects of methanolic extracts of nine edible vegetables in southwest Nigeria using 1, 1-diphenyl-2-picrylhydrazyl free radical assay. *Crassocephalum rubens* showed the highest antioxidant activity (56.5%), *Solanum americanum* and *Vernonia amygdalina* exhibited moderate antioxidant activity (26.0-37.5% and 14.8-36.2% respectively). While *Celosia argentea* and *Talinum triangulare* were pro-oxidants. The methanol extract of *Helichrysum plicatum* had been reported to have antioxidant activity using two *in vitro* methods, namely DPPH and β-carotene linoleic acid assays (Tepe *et al.*, 2005). Pourmorad *et al.* (2006) investigated the relative antioxidant activity in selected Iranian medicinal plant extracts. The antioxidant properties of 25 edible tropical plants were studied using trolox equivalent capacity, DPPH scavenging, reducing power and total polyphenol contents by Wang *et al.* (2006).

Siddhuraju and Becker (2007) studied the antioxidant and free radical scavenging activities of processed cowpea seed extracts. The crude aqueous extracts of *Chlorophytum borivilianum* had been shown to scavenge DPPH radical and decrease TBRAS (Thiobarbituric Acid Reactive Substances), revealing that it is a promising anti-stress agent as well as a potential antioxidant (Kenjale *et al.*, 2007).
The antioxidant activity of the aqueous extracts of the leaves of *Bauhinia forficata* and *Cissus sicyoides* were determined using several different assay systems (Khalil et al., 2008). Makari et al. (2008) reported the antioxidant activity of hexane and methanol extracts of leaves of *Cordia wallichii* by DPPH radical scavenging and reducing power methods. The methanol extract of *Annona squamosa* and *Sapium macrocarpum* showed two times more DPPH scavenging activity than the commercial antioxidant butylated hydroxyl anisole (Ruiz et al., 2008). An aqueous extract from *Choerospondias axillaries* showed a potent scavenging effect on DPPH (Wang et al., 2008). Methanol extract of bark, fruits and leaves of *Ficus microcarpa* exhibited excellent ABTS scavenging activity (Ao et al., 2008).

The antioxidant and antibacterial properties of the acetone and methanol extracts from leaves and roots of *Sansevieria hyacinthoides* were investigated. The leaves extract at 1 mg/ml exhibited over 80% DPPH activity, while acetone and methanol extracts from the roots at 0.75 mg/ml showed 91.4 and 92.8% DPPH scavenging activity (Aliero et al., 2008). Desai et al., (2008) reported the free radical scavenging potential of the aqueous extract of roots of *Baliospermum montanum* by DPPH and nitric oxide (NO) scavenging assay which showed a high concentration-dependent free radical scavenging activity.

Hydro-alcoholic extract of the leaf, stem and root of *Jatropha curcas* showed significant antioxidant activity using *in vitro* antioxidant models (Diwani et al., 2009). The antioxidant potential of four varieties of *Solanum melongena* were evaluated in terms of total phenolics content, DPPH, total reducing power, superoxide radical scavenging activity, metal chelating activity and total anthocyanin content by Nisha et al. (2009). The methanol extracts of leaves and flowers of *Lippia alba* exhibited very significant DPPH radical scavenging activity compared to the standard
antioxidant ascorbic acid (Ara and Nur, 2009). The methanol extract of *Manikara sapota* showed strong activity on scavenging DPPH radical, which implicated an essential defence against the free radicals (Kaneria *et al.*, 2009).

The hot water extract of *Perilla frutescens* stalk showed moderate DPPH radical scavenging abilities than the leaf and seed extracts (Chou *et al.*, 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 antioxidants activity. *In vitro* antioxidant activity (DPPH and reducing power assay) of methanolic leaf and flower extracts of *Lippia alba* were determined by Nanzin and Hasan (2009). The aqueous, methanol and ethanol extracts of *Melissa officinalis*, *Matricaria recutia* and *Cymbopogan citratus* were found to possess DPPH scavenging activity (Pereira *et al.*, 2009).

Shajiselvin and Kottaimuthu (2010) studied *in vitro* free radical scavenging potential of various extracts of whole plant of *Borreria hispida*. Vinay *et al.* (2010) reported a high radical scavenging activity in the stem of *Kigelia* followed by leaf of *Hibiscus, Gemelia* and *Kigelia*. Pavithra *et al.* (2010) estimated antioxidant activity of *Evolvulus nummularius* methanolic extract. The essential oils of *Myrtus communis* contained compounds such as 1, 8-cineole and methyl eugenol that showed considerable DPPH scavenging activities (Dukic *et al.*, 2010). The antioxidant capacity and total phenolic contents present in the acetone and methanolic extracts of leaves, stem, fruits and roots of *Melothria maderaspatana* were evaluated by Sowndharajan *et al.* (2010). Methanolic extracts of *Carica papaya*, *Fagara zanxhoxyloides*, *Cajanusa cajan* and *Parquetina nigrescens* were evaluated for their antioxidant activities (Imaga *et al.*, 2010).
Igbinosa et al. (2011) assessed the polyphenolic contents and antioxidant potential of the aqueous ethanol and methanol stem bark extracts of *Jatropha curcas*. There was correlation between total phenol, total flavonoids, total flavonol and total proanthocyanidins (r=0.996, 0.978, 0.908, and 0.985) respectively. This study also indicated that *Jatropha curcas* is a potential source of natural antioxidants and may be a good candidate for pharmaceutical plant based product.

Omoregie and Osagie (2011) studied the effect of *Jatropha tanjorensis* leaves on the activities of superoxide dismutase, Catalase, Vitamin E, Vitamin C and malondialdehyde in male albino rats of the Wister strain. The study suggested that *J. tanjorensis* leaves may have antioxidative potential against reactive oxygen species that are produced in protein energy malnutrition. Gayatri et al. (2011) observed that the piperine, an alkaloid found naturally in *Piper nigrum* and *Piper cubeba*. It is widely used in various herbal cough syrups and antiinflammatory, antimalarial, antileukemia treatement. Ethanol extract of *Piper cubeba* showed high antioxidant activity. Sathisha et al. (2011) determined antioxidant potentials of some herbal plants, *Curcuma longa, Coffea arabica, Tribulus terrestris, Bacopa monnieri* and *Trigonella foenumgraceum* using various in vitro assays.

Narayanaswamy and Balakrishnan (2011) evaluated the antioxidant properties of 13 important medicinal plants and it showed that *Ocimum basilicum* leaf, *Alpina calcarata* leaf, *Jatropha multifida* flower, *Hyptis suaveolens* leaf, *Solanum indicum* leaf and *Clitoria ternatea* leaf and flower possessed higher DPPH scavenging activity. The chloroform and methanolic leaf extracts of 124 Egyptian plant species belonging to 56 families were investigated and compared for their antioxidant activity by DPPH scavenging assay (Moussa et al., 2011). Arun and Brindha (2012) studied the antioxidant and arthritic potential of *Jatropha tanjorensis*. This study revealed
that the antiarthritic effect is by preventing protein denaturation, increasing membrane stabilization by proteinase inhibition.

Omoregie and Osagie (2012) studied the antioxidant properties of methanolic extracts of six locally consumed plants in Nigeria. Among the six plants, the leaf extracts of *Jatropha tanjorensis* phenolic content and flavonoid content is significantly high (p>0.05). These result also suggested that the plant leaves possess varied degrees of antioxidant activity. Hirota *et al.* (2012) investigated the antioxidant activity of *Jatropha multifida*. Safi *et al.* (2012) studied the biological activities of methanol extract of the root of *Jatropha curcas* like antimicrobial and free radical scavenging activities. In the evaluation of DPPH free radical scavenging activity, methanolic crude extract and chloroform soluble fraction showed strong antioxidant activity with IC50 value of 35, 62 µg/ml and 43.81 µg/ml respectively where the standard antioxidant butylated hydroxytoluene (BHT) showed the IC50 value of 18.31 µg/ml. The highest amount of phenolic contents were found in methanolic crude extract and chloroform soluble fraction having TPC value of 36.37 and 27.01mg of GAE/gm of extractive respectively.

Verma *et al.* (2012) studied the physicochemical, phytochemical, antioxidant activity of *Jatropha curcas* seeds. Ethanolic, aqueous and hydroalcoholic extracts from *Jatropha curcas* were screened for antioxidant activity. Protocatechuic acid and Gallic acid are the two potential antioxidants present in this species. In *Jatropha curcas*, IC50 of ethanolic, aqueous and hydroalcoholic extract were found to be 46 ±3.46 µg/ml, 36.66 ± 0.57 µg/ml and 32.66 ± 1 µg/ml, respectively.

Jain *et al.* (2013) studied in vitro free radical scavenging activity of *Jatropha gossypifolia* containing phenolic compounds. Ethanolic extract of *Jatropha
gossypifolia showed 58.7 ± 0.62% inhibition in superoxide scavenging model. Aqueous extract also showed almost similar activity (54.9 ± 0.53%). Jatropha gossypifolia had the highest total phenolic content (42.60 mg tannic acid equivalent (TAE) /100 g fresh weight). Total phenolic content had positive correlation with antioxidant potential. This shows that the plants, especially J. gossypifolia, may be potent source of natural antioxidants.

Olabinri et al. (2013) investigated in vitro antioxidant and nitric oxide radical scavenging capabilities of Jatropha gossypifolia extract. The result showed that the nitric oxide scavenging activity of the aqueous extract of Jatropha gossypifolia stem bark in the dry season was significantly higher than the antioxidant activity of the aqueous leaf extract of the plant in the wet season (P<0.001).

**Anticancer Activity**

Cancer is one of the most life-threatening diseases with more than 100 different types. Due to lack of effective drugs, expensive cost of chemotherapeutic agents and side effects of anticancer drugs, cancer can be a cause of death. Plants have been a long history in the treatment of cancer. The search of natural products as potential anticancer agents dates back, at least to the Ebers papyrus in 1550 BC; but the scientific period of this search is much more recent, beginning with investigations by Hartwell and co-workers in late 1960s Podophyllotoxin and its derivatives as anticancer agents.

Hartwell in his review of 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 the discovery and development of Vinca alkaloids, Vincristine and Vinblastine and
isolation of the cytotoxic podophyllotoxins. These discoveries promoted the United States National Cancer Institute (NCT) to initiate an extensive plant collection program in 1960. This lead to the discovery of many novel chemotypes showing a range of cytotoxic activities, including the taxanes and camptothecins. The first clinically used anticancer drug was isolated from *Catharanthus roseus* of Apocynaceae i.e., Vincristine and Vinblastine.

Wiedhopf *et al.* (1973) isolated a new lactam, Jatropha (5-hydroxyl -4methyl -3-pyrrolin -2-one) from *Jatropha macrorhiza* showed tumour inhibitory properties against the P-388 lymphocytic leukemia test system. The triterpene acetylaleuritolic acid was isolated from *Jatropha macrorhiza* root and showed tumour-inhibitory properties towards the P-388 lymphocytic leukemia test system (Torrance *et al.*, 1977). The diterpenes spruceanol and cleistanthol were isolated from acetone extracts of *Jatropha divaricata* (aerial parts (stem /bark)). Spruceanol was reported to be responsible for cytotoxic and antitumour activity (Gunasekera *et al*., 1979). Scientists all over the world are concentrating on the herbal medicines to boost immune cells of the body against cancer. Pharmaceutical companies have screened more than 25,000 plants for anticancer drugs (Saxe, 1987).

A new cytotoxic macrocyclic diterpenoid named Japodagrol was isolated from *Jatropha podagrica*. It showed significant inhibitory activity *in vitro* against P-388 lymphocytic leukemia and carcinoma cell culture (Sanni *et al*., 1988). *Phyllanthus amarus* extract administration had been shown to inhibit the liver tumour development induced by N-nitrosodiethylamine in rats and increased the life span of hepatocellular carcinoma harboring animals (Joy and Kuttan, 1998; Rajeshkumar and Kuttan, 2000). Lin *et al.* (2003) studied the antitumour effects of curcin in seeds from *Jatropha curcas* by MTT assay. The curcin had a powerful inhibitory action upon
protein synthesis in reticulocyte lysate with an IC$_{50}$ value of 0.19 (0.11-0.27) nmol/L. The IC$_{50}$ of curcin on SGC-7901, SP2/0 and human hepatoma was 0.23 (0.15-0.32) mg/L, 0.66 (0.35-0.97) mg/L, 3.16 (2.74-3.58) mg/L respectively. The antitumour activity of ethanol extract of Bauhinia variegata was evaluated against Ehrlich scites carcinoma in Swiss albino mice and found to be a potent cytotoxic towards EAC tumour cells (Rajkapoor et al., 2003).

The application of Ajoene, a constituent of garlic, may have an application in the treatment of acute myeloid leukemia (AML) was studied and this compound was shown to inhibit proliferation and induce apoptosis of several human leukemia CD-34 negative cells including HL-60, U937, HEL and OCIM-1 (Hassan, 2004). Qin et al. (2005) reported the gene for curcin-2 (32 kDa) was studied from Jatropha curcas seeds and antitumour activity of curcin was demonstrated. Singh et al., (2006(b)) carried out an experiment to assess the anticancer efficacy of linarin (LN), linarin acetate (LA) and acacetin (AC), the flavonoid compounds with the same flavone ring structure against human prostate cancer (PCA), LNCaP and DU145 cells. LN was isolated and purified from Chrysanthemum zawadskii; LA was chemically synthesized from LN, and AC obtained commercially. 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). Various parts of T. brevifolia and other Taxus species, T. canadiensis, T. baccata are used for the treatment of some non-cancerous conditions. The leaves of T. baccata are used in traditional Asiatic Indian Ayurvedic medicine system, with one reported 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* Deche (Nyssaceae), known in China as the tree of joy. The derivatives of Camptothecine, 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, epipodophyllotaxin (an isomer of podophyllotaxin), may be considered as being more closely linked to a plant, *Podophyllum* species used for the treatment of cancer. *Podophyllum peltatum* L. (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 podophyllotaxin. With the identification of an increasing number of molecule targets associated 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).

Two new cyclic heptapetides, integerrimides A and B, have been isolated from the latex of *Jatropha integerrima*. At 50 mMole both peptides 1 and 2 significantly inhibited neurite outgrowth in neuronal cell culture. They also partially inhibited proliferation of human IPC-298 melanoma cells as well as migration of human Capan
II pancreatic carcinoma cells, but were inactive in HSV-1, antifungal and antimalarial assays (Mongkolvisut et al., 2006). Luo et al. (2006) studied the antitumour activity of the recombinant protein of curcin from Jatropha species. The target protein was incubated with the tumour cells at different concentration for different times and the results demonstrated that the target protein could inhibit the growth of tumour cells (NCI-H446, SGC-7901 and S180) at 5 mg/ml. The ethanol, petroleum ether and dichloromethane extracts of Thelesperma megapotamicum, Oxalis erythrorhiza and Larrea divaricata showed high inhibitory activity on MCF-7 (cell line from human breast cancer) cell line proliferation (Bongiovanni et al., 2006).

The aqueous extract from the roots of Glycyrrhiza glabra inhibited the in vivo and in vitro proliferation of Ehrlich ascites tumour cells and may be used as a potential supplemental source for cancer therapy (Sheela et al., 2006). Two medicinal herbs Linum persicum and Euphorbia cheiradenia that are native to Iran were tested for their possible anticancer effect and apoptosis induction property on human tumour cell lines including leukemia cell lines by Amirghofran et al. (2007). Pradhan et al. (2008) studied the effect of methanolic extracts of Foeniculum vulgare and Helicteres isora against normal human blood lymphocytes by micronucleus assay and antitumour activity against B16F10 melanoma cell line by 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. Das et al. (2009) isolated a novel lathyrane type diterpene, multifidone from the stems of Jatropha multifida, its cytotoxicity was measured on four different cancerous cell lines.

The anticancer activity of ethanolic extract of curcumin was done in vivo on mice and in vitro on cell line. The extract showed a considerable anticancer activity against the cell line of human hepato cellular liver carcinoma (Naama et al., 2009).
Abdelwahab et al. (2009) studied the chemical compositions, antibacterial, antioxidant, and anticancer properties of *Goniothalamus umbrosus*. The methanol extract of the fruits of *Solanum nigrum* was evaluated for the anticancer activity on the HeLa cell line. The methanol extract of these drug showed greater activity on HeLa cell line, indicating *Solanum nigrum* can be used as anticancer agent (Sanjay et al., 2009).

Khalafalla et al. (2010) conducted an experiment to test different extracts from the leaves of *Moringa oleifera* for activity against leukemia and hepatocarcinoma cells *in vitro* had shown anticancer activity. Baiyi, et al. (2010) studied the antitumour activities of a triterpenoid-rich extract of bamboo shavings and its main component, friedelin was evaluated for anticancer activity.

The extracts from *Atractylodes lancea*, *Kaempferia galangel*, *Zingiber officinale*, *Piper chaba*, *Mesua ferrea*, *Ligusticum sinense* and *Mimusops elengi* exhibited promising activity against the cholangio carcinoma CL-6 cell line with survival of less than 50% at the concentration of 50 μg/ml. (Wiratchanee et al., 2010). Abdullah et al. (2010) conducted experiments to determine the mechanism of antitumour effects of ginger extract for evaluating apoptosis rate and cell cycle progression status in colon cancer cell lines HCT 116 and p53 defective HT 29.

Zakaria et al. (2011) investigated the *in vitro* cytotoxic and antioxidant properties of the aqueous, chloroform and methanolic leaf extracts of the *Dicranopteris linearis*. The cytotoxic effect was determined against the normal (3T3) and cancer cell lines (MCF-7, HeLa, HT-29, HL-60, K-562 and MDA-MB-231) by using the 3, (4,5-dimethylthiazol-2-yl)-2,5-diphenyltetrazolium bromide (MTT) assay, Vishnu Priya et al. (2011) studied the anticancer activity of aqueous and acetone
flower extract of *Tridax procumbens* on prostate epithelial cancerous cells PC3 by measuring cell viability using MTT assay. The flower acetone extract showed 82.28% cancer cell death within 24hrs and aqueous extract exhibited a very weak anticancer activity.

Chianese et al. (2011) isolated a diterpenoid, spirocurcasone, eleven known and two other new diterpenoids from the root barks of *Jatropha curcas*. Some of the isolated diterpenoids showed a potent activity against L5178Y, a mouse lymphoma cell line. Oskoueian et al. (2011(b)) studied the phytochemical contents and biological activities of the methanolic extracts from different parts of *Jatropha curcas*. The extracts of different plant parts contained various levels of phenolics, flavonoids and saponins. The cytotoxicity assay results indicated the anticancer therapeutic property of the root extract against human colon adenocarcinoma (HT-29) cell line but its cytotoxic effect on human hepatocyte (chag cell) was high. Muangman et al. (2012) investigated the antimitastatic effects of curcusone B, a diterpene from *Jatropha curcas* against four human cancer cell lines. Treatment with non-cytotoxic doses of curcusone B resulted in a strong reduction of *in vitro* invasion, motility and secretion of matrix-metalloproteinases (MMP) of the cancer cells, whereas the ability to adhere to a Matrigel-coated surface was variably sensitive to curcusone B treatment.

Hydroalcoholic extract of *Jatropha podagrica* showed significant antitumour activity against the A549 and PC12 cells was assessed by MTT assay. (Ghali et al., 2013). 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, *Rubia cordifolia* and *Plumbago zeylanica* showed nearly 50% MCF-7 cell line inhibition at 200µg/ml tested dose.
Antidiabetic Activity

Diabetes mellitus is a disease in which glucose (sugar) in the blood vessels are high because the body does not produce or properly use insulin. There are two major forms of diabetes mellitus. Type 1 diabetes develops when the pancreas does not produce insulin. Type 2 diabetes occurs when the body cell resist insulin’s effect. This condition leads to elevated levels of blood glucose. The normal range of blood glucose level in blood between 70-110mg/dl. Insulin is a hormone that helps to maintain normal blood glucose level by making the body’s cell absorbs glucose so that it can be as a source of energy. In people with diabetes glucose levels build up in the blood and urine causing excessive urination, thirst, hunger and problems with fats and protein metabolism because the body cannot convert glucose into energy, it begins to break down stored fats for fuel. This produces increasing amounts of acidic compounds in the blood called ketone bodies which interfere with cellular respiration energy producing process in cells. The World Health Organization (WHO) reported that 300 million peoples would suffer from diabetes mellitus by the year 2025. The treatment with modern medicines is mostly associated with the side effects. To overcome the toxic effects caused by these drugs an alternative system of treatment is required. There are numerous traditional medicinal plants reported to have hypoglycemic properties.

*Achyranthes aspera* extract produced a significant dose-related hypoglycemic effect in normoglycemic and alloxan induced diabetic rabbits. In these animals, water and methanol extracts decreased blood sugar levels. The plant may 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* (garlic) that is the precursor of
allicin and garlic oil, has been found to show significant antidiabetic effects on rats. Administration of a dose of 200 mg/kg significantly decreased the concentration of serum lipids, blood glucose and activities of serum enzymes like alkaline phosphatase, acid phosphatase and 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). *Azadirachta indica* leaf extract was found to have most potent blood sugar lowering property followed by *Catharanthus roseus*, *Gymnema sylvestre* and *Ocimum sanctum* (Chattapadhyay, 1993).

The leaf extract of *Aegle marmelos* was found to be effective as insulin in the restoration of blood glucose and body weight to normal levels. So it can be used as potential hypoglycemic agent (Benjamin *et al*., 1994). Saponin isolated from the leaves of *Acanthopanax senticosus* injected to mice decreased experimental hyperglycemia induced by injection of adrenalin, glucose and alloxan. (Sui *et al*., 1994). The methanolic extract of *Nelumbo nucifera* (East Indian Lotus) caused a decrease in glycemia in streptozotocin-induced diabetic rats by 53% to 55% at the end of 12hrs (Mukherjee *et al*., 1995).

The antihyperglycemic effect of *Cuminum cyminum* was studied in healthy rabbits subjected to weekly subcutaneous glucose tolerance tests after gastric administration of water, tolbutamide or a traditional preparation of the plant. The results showed that the *C. cyminum* significantly decreased the area under glucose tolerance curve and the hyperglycemic peak (Roman-Ramos *et al*., 1995). 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 hypoglycemic effect was seen with 1500 mg/kg body wt (Garg
Administration of extracts obtained from *Beta vulgaris* var. *cicla* leaf inhibited the increase in the nonenzymatic glycosylation of skin proteins and blood glucose. These results demonstrated the ability of this plant in preventing or at least retarding the development of some diabetic complications (Tunali *et al*., 1998).

Oral administration of an aqueous extract of *Tinospora cordifolia* roots produced a significant decrease in glycemia and brain lipids in alloxan-induced diabetic rats (Stanley *et al*., 1999). An alcoholic extract of *Phyllanthus niruri* was found to reduce significantly the blood sugar in normal rats and in alloxan diabetes rats and indicated its potential antidiabetic action (Raphael *et al*., 2000). The plant extracts of *Beta vulgaris* L.var. *cicla* has been used as a hypoglycaemic agent by diabetes mellitus patients in Turkey and it had been documented that there was a great number of β-cells and secretory granules after treatment with herbal extracts (Bolkent, 2000). Olayiwola *et al.* (2004) studied the antidiabetic potential of *Jatropha tanjorensis* leaves and the results indicated that the hypoglycemic effect of Et OH/H2O (1:1) leaf extract was evaluated in fasted and glucose–loded rats at the doses of 1 and 2g/kg *in vivo* and three fractions of the extract were assessed for their antidiabetic potentials *in vitro* to stimulate the release of insulin secretion from INS-1 cells. 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 ethyl acetate fraction.

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 (Tailang *et al*., 2008). *Gymnema sylvestre* had significant antidiabetic activity and a hypolipidemic activity in alloxan induced and normal
fasting rats (Mall et al., 2009). Mishra et al., (2010) investigated the antihyperglycemic effect of 50% ethanolic extracts of leaves of *Jatropha curcas* (JCE) in alloxan induced diabetic rats. Oral administration of JCE at a dose of 250 and 500mg/kg bw respectively showed potent antihyperglycemic activity in alloxan induced diabetic rats. Ethanolic extract of *Euphorbia hirta* had significant antihyperglycemic activity in streptozotocin induced diabetic mice (Kumar et al., 2010). The chloroform extract of *Jatropha curcas* leaves demonstrated significant antidiabetic property at 250 and 500mg/kg dose in alloxan induced diabetic rats (Patil et al., 2011).

Madhu et al., (2011) investigated the antidiabetic effect of ethanolic stem bark extract of *Jatropha multifida* in wister strain of albino rats using alloxan-induced diabetes. This study indicated that the ethanolic stem bark extract of *Jatropha multifida* had beneficial effects on blood glucose level. It has the potential to improve the therapeutic effects in diabetes. The methanolic extract of *Euphorbia thymifolia* showed significant activity against streptozotacin induced diabetic neuropathy (Pooja et al., 2011).

Zahid et al., (2013) evaluated the antidiabetic potential of three species of *Euphorbia* (*Euphorbia prostrata*, *Euphorbia hirta* and *Euphorbia helioscopia*). Methanolic extract of *Euphorbia prostrata* and *Euphorbia hirta* showed excellent potential as compared to commercially available drugs. *Euphorbia helioscopia* enhanced the blood glucose level so it can be recommended to the patients of hypoglycemia. *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 at 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). Ethanolic extract of *Gingo biloba* showed significant antihyperglycemic, antioxidant and antihyperlipidemia activities in streptozotocin induced diabetic in rats. (Cheng *et al.*, 2013). Verma *et al* (2013) evaluated antidiabetic, antihyperlipidemic and pancreatic regeneration potential of *Clitoria ternatea* and they concluded that the antidiabetic potential of the extract is due to pancreatic regeneration, decrease in oxidative stress, decrease in serum lipid profile and decrease level of SOD, GSH and CAT enzyme activity.

**Hepatoprotective Activity**

Liver is the largest organ in the vertebrate body and also an important organ actively involved in metabolic functions such as production and secretion of bile, prothrombin and fibrinogen. The liver is also responsible for detoxifying poisonous substances in the body by transforming and removing toxins, waste, and pollutant xenobiotics. Hepatotoxicity may be caused by thousands of synthetic chemical, drugs, bacteria, fungi, plant and animal toxicants. Most of the hepatotoxic chemicals damage liver cells mainly by inducing lipid peroxidation and other oxidative damage in the liver. Management of liver disease is still a challenge to the modern medicine. Due to limited therapeutic option and disappointing therapeutic success of the modern medicine, use of herbal drugs has increased Worldwide. Ayurvedic and other traditional medical practioners of the world have claimed for centuries that, the extracts from plants and their formulations can be effectively used for the alleviation of different types of liver diseases.
Visen et al. (1992) studied the hepatoprotective activity of *Ricinus communis* leaves in albino rats. An ethanol extract of the leaves showed significant protection against galactosamine-induced hepatic damage. Nadeem et al. (1997) studied the effect of ethanol and petroleum ether extracts of *Solanum nigrum* against CCl₄ induced liver damaged rats and it revealed that it had moderate to good hepatoprotective action as evidenced by enzymatic and histopathological examination.

Mangathayaru et al. (2005) reported hepatoprotective effect of methanolic extract of aerial parts of *Leucas aspera* in rats against CCl₄ induced liver damage model. Manjunatha et al. (2005) evaluated the hepatoprotective activity of methanolic and aqueous extracts of leaves of *Leucas hirta* against carbon tetrachloride induced liver damage in rats. Hepatoprotective effect of the alcoholic extract of *Centella asiatica* with oral administration (20 and 40 mg/kg/day) in rats having CCl₄ induced liver injury was studied. The plant extracts effectively inhibited the biochemical changes. The histopathological examination of liver corroborated well with the biochemical changes. Hepatic steatosis, hydropic degeneration and necrosis observed in the CCl₄ treated group were completely absent in the herbal extract administered group (Antony et al., 2006). Dash et al. (2007) reported that chloroform and methanol extracts of entire plant of *Ichnocarpus frutescens* were effective as hepatoprotective agents against paracetamol induced liver damage in rats. Afzal et al. (2007) reported antioxidant and hepatoprotective potential of fruits and leaves of *Cordia myxa*.

Chandrashekar et al. (2007) studied the hepatoprotective activity of the *Leucas lavandulaefolia* on D(+) -galactosamine-induced hepatic injury in rats. Gond and Khadabadi et al. (2008) tested the petroleum ether (60-80\(^{\circ}\)) extract of *Ficus carica* for antihepatotoxic activity on rats treated with 50 mg/kg of rifampicin orally. The
significant reversal of biochemical, histological and functional changes induced by rifampicin treatment in rats by petroleum ether extract treatment, indicating promising hepatoprotective activity. Kotoky et al. (2008) reported the protective effects of *Leucas lavendulaefolia* extracts against D-galactosamine induced hepatotoxicity in rat. Mohammed et al. (2008) demonstrated the hepatoprotective effect of alcoholic and water extract of *Annona squamosa* in hepatotoxic animals with a view to explore its use for the treatment of hepatotoxicity in human. In the isoniazid with rifampicin induced hepatotoxic animals there was a significant decrease in total bilirubin accompanied by significant increase in the level of total protein. Alanine amino transferase (ALT), aspartate amino transferase (AST), alkaline phosphatase (ALP) and gamma glutamate transpeptidase (γ- GT) levels were decreased in treatment group as compared to the hepatotoxic group.

Tandon et al. (2008) investigated the hepatoprotective activity of *Vitex negundo* leaf ethanolic extract against hepatotoxicity. The results indicated that effect of *Vitex negundo* leaf ethanolic extract was evident in the doses of 250 and 500 mg/kg as there was a significant decrease in TB, AST, ALT and ALP levels than control. Histology of the liver section of animals treated with the *Vitex negundo* leaf ethanolic extract in the doses of 250 and 500 mg/kg further confirmed the hepatoprotective activity. Sangameswaran et al. (2008) evaluated the hepatoprotective effect of *Andrographis lineata* (extracts in carbon tetrachloride induced liver injury in rats. The pharmacological evidences supported the folklore claim that it is used as a hepatoprotective agent.

Hepatoprotective activity of methanol leaf extracts of *Orthosiphon stamineus* against paracetamol induced hepatotoxicity in rats was investigated by Maheshwari et al. (2008). Alteration in the levels of biochemical markers of hepatic damage like
SGOT, SGPT, ALP and lipid peroxides was tested in both paracetamol treated and untreated groups. Treatment of methanolic extract of Orthosiphon stamineus leaves (200 mg/kg) had brought back the altered levels of biochemical markers to the near normal levels in the dose dependent manner and it was suggested that this leaf extract possessed a significant hepatoprotective activity.

Iniaghe et al. (2008) reported that the aqueous extract of leaves of Acalypha racemosa had exhibited effective hepatoprotective activity against CCl₄ induced liver damage. Manokaran et al. (2008) investigated the hepatoprotective activity of hydroalcoholic extract of Aerva lanata (600mg/kg) administered orally to the animals with hepatotoxicity induced by paracetamol (3gm/kg) and silymarin (25mg/kg) given as reference standard. Panda et al (2009) studied the effect of aqueous and methanolic extracts of the aerial part Jatropha gossypifolia given to Wister albino rats with liver damage induced by carbon tetrachloride, it was found that there was normalization of the serum levels of liver marker enzymes (serum glutamate oxaloacetate transaminase (SGOT), serum glutamate pyruvate transaminase (SGPT), serum alkaline phosphatase (ALP), total bilirubin, SOD and catalase).

Sambo et al. (2009) studied the effect of Psidium guajava extract on erythromycin-induced liver damage in albino rats. The aqueous extract of Psidium guajava leaf showed the hepatoprotective property at lower dose and a hepatotoxic property at higher dose. Ahsan et al. (2009) demonstrated the role of hepatoprotective activity of crude methanol extracts of plant materials of Casuarina equisetifolia, Bixa orellana, Glycosmis pentaphylla and Cajanus cajan in carbon tetra chloride induced hepatotoxicity at different doses. Balaji et al. (2009) evaluated hepatoprotective activity of methanolic fraction of Jatropha curcas on Aflatoxin B1 induced Hepatic Carcinoma. These results suggested that this extract could protect liver against the
AFBI-induced oxidative damage in rats, which may be due to its capability to induce the in vivo antioxidant system. 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.

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 B1 intoxicated livers of albino male Wistar rats. Kumar et al. (2010) studied the diethyl ether leaf extract of Coccinia indica for hepatoprotective activity against carbon tetrachloride induced liver toxicity 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 silymarin. Pattnayak et al. (2011) investigated the hepatoprotective activity of crude flavonoids extract of Cajanus scarabaeoides in paracetamol intoxicated albino rats. This extract showed hepatoprotective activity. Aghel et al. (2011) studied the hepatoprotective action of Ficus carica ethanolic leaf extract in animal model of hepatotoxicity induced by carbon tetrachloride. The treatment with Ficus carica leaf extract in dose of 200 mg/kg enhanced protection against CCL4 induced hepatic damage. Gunasekaran et al. (2012) evaluated the hepatoprotective activity of the whole plant Indigofera tinctoria on the chang cell (normal human liver cells). The ethanolic extract tested for its inhibitory effect on chang cell line. The percentage viability of the cell line was carried out.

Anitha et al. (2012) evaluated the hepatoprotective and antioxidant effect of ethanol extract of whole plant of Cynoglossum zeylanicum on CCL4 induced
hepatotoxicity in rats. Activities of liver marker enzymes, SGOT, SGPT and ALP, total protein, albumin, globulin, total conjugated and unconjugated bilirubins at an oral dose of ethanol extract of *Cynoglossum zeylanicum* (50, 100 and 150 mg/kg) showed a significant hepatoprotective effect. These extracts also exhibited a significant antioxidant 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 sequential extraction method significantly reduced the serum level of liver enzyme aspartate aminotransferase (AST), Alanine Amino Transferase (ALP). Further the lipid peroxidation activity of the methanolic extract was analyzed which showed significant result with IC$_{50}$ = 0.176 mg/ml and this hepatoprotective effect may be probably by promoting the antioxidant defense system.

**Antiinflammatory Activity**

Inflammation is the defense mechanism by which body tries to resist the entry of invading pathogen(s) 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 results in vasodilatation, vascular leakage (edema) and leukocyte migration. Clinical signs of inflammation include heat (Calor), pain (Dolor), redness (Rubor), swelling (Tumour) and loss of function. Mucus production and smooth muscle cell constriction are also associated with acute inflammation. Chronic inflammation results from tissue destruction by inflammatory
cells (abscess formation) and attempts taken during repair with fibrosis (excessive fibrin deposition), angiogenesis. Medicines of plant origin has been used as antiinflammatory agents since long time without any adverse effects.

Ficarra et al. (1995) studied analgesic, antiinflammatory and antiarthritic activities of petroleum ether and alcoholic extracts of Cordia francisci, Cordia martinicensis, Cordia myxa, Cordia serratifolia and Cordia ulmifolia leaves in rat. Saha et al. (1996) investigated the antiinflammatory activity of Leucas lavandulaefolia plant extract against carrageenan, histamine, serotonin and dextran induced rat hind paw edema. The alcoholic extract of Clerodendron serratum root was evaluated for its antiinflammatory activity in animal models (Narayanan et al., 1999). The extracts of the plant Crinum asiaticum was shown to possess antiinflammatory activity on bradykinin induced contractions in uterus (Samud et al., 1999). Fangchinoline and tetrandrine, major alkaloids from Stephania tetrandrae had been used traditionally to treat inflammatory diseases in Korea. Both fangchinoline and tetrandrine showed antiinflammatory effects on the mouse (Choi et al., 2000).

Ku et al. (2000) investigated the antiinflammatory activity of the isolated fractions of Leucas mollissima. Al-Awadi et al. (2001) studied the antiinflammatory effects of Cordia myxa fruits on experimentally induced colitis in rats. Satureja hortensis is a medicinal plant used in Iranian folk medicine as muscle and bone pain reliever. In the hydroalcoholic 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 edema in rats (Hajhashemi et al., 2002).

The ethanol extract of the rhizomes of Cistanche deserticola has been evaluated for its antiinflammatory activity (Lin et al., 2002). Satureja hortensis is a
medicinal plant used in Iranian folk medicine as muscle and bone pain reliever. 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). The crude ethanol extract and the chloroformic and aqueous fractions of *Sideritis canariensis var. pannosa* had been examined for their antiinflammatory and analgesic effects in several animal models (Hernandez-Perez and Rabanal, 2002).

Erdemoglu *et al*., (2003) reported potent antiinflammatory activity of dried and fresh flowers of *Nerium oleander* against carrageenan induced hind- paw edema model in mice without inducing any gastric damage. Nerium oleander had been found to possess potent antinoceptive and anti-inflammatory activity. Antiinflammatory activity of ethanol extracts from 9 vine plants used in traditional Chinese medicine to treat inflammatory conditions were evaluated (Li *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). The leaves of *Acanthus ebracteatus*, stem bark of *Oroxylum indicum* and the stems of *Cryptolepis buchanani* and *Derris scandens* are used as traditional remedies in Thailand for arthritis. Aqueous and alcoholic extracts were tested using three different *in vitro* systems for effects relevant to antiinflammatory activity (Laupattarakasem *et al*., 2003).

*Nerium oleander* had been found to possess potent antinociceptive and antiinflammatory activity. Mujumdar and Misar (2004) reported the antiinflammatory activity of topical application of *Jatropha curcas* root powder in paste form in TPA-induced ear inflammation in albino mice. Aerial parts of *Phyllanthus amarus*
exhibited marked antiinflammatory properties and suggested that these lignans are the main active principles responsible for the traditional application of this plant for the inflammatory complaints (Kassuya et al., 2005).

Shetty et al. (2006) studied the wound healing properties of crude bark extract of *Jatropha curcas* in Wistar albino rats. The results indicated that *Jatropha curcas* accelerated the healing process by increasing the skin breaking strength, granulation of tissue, wound contraction, dry granulation tissue weight and hydroxyproline levels. Aquino et al. (2006) evaluated the wound healing effect of ethanol extract of *Jatropha gossypifolia*. The results showed that on macroscopic examination more intense adhesion was found in the *Jatropha* extract treated groups in both third and seventh post-operative days. The vascular neoformation was greater in third post-operative day of *Jatropha* group. However the intraperitoneum injection of *Jatropha* extract did not have any significant improvement for the wound healing on ventral abdominal wall on the evaluated animals. Balian et al. (2006) evaluated the antiinflammatory potential of *Silybum marianum* in rats. They found that the leaf and leaf callus of *Silybum marianum* inhibited the formation of paw oedema to significant levels in rats treated either with carrageenan or formalin.

The petroleum ether, chloroform, methanol and aqueous extracts of *Sesbania sesban* leaves were investigated for antiinflammatory activity in albino rats (Tatiya et al., 2007). The petroleum ether, ethyl acetate, ethanol and aqueous extracts of *Calotropis gigantea* leaves were screened for antiarthritic activities in albino rats (Patil et al., 2007). The aqueous extract of *Eucalyptus globulus* was investigated for its antiinflammatory activity in carrageenan induced paw oedema and cotton pellet granuloma technique in albino rats (Deb et al., 2007). Uche and Aprioku (2008) studied the antiinflammatory, analgesic activity and phytochemical constituents
present in the methanol extract of *Jatropha curcas* leaves. The result indicated *Jatropha curcas* can be recommended for acute inflammatory disorders and disease associated with pains. Topical application of the methanol leaf extract of *Jatropha curcas* incorporated into an ointment base on the excision wound in rats caused a significantly (P<0.05) higher rate of wound healing and reduced the epithelialization period in a dose-related manner (Esimone *et al*., 2008).

Wound healing properties of methanolic extracts of the leaves of *Jatropha curcas* was compared to that of the standard antibiotic, cicatrin. The acute toxicity (L<sub>50</sub>) showed that it is safe even at a dose of 5000 mg/kg there was no mortality. The prohealing action was due to increased collagen deposition. Phytochemical analysis revealed the presence of alkaloids, glycosides, saponins, flavnoids, steroids, proteins, tannins, reducing sugars, fats and oils (Odoh *et al*., 2010). Methanolic extracts of root and latex of *Jatropha curcas* inhibited the inducible nitric oxide synthase in macrophages RAW 264.7, comparable to L-Nitro-Arginine Methyl Ester (L-NAME) indicating appreciable antiinflammatory activities (Oskoueian *et al*., 2011).

Al-sobarry *et al*. (2011) evaluated the analgesic activity of methanolic leaf extract of *Jatropha unicostata*, using chemical and thermal models which will induce acute pain in mice and rats. The analgesic activity of methanolic extract of *Jatropha unicostata* at the dose of (100 and 200 mg/kg,p.o) showed significant (P<0.001) in reducing abdominal writhing when compared with control and standard drug (Aspirin, 200 mg/kg, p.o.) showed significant (P<0.001) central analgesic action when compared with control and morphine (5mg/kg, S.C) as reference drug. *Psychotria octosulcata* had significant reduction in inflammation i.e. 67.94% (200 mg/kg body weight) in paw edema 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).

**Other bioactivities of plant extracts**

The water extract of the branches of *Jatropha curcas* inhibited strongly the HIV-induced cytopathic effects with low cytotoxicity (Matsuse et al., 1998). Aiyelaagbe et al. (2000) studied the antimicrobial activity of roots of *Jatropha podagrica*. Hexane, chloroform and methanol extracts of the root, wood and root barks of *Jatropha podagrica* exhibited broad spectrum antibacterial activity at a concentration of 20mg/ml. The hexane extract of the yellow root bark was the most active of all the extracts. Osoniyi and Onajobi (2003) studied the coagulant and anticoagulant activities in *Jatropha curcas*.

Abreu et al. (2003) studied the hypotensive and vasorelaxant effects of ethanolic extract from *Jatropha gossypifolia* in rats and result showed that this extract can elicit hypotension, by oral via, in conscious normotensive rats and vasorelaxant activity on rat mesenteric rings precontracted with norepinephrine (NE) or Ca (2+). Can-Ake et al. (2004) studied that the methanolic root extracts of *Jatropha gaumeri* showed antimicrobial activity. The purification of root extract allowed the identification of 2-epi-Jatrogressidione, a rhamnofolane diterpene and was responsible for the antimicrobial activity.

Marquez et al. (2005) identified a penta –substituted pyridine, namely 2,6-dimethyl-4-phenyl-pyridine-3,5-dicarboxylic acid diethyl ester from the extract of *Jatropha elliptica*. This compound was assayed for *invitro* antibacterial and resistance –modifying activities against strains of *Staphylococcus aureus*. Antibiotic efflux studies indicated that it acts as an inhibitor of the NorA efflux pump and restored the
level of intracellular drug concentration. The chloroform and methanol extracts of the leaves of *Jatropha gossypifolia* were found to be active against *Salmonella typhi, Staphylococcus aureus* and *pseudomonas aeroginosa*. (Ogundare, 2007).

Aiyelaagbe *et al.* (2007) isolated Japodarin and Japodagron, two macrocyclic diterpenoids from the root of *Jatropha podagrica*. Four other diterpenoids were isolated from this plant. The compounds displayed antibacterial activity against some gram-positive bacteria. Hexane extract of stem bark of *Jatropha podagrica* was found to be active on most of clinical isolates of *Staphylococcus aureus, Escherichia coli* and *Candida albicans*. In most cases 15mg/ml concentration showed maximum activity (Bhaskarwar *et al.*, 2008).

Aiyelaagbe *et al.* (2008) investigated the antimicrobial activity of the plant *Jatropha multifida*. A new aliphatic acid, Japodic acid with a germ – dimethyl cyclopropane ring was isolated from the roots of *Jatropha podagrica*. Japodic acid isolated from the roots of *Jatropha podagarica* showed mild insect growth inhibition activity against *Helicoverpa zea* (37% growth reduction at 100ppm). Fraxidin and Erythrinatasinate exhibited antibacterial activity against *Bacillus subtilis*. (Aiyelaagbe and Gloer 2008). Igbinosa and Aiyegora (2009) investigated the antimicrobial activity of crude ethanolic, methonolic and water extracts of the stem bark of *Jatropha curcas*. The extracts exhibited antimicrobial activities with zones of inhibition ranging from 5 to 12, 8 to 20 and 0 to 8mm for ethanol, methanol and water extracts respectively.

Barzinji *et al.* (2009) evaluated the effect of aqueous and methanolic extracts of *Dendrosicyos socotrana* and *Jatropha unicostata* on the viability of *Echinococcus granulosus* protoscoleces *in vitro*, and on the development of secondary hydatid cysts, *in vivo*. Oral and intraperitoneal administration of the extracts in white mice invoked
noticeable inhibitory effects on the *in vivo* development of secondary hydatid cysts. These effects were compared with those of albendazole sulfoxide, a commonly used treatment for hydatidosis.

Seth and Sarin (2010) studied the antibacterial activity of different solvents extracts of *Jatropha gossypifolia* against *Escherichia coli* and *Bacillus subtilis*. The maximum efficacy was exhibited in Benzene fraction. Saetae and Suntornsuk (2010) studied the antifungal activities of ethanolic extract from *Jatropha curcas* seed cake. The ethanolic extract of *Jatropha curcas* seed cake showed antifungal activities against important phytofungal pathogens. *Fusarium oxysporum, Pythium aphanidermatum, Lasidoplodia theobromae, Curvularia lunata, Fusarium semitectum, Colletotrichum capsici* and *Colletotrichum gloeosporioides*. The extract contained phorbolesters mainly responsible for antifungal activities.

Purohit and Reena (2011) studied the antimicrobial activity of methanol and petroleum extracts of dried bark extracts of *Jatropha gossypifolia*. The methanol extracts of bark of the plant showed prominent antimicrobial activity in comparison to petroleum ether extracts at specific dose 200ug/100ul. Arekemase (2011) analysed the antimicrobial activity of the hexane, ethanolic and aqueous extracts of *Jatropha curcas* against different microorganisms responsible for various human infections. The extracts and latex displayed potent antimicrobial activity against *staphylococcus aureus, Neisseria gonorrhea, Pseudomonas aeurginosa, Escherichia coli, Candida albicans* and *Aspergillus flavus*. The minimum inhibitory concentration was as low as 0.5mL. The results confirmed the potency of this plant in treating human infections including sexually transmitted diseases.
Omoregie and Sisodia (2012) evaluated the antiplasmodial activity of the extracts from *Jatropha tanjorensis* leaves. The antiplasmodial activity of the crude ethanolic extract was moderate when compared with the standard antimalaria drug chloroquine (IC50 0.087±0.003ug/ml). The antiplasmodial activity of the plant leaves supported the local claims on its efficacy in the treatment of malarial infection. Dhale and Birari (2013) studied the antimicrobial effects of petroleum ether, alcohol and chloroform extracts of *Jatropha gossypifolia* against gram-positive species *Staphylococcus spp.* and *Bacillus spp.* and gram negative species like *Escherichia spp.* and *Pseudomonas spp.* by agar disc diffusion method. The alcoholic extract of leaves showed maximum antibacterial activity. The significant antibacterial activity of active extract was compared with standard antibiotic Amoxicillin.

Abu *et al.* (2013) investigated the neuropharmacological, analgesic and antidiarroheal activities of the methanol extract of *Jatropha gossypifolia* fruits. The extract showed highly significant (P<.001) analgesic activity with % inhibitions of writhing response at doses 200 and 400mg/kg body weight were 77.86% and 71.28% respectively. The extract at both doses showed significant (P<0.05) sedative effective in-hole cross test. In-hole board test, the extract showed highly significant (P<0.001) anxiolytic activity at lower dose whereas this activity was observed at higher dose in EPM test. The extract showed highly significant (P<0.001) antidiarrheal activity.