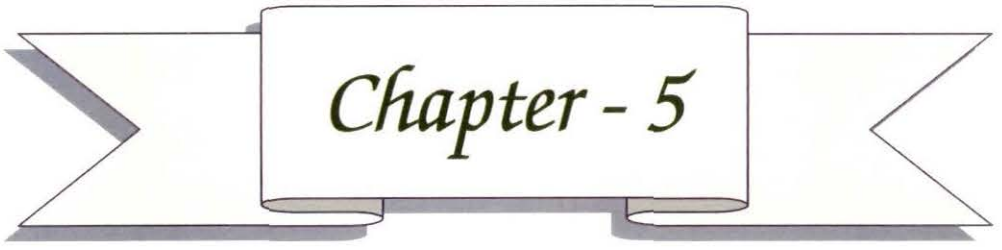

DISCUSSION

Medicinal plants which constitute a segment of the flora provide raw material for use in all indigenous systems of medicine in India namely Ayurveda, Unani, Siddha and Tibetan Medicine. On account of the fact that the derivatives of medicinal plants are non-narcotic having no side-effects, the demand for these plants is on the increase in both developing and developed countries. Some good works of the preliminary sort have been done several years earlier by Kiritikar and Basu (1935), Nadkarni (1954), Chopra *et al.* (1956) and many others. Higher plants are still "the sleeping giant of drug development", a virtually untapped reservoir of potentially useful sources of drugs (Farnsworth, 1994) that will continue to serve mankind in the 21st century as they have done since the dawn of history.

The present course of investigation has been carried out to know the traditional knowledge about the uses of medicinal plants, generally predominant in the selected areas of Dakshin Dinajpur district and test a few selected plants scientifically to confirm the ethnobotanical reports. The proposed work was divided into two phases. In the first phase the traditional knowledge about medicinal plants of the villagers was collected from the selected areas of the district. In the second phase few of the lesser known ones have been selected and detailed studies have been made on them. Regarding medicinal properties, attempts were made to study the properties like pharmacological, antimicrobial, production of antioxidants and suppression of hyperglycemia.

The present study has revealed that the tribals of Dakshin Dinajpur district are very rich in traditional knowledge. The studies were carried out in 48 villages of Dakshin Dinajpur district. After repeated interactions with the local doctors practicing siddha, Ayurveda and unani (Indian alternative medical systems) as well as villagers it was learnt that these plants listed in the investigation were very much used by them in making various formulations for a variety of ailments. The tribal inherit rich traditional knowledge about the flora investigated and apply this knowledge for making crude phytomedicines to cure infections as simple as cold to as complicated as cancer. These crude herbal medicines were based not only on traditional knowledge but also on rituals and beliefs. The data were gathered with the help of elders and especially tribal villagers. The youngsters are not well versed about the uses as well as not much interested to use the medicinal plants. Due to changing lifestyle and modernization the younger villagers prefer allopathic medicines. Therefore, an ethnobotanical survey is necessary to record this vanishing traditional knowledge.

The information about medicinal plants on scientific name, local name, plant part(s) used and method of dosage has been provided. There are several reports of similar works. During the ethnomedicobotanical survey of Jaunsar-Bawar (Jain and Puri, 1984) a hilly tribal inhabited area in Uttar Pradesh, India, it was observed that about 100 plants were being used by the local Jaunsari tribe for the treatment of various ailments. An alphabetical list of the plants was given along with their family, local name, local uses, and locality and collection number. Jain *et al.* (2005) made another survey on the medicinal plants diversity of Sitamata wildlife sanctuary of Chittorgarh and Udaypur district located in south-west region of Rajasthan. Two hundred forty-three genera belonging to 76 families have been reported which were used by the tribal of about 48 villages around the sanctuary as of means of primary health care to cure various ailments.

The present investigation has revealed the usage of 107 medicinal plants species mentioned by the villagers of Dakshin Dinajpur of West Bengal. These plants belong to the 96 genera and 48 families. Highest number of medicinal plants (14) was found in the family Leguminaceae followed by Acantheceae, Apiaceae, Apocynaceae, Cucurbitaceae, Euphorbiaceae containing each 4 medicinal plants. It was revealed that the ethnomedicinal plants were mostly used to cure the diseases like dysentery, stomach/ liver diseases, cold-cough, rheumatism, skin diseases, urinary track infection etc. An ethnomedicinal survey was carried out by Ayyanar and Ignacimuthu (2005) among the ethnic group (Kani/Kanikaran) in Southern-western Ghat of India. The documented ethnomedicinal plants were mostly used to cure skin diseases, poison bites, wounds and rheumatism. Some indigenous tribes from Northwest Mexico have traditionally used this plant to treat skin ailments by externally applying it on the affected areas (Lopez and Hinojosa, 1988; Xolapa- Molina, 1994). Muthu (2006) also documented medicinal plants for the treatment of stomachache; skin diseases, poison bites and nervous disorders after he made a survey on the uses of medicinal plants in Kancheepuram district of Tamil Nadu. Leporatti *et al.* (1985) while investigated on some new therapeutic used of several medicinal plants in the Province of Terni (Umbria, Central Italy) reported the use of 18 medicinal plants for that therapeutic purpose.

In the present study, more traditional knowledge was also collected about the antidiabetic plants. The plants used to treat diabetes are *Abroma augusta, Aegel marmelos, Cajanus indicus, Catheranthus roseus, Cinnamomum tamala, Coccinia cordifolia, Enhydra fluctuans, Ficus carica, Melia azadirecta, Mimosa pudica, Momordica charanta, Moringa*

oleifera, Murraya koenigi, Musa paradisiacal, Piper longum, Punica granatum, Scoparia dulcis, Syzigium cumini, Tamarindus indica. Chhetri (2005) made a survey on the antidiabetic plants used by Sikkim and Darjeeling Himalayan tribes, India. Harbal medicine was the dominant system of medicine practiced by the local tribes of that region for the treatment of diabetes. During the course of their studies it was found that 37 species of plants belonging to 28 families were used as antidiabetic agents in the folk medicinal practice in the region and 80% of those plants wee hitherto unreported as hypoglycemic agents. Their finding may lead to serious research towards developing new and efficient drugs for diabetes.

Among the 107 plants reported to contain some or other medicinal properties, four have been selected viz., *Clerodendrum viscosum, Cinnamomum tamala, Moringa oleifera* and *Scoparia dulcis* for detailed study. After selection of these plants, the effectiveness of the leaves of *C. viscosum, C. tamala, M. oleifera* and *S. dulcis* by phytochemical, microbiological, antioxidants and suppression of hyperglycemia were investigated in detail.

M. oleifera is the most widely cultivated species of a monogeneric family, the Moringaceae that is native to the sub-Himalayan tracts of India, Pakistan, Bangladesh and Afghanistan. *M. oleifera*, or the horseradish tree, is a pan-tropical species that is known by such regional names as benzolive, drumstick tree, kelor, marango, mlonge, mulangay, nébéday, saijhan, and sajna. Over the past two decades, many reports have appeared describing its nutritional and medicinal properties. In the West, one of the best known uses for *M. oleifera* is the use of powdered seeds to flocculate contaminants and purify drinking water (Berger *et al.*, 1984; Olsen, 1987; Gassenschmidt,1995 but the seeds are also eaten green, roasted, powdered and steeped for tea or used in curries (Gassenschmidt, 1995). This tree has in recent times been advocated as an outstanding indigenous source of highly digestible protein, Ca, Fe, Vitamin C, and carotenoids suitable for utilization in many of the so-called "developing" regions of the world where undernourishment is a major concern.

In the present study, the survey has shown that *M. oleifera* is used to treat various ailments i.e, blood sugar, rheumatism, cardiac problem etc. *M. oleifera* preparations have been cited in the scientific literature as having antibiotic, antitrypanosomal, hypotensive, antispasmodic, antiulcer, anti-inflammatory, hypocholesterolemic, and hypoglycemic activities, as well as having considerable efficacy in water purification by flocculation, sedimentation, antibiosis and even reduction of *Schistosome cercariae* titer. *Moringa*

species have long been recognized by folk medicine practitioners as having value in tumor therapy (Hartwell. 1967-1971; Fahey *et al.,* 2004). The benefits for the treatment or prevention of disease or infection that may accrue from either dietary or topical administration of *Moringa* species preparations (e.g. extracts, decoctions, poultices, creams, oils, emollients, salves, powders, porridges) are not quite so well known (Palada, 1996).

Scoparia dulcis L. (Scrophulariaceae) is a perennial herb widely distributed in tropical and subtropical regions. In these regions, the fresh or dried plant of *Scoparia dulcis* has traditionally been used as one of the remedies for stomach troubles (Satyanarayana, 1969), hypertension (Chow *et al.* 1974), diabetes (Perry, 1980), inflammation (Gonzales, 1986), bronchitis (Farias *et al.* 1993), hemorroids and hepatosis (Satyanarayana, 1969) and as analgesic and antipyretic (Gonzales, 1986). In the present survey, it was found that *Scoparia dulcis* is used by the people for long time for the diseases like blood sugar, anti-inflamatory, sore and cough.

Leaves of *Cinnamomum tamala* are used in colic and diarrheal preparations. *C. tamala* leaf extracts produce a hypoglycaemic effect in experimental rats. Leaves of *Clerodendrum viscosum* used in malarial fever, any fever, worm, dysentery, piles etc.

In the present work, comparative study has been made to determine the effectiveness of phytochemical, microbiological, antioxidative and antidiabetic potential of the leaves of *C. viscosum, C. tamala, M. oleifera* and *S. dulcis.* The plants used for this study was not chosen at random, but on the basis of analysis of survey.

Phytochemical screening of *C. viscosum, C. tamala, M. oleifera* and *S. dulcis* revealed the presence of secondary metabolites including alkaloids, flavonoids, tannins, saponins, cardic glycosides and terpenoids. Saponins have been reported to possess good antihyperglycemic activity in recent studies (Sauvaire *et al.*, 1996; Vats *et al.*, 2003). Glycosides are the plant compounds containing glucose (or a different sugar) combined with other non-sugar molecules, such as glucose + terpene or glucose + phenolic compound. The terms glycoside and glucoside are used interchangeably; however, glucoside is generally used if the sugar component is glucose. Saponins are a group of glycosides (glucosides) found in several plant species, and are characterized by their soap-like property of foaming in a water solution.

Steroid was present in *C. viscosum, C. tamala, M. oleifera* but absent in *S. dulcis.* Some of these compounds were shown to have anti-inflammatory, antibacterial, hepatoprotective, immuno-modulator, cardiovascular, diuretic, protozoocidal, fungicidal, molluscidal, cytotoxic, cytostatic, antitumar activities (Guisalberti, 1998; Bermejo- Benito *et al.* 1998; Emam *et al* 1997; Nishibe, 1994; Lacaille- Duubois and Wagner, 1996). Similar findings have been observed by Shirwaikar *et al.*, 2005. In their work, preliminary screening of the aqueous extract of *Coccinium fenestratum* revealed the presence of saponin, alkaloids, and phenolic substances.

Among the four studied plants highest amount of alkaloid was present in *C.* tamala (4.92% alkaloid/ g tissue), followed by *M. oleifera* (2.56% alkaloid/ g tissue), *C. infortunatum* (1.76% alkaloid/ g tissue) *and S. dulcis* (0.84% alkaloid/ g tissue). Alkaloids are important defense of the plant against pathogenic organisms and herbivores. It is also toxic to insects which further modify the alkaloids and incorporate them into their own defense secretion (Hartmann, 1991).

In the present study, tests revealed that leaves of *M. oleifera* contained more amount of protein than the leaves of other three studied plants and also the total sugar and reducing sugar content were very high in leaves of *M. oleifera* than the leaves of other three studied plants. Ascorbic acid (vitamin C) is an abundant component of plants. Vitamin C protects cells from the damaging oxidation of free radicals. The spetrophotometric analysis of ascorbic acid revealed that *C. tamala* contained the highest amount of ascorbic acid followed by *M. oleifera, S. dulcis.* The least amount of ascorbic acid found in the *C. viscosum.*

The most active form of vitamin E, μ-tocopherol, is a 6-hydroxychroman derivative with methyl groups in position 2, 5, 7, and 8 and a phytyl side chain attached at carbon 2. Vitamin E is important for human and animal health. Many human diseases, such as certain cancers and neurodegenerative and cardiovascular disease, are associated with the insufficient intake of vitamin E. Protective effects of vitamin E as an antioxidant in diabetes were studied extensively (Baydas *et al.*, 2002; Celik *et al.*, 2002). The presence of μ-tocopherol in the n-hexane extract of *Ficus carica* leaves was determined by thin-layer chromatography (TLC) by Konyalioglu *et al.*, 2005). The amount of μ-tocopherol extracted for 100g of dried leaves of *Ficus carica* was 57mg. In comparison with previous studies on the μ-tocopherol content of plant leaves, the amount of μ-tocopherol in dried leaves of *Myrtus communis, Rhamnus alternus* and *Phillyrea angustifoia* were found to be 846, 627,

480 and 442 ppm (Chevolleau *et al.*1993). The major industrial source of μ-tocopherol is a residue obtained from the distillation of soya bean oil (Slover, 1983). In the present investigation also, the presence of μ-tocopherol in the n-hexane extract of *C. viscosum, C. tamala, M. oleifera* and *S. dulcis* leaves were determined by thin-layer chromatography (TLC). Lako *et al.*, (2007) have investigated the phytochemical flavonols, carotenoids and the antioxidant properties of a wide selection of Fijian fruit, vegetables and other readily available foods. A number of herbs exhibited high antioxidant capacity: *Ipomoea batatas* (sweet potato) leaves have the highest TAC (650 mg/100 g) and are rich in TPP (270 mg/100 g), quercetin (90 mg/100 g) and β-carotene (13 mg/100 g). *Moringa oleifera* (drumstick) leaves were rich in TPP (260 mg/100 g), quercetin (100 mg/100 g), kaempferol (34 mg/100 g) and β-carotene (34 mg/100 g). *Curcuma longa* (turmeric ginger) had a high TAC (360 mg/100 g), TPP (320 mg/100 g) and was rich in fisetin (64 mg/100 g), quercetin (41 mg/100 g) and myricetin (17 mg/100 g). *Zingiber officinate* (white ginger) also had a high TAC (320 mg/100 g) and TPP (200 mg/100 g). *Zingiber zerumbet* (wild ginger), a widely used herb taken before meals was the richest source of kaempferol (240 mg/100 g).

The phytochemical screening and quantitative estimation of the percentage crude yields of chemical constituents of the plants studied showed that the leaves and stems were rich in alkaloids, flavonoids, tannins and saponins. They were known to show medicinal activity as well as exhibiting physiological activity (Sofowara, 1993). Edeoga *et al.*, (2005) made a study on ten medicinal plants for the analysis of alkaloids, tannins, saponins, steroids, terpenoids, phlobatannin and cardiac glycoside.

Plant derived natural products such as flavonoids, terpenoids and steroids etc. have received considerable attention in recent years due to their diverse pharmacological properties including antioxidant and hepatoprotective activity (DeFeudis *et al.*, 2003, Takeoka and Dao, 2003, Banskota *et al.*, 2000).There has been a growing interest in the analysis of certain flavonoids, triterpenoids and steroids stimulated by intense research into their potential benefits to human health. One of their main properties in this regard is their antioxidant activity. Antioxidants play an important role in inhibiting and scavenging radicals, thus providing protection to humans against infection and degenerative diseases.

In recent time much attention has been focused on the protective biochemical function of naturally occurring antioxidants in biological systems and on the mechanism of their action. The TAC method, based on the reduction of Mo (VI) to Mo (V) by sample analyze,

was used to measure the amount of antioxidant capacity. The spectrometric assay for the quantitative determination of antioxidant capacity was previously determined for *Hypericum* species. The results expressed as nM μ-tocopherol acetate/g dry mass were in the range 4.615-5.483 (Merel, 2003). The antioxidant capacity for *Ficus carica* leaves ranged from 14.0 to 23.5 mM μ-tocopherol acetate/g dry mass with the water extract having the highest activity (Konyalioglu *et al.*, 2005). The results of their study showed that water extract also has the highest total phenol and flavonoid content. There was a correlation between the amount of total phenol and flavonoid contents and the antioxidant capacity.

The spectrophotometric assay for the quantitative determination of phenol revealed that *C. tamala* contained the highest amount of phenol, *C. viscosum* contained the least amount, *M. oleifera* and *S. dulcis* contained significant amount respectively. The spectrophotometric results expressed as mg α-tocopherol acetate/ g dry mass were 11.2 in *C. tamala* that is highest quantity among the other three plants in *M. oleifera* 7.0, in *S. dulcis* 5.9 and in *C. viscosum* 4.5 mg α-tocopherol acetate/ g dry mass. Thus it was found that all the studied plant leaves posses substances having high antioxidant activity. Despite much interest in the antioxidant activity of the studied leaves, it is uncertain which of the phenols and μ-tocopherol exhibit the greatest antioxidant effect.

In order to partially characterize the extracts, the leaves were extracted with different solvents and analysed by UV-spectrophotometer. Absorption maxima were in the range of 202-208 nm in most cases. Interestingly, except *Poria hypobrumea* all the aqueous extracts, as well as solvent extracts had no antimicrobial activity, though there are several reports of plant extracts showing anti-microbial activity. Anti-microbial activity of higher plants was well documented (Saxena and Vyas, 1986; Ahmed *et al.*, 1995; Ahmed *et al.*, 1998; David, 1997; Perumalsamy *et al.*, 1988). A number of studies on anti-microbial activity of plants have been carried out in different parts of world (Belachew, 1993; Lajubuter *et al.*, 1995; Didry *et al.*, 1998; Yadava and Barsainya, 1998). The antimicrobial and antifungal effects of different concentrations of chloroform/methanol fractions of *Scoparia dulcis* were investigated by Latha *et al.*, (2006). The isolated fractions were tested against different bacteria like *Salmonella typhii*, *Staphylococcus aureus*, *Escherichia coli*, *Bacillus subtilis*, *Pseudomonas aeruginosa*, and *Proteus vulgaris* and fungal strains such as *Alternaria macrospora*, *Candida albicans*, *Aspergillus niger*, and *Fusarium oxysporum*.

Though the present investigation was started with four plants, further work on anti hyperglycaemic activity was carried out only with *M. oleifera*, *S. dulcis* and *C. tamala*, but not with *C. viscosum* as no such ethnomedicinal claim has been reported for this plant.

Traditional preparations for the treatment of diabetes mellitus continue to receive wide spread use in many countries (Said, 1969). Several such plant preparations have shown to posses hypoglycemic properties in animal models of diabetes and in human non- insulin dependant diabetes mellitus patients (Hale *et al.*, 1989; Ruvin Kumar, 1998). The use of local plants for the treatment of diabetes mellitus is quite common in Asia and Middle Eastern countries. More than 400 local plants treatments for diabetes mellitus have been recommended by traditional health care providers (Ajaonkar, 1979; Bailey and Day, 1989; Ivorra *et al.*, 1989). In Indian folk medicine, many plants are used in the treatment of diabetes mellitus e.g., *Syzigium cumini, Musa sapientum* etc. (Prince *et al.*, 1998; Pari and Maheswari, 2000).

For testing the antidiabetic property, *C. tamala, M. oleifera* and *S. dulcis* were selected. For detecting the hyperglycemia in rats the parameters tested were fasting blood glucose, urine sugar, and glycogen, TBARS and GSH of liver tissues. Diabetes was induced in male rats via a single intraperitoneal (i.p.) injection of 55mg/kg body weight streptozotocin in 0.1M citrate buffer, pH 4.5, in a volume of 1ml/kg (Siddique *et al.*, 1987). After 48 h of streptozotocin administration, rats with moderate diabetes having glycosuria and hyperglycemia (i.e., with blood glucose of 200-300mg/dl) were taken for the experiment.

Decrease in bodyweight due to derangement of metabolic pathways is a common feature in diabetes (Al-Shamaony *et al.*, 1994). Administration of *Coccinia indica* leaves extract (Venkateswaran and Pari, 2002) to diabetic rats significantly reversed the loss in body weight, apparently due to its ability to reduce hyperglycemia. Treatment with 2.5 g/kg body weight/day of methanol extract of *Enicostemma littorale* to alloxan-induced diabetic rats up to 20 days showed a 50% reduction in blood glucose levels (Maroo *et al.*, 2003). Oral administration of the methanol fraction of *Salacia reticulata* twice daily to the diabetic animals gained the body weight (Rubin Kumara *et al.*, 2005).

In the present study the body weight of the diabetic rats decreased significantly after the treatment with STZ. The body weights of *C. tamala, M. oleifera* and *S. dulcis* treated

groups were increased significantly after the 20th day compared with control and diabetic control.

Increased urea production in diabetes may be accounted due to enhanced catabolism of both liver and plasma proteins (Morris and Leon, 1960). Qualitative estimation of Urine was a conventional method for the determination of sugar level in urine. The results of the test were positive (+++) to the diabetic rats and amount of sugar were nil to the *C. tamala, M. oleifera* and *S. dulcis* (250mg/kg) treated groups. Least amount (+) of sugar were found in the *C. tamala, M. oleifera* and *S. dulcis* (125mg/kg) treated groups.

Venkateswaran and Pari (2002) found that the diabetic rats showed a significant increase in blood glucose. In their experiment it was observed that the administration of *Coccinia indica* leaves extract and glibenclamide in diabetic rats restored the level of blood glucose to near normal levels. Diabetic rats treated with *Salacia reticulata* showed a significant reduction in the fasting blood glucose levels within 50 days compared with the control groups (Ruvin Kumara *et al.*, 2005). Pari and Latha (2002) demonstrated the levels of blood glucose in normal and experimental animals while they have worked on the antidiabetic activity of *Cassia auriculata* flowers. There was a significant increase in blood glucose. The effect of administration of *Cassia auriculata* flower extract at 0.15g was not significant, whereas 0.30 and 0.45g/kg body weight of *Cassia auriculata* flower extract and glibenclamide tended to bring the blood glucose toward a normal value. The leaf juice of *Catharanthus roseus* and the seed powder of fenugreek were tested for their hypoglycemic action individually and in combination in normal and alloxan-induced diabetic rabbits. *Catharanthus roseus* at dose levels of 0.5, 0.75 and 1.0ml/kg body weight produced maximum blood glucose reduction of 16.66% ($p<0.05$), 28.65% ($p<0.05$) and 38.49% ($p<0.001$) respectively. Duration and intensity of action increased in a dose-dependent manner. Fenugreek seed powder produced signicant reduction in blood glucose of 26.98% ($p<0.01$) and 39.21% ($p<0.001$) at a doses of 100 and 150mg/kg body weight, respectively. The combination of *Catharanthus roseus* (0.5ml/kg) and fenugreek (50ml/kg) produced significant ($p<0.001$) reduction in blood glucose 35.41% at 10h and increased the duration of action compared to either one (Satyanarayana *et al.*, 2003). The butanolic fraction of *Helicteres isora* root at a dose of 250mg/kg produced maximum fall (48.86%) in the blood glucose of diabetic rats (Venkatesh *et al.*, 2003). The whole seed powder of *Trigonella foenum-graecum*, its methanol extract and the residue which remained after methanol

extraction were reported to lower blood glucose levels in normal and sreptozotocin-induced diabetic rats (Liaquot *et al.*, 1995). The effect of treatment with *Anacardium occidentale* on fasting blood glucose in normal and fructose-fed rats was investigated by Olatunji *et al.*, (2005). Fasting plasma glucose levels of fructose-fed rats were significantly higher than those in normal rats. Treatment with extract of *A. occidentale* significantly abolished the increase in fasting plasma glucose levels induced by high-fructose diet. Some genera of cucurbitaceae have been mentioned anti-diabetic by Marles and Farnsworth (1995) such as *Benincasa, Bryonia, Citrullus, Coccinia, Cucumis, Cucurbita, Lagenaria, Luffa, Melothria, Mamordica* and *trichosanthes*.

In the present investigation it has been observed that the aqueous extract of *C. tamala, M. oleifera* and *S. dulcis* showed better hypoglycemic response on tested mice, at a dose of 250 mg/kg body weight than the dose of 125 mg/kg body weight.

Diabetes mellitus is associated with a marked decrease in the level of liver glycogen (Pugazhenthi *et al.*, 1991). The regulation of glycogen synthase and glycogen phosphorylase is of a recipropal nature. Roessler and Khandelwal (1986) have observed the increased glycogen phosphorylase and decreased glycogen synthase activity in the liver of diabetic mice. The reduced glycogen store has been attributed to reduced activity of glycogen synthase and increased activity of glycogen phosphorylase. All these activities result in an increased blood glucose level typical for diabetes. Pari and Latha (2004) have shown that the hepatic and skeletal muscle glycogen content was reduced significantly in diabetic control. Glycogen synthesis in the rat liver and skeletal muscles is impaired during diabetes (Huang *et al.*, 2000). In diabetic animals treated with the extract, the significant increase in the liver glycogen may be due to the activation of the glycogen synthesis system by the aqueous extract. Glycosylated hemoglobin is known to increase in patients with diabetes mellitus (Koeing *et al.*, 1976), and the increase has been found to be directly proportional to the fasting blood glucose level (Jackson *et al.*, 1979).

Similar result were also found in the present investigation, where the level of glycogen content decreased significantly in STZ- diabetic rats in compare to normal (both distilled water and citrate buffer treated). But after 20th day's treatment with *C. tamala,* and *S. dulcis* at a dose of 250 mg/kg body weight, the level of glycogen content increased better than the dose of 125 mg/kg body weight. Since Streptozotocin (STZ) - induced hyperglycaemia has been described as a useful experimental model to study the activity of

hypoglycaemic agents (Junod *et al.*, 1969). Streptozotocin (STZ) destroys β-cells of the pancreas and induces hyperglycemia (Palmer *et al*, 1998). Due to this observed effect, enhancement of peripheral utilization of glucose may be associated in the possible mechanisms involved in the hypoglycemic action of *C. tamala, M. oleifera* and *S. dulcis* leaves extracts.

An elevated level of lipid peroxides in the plasma of streptozotocin diabetic rats and lipid peroxidation is one of the characteristic features of chronic diabetes (Maxwell *et al.*, 1997). The increased levels of thiobarbituric acid reactive substances (TBARS), conjugated dienes (CD), malonaldehyde and hydroperoxides are indices of lipid peroxidation (Krishnakumar *et al.*, 1999). Lipid peroxide mediated tissue damage has been observed in the development of both type I and type II diabetes mellitus. Increased con00000.centration of TBARS and hydroperoxide were observed in liver during diabetes. Previous studies have reported that there was an increased Lipid peroxidation in the liver of diabetic rats (Prince and Menon, 2000). Kamalakkannan and Stanely (2004) investigated on the antidiabetic and antioxidant activity of *Aegel marmelos* in streptozotocin-induced diabetic rats. The diabetic rats showed a significant increase in TBARS and hydroperoxides in liver and kidney. Oral administration of *Aegel marmelos* fruit extract maintained the tissue TBARS and hydroperoxides to near normal status. Pari and Latha (2002) demonstrate the levels of TBARS in normal and experimental animals while they have worked on the antidiabetic activity of *Cassia auriculata* flowers. There was a significant elevation of lipid peroxides in liver and kidney during diabetes when compared to the normal group. Administration of *Cassia auriculata* flowers extract at 0.45g/kg body weight was more effective than glibenclamide was found in their study. The effect of treatment with *Anacardium occidentale* on lipid peroxidation index (MDA) in normal and fructose-fed rats was investigated by Olatunji *et al.*, (2005). The MDA levels were significantly higher in fructose-fed rats compared with those in normal rats. Treatment with *Anacardium occidentale* produced significant reduction in MDA.

Our study showed that after administration of leaves of *C. tamala, M. oleifera* and *S. dulcis* aqueous extracts at a dose of 250 mg/ kg body weight tended to be near normal. This indicates that the study plants may inhibit oxidative damage of hepatic tissues.

Antioxidant effect of methanol extract of *Enicostemma littorle* was evaluated by measuring blood GSH levels erythrocyte CAT activity and LPO. Significant changes were observed in the above parameters in the extract treated diabetic rats. That extract treatment

caused a 23% increase in GSH levels in diabetic rats. There was a 29% decrease in erythrocyte CAT activity and a 21% decrease in erythrocyte LPO levels in extract treated diabetic rats. In their case of extract treated control rats, no significant changes were observed in the above antioxidant parameters (Maroo *et al.*, 2003).

Kamalakkannan and Stanely (2004) reported that there was a significant reduction in glutathione and glutathione peroxidase in liver and kidney in diabetic rats. Oral administration of *Aegel marmelos* fruit extract to diabetic rats significantly increased the liver and kidney glutathione and glutathione peroxidase to near normal. It was also observed in the present study that there was an increase in hydroperoxides in the liver and kidney of diabetic rats. Our results are also consistent with other reports on an increase of hydroperoxides in liver of animals with experimental diabetes (Kowluru *et al.*, 1996; Halliwell and Gutteridge, 1984; Yagi, 1987). This phenomenon is possibly caused by the decreased activity of antioxidant enzymes, which is a favorable factor for uncontrolled generation of free radicals and subsequent generation of lipid hydroperoxides (Halliwell and Gutteridge, 1984; Yagi, 1987). Pari and Latha (2002) demonstrate the levels of GSH in normal and experimental animals while they have worked on the antidiabetic activity of *Cassia auriculata* flowers. Their study showed that GSH level was significantly lower in diabetic rats than in normal rats. Administration of *Cassia auriculata* flower extracts at a0.45g/kg body weight and glibenclamide increased significantly the GSH levels as compared with the levels in diabetic rats.

Under *in vivo* condition glutathione (GSH) acts as an antioxidant and its decrease is reported in diabetes mellitus (Baynes and Thrope, 1999). Hydroperoxides are molecules with high toxicity and a high potential for destroying enzymatic proteins and cell membranes (Wang *et al.*, 1996). A significant decrease in GSH levels in liver during diabetes was also observed in the present study. The decrease in GSH levels represents increased utilization due to oxidative stress (Anuradha and Selvam, 1993). The increased GSH content in the *C. tamala, M. oleifera* and *S. dulcis* leaf extracts treated rats may be a factor responsible for inhibition of lipid peroxidation. In a study by Bharali *et al.*, (2003) it was revealed that administration of hydroalcoholic extract of *Moringa oleifera* at both dose levels (125 and 250 mg/kg body weight) for 7 and 14 days daily enhanced the levels of hepatic cytochromes b_5, cytochrome P_{450} and glutathione- S- transferase elucidating that *M. oleifera* acts as a biofunctional indeces as it induces both Phase-I and Phase-II system enzymes that finish the balance of xcuobiotic metabolism towards detoxification.

Treatment with *C. tamala, M. oleifera* and *S. dulcis* leaf extracts lowered oxidative stress in STZ diabetic rats by lowering glucose level in blood and by increasing the antioxidant enzyme activities. It has been previously reported that the supplementation with Vitamin C and Vitamin E were necessary to protect STZ diabetic rats against oxidative stress (Ihara *et al.*, 2000; Garg and Bansal, 2000; Head, 2000). In the present study it was found that high amount of ascorbic acid (Vitamin C) was present in *C. tamala* and *M. oleifera* which also could suppress diabetes significantly.

The present study was undertaken to verify the claim and evaluate the medicinal properties specially antioxidant and antidiabetic potential of *C. tamala, M. oleifera* and *S. dulcis*. Most of the available antidiabetic drugs are targeted towards hyperglycemia. Oxidative stress is believed to be a pathogenic factor in the development of diabetic complications. These plants extracts can act as free- radical scavengers *in vitro*. Therefore, antioxidant therapy is essential for diabetes along with hypoglycemic drugs. Our observations show that the leaf extracts of study plants viz, *C. tamala, M. oleifera, S. dulcis* have a glucose lowering effect as well as an antioxidant effect. Such plants having both hypoglycemic as well as antioxidant properties are very useful for the treatment of diabetes and have great potential for development as antidiabetic agents. All the parameters studied with *C. tamala, M. oleifera* and *S. dulcis* leaves extracts at 250mg/kg body weight showed higher antioxidant action. Thus, the claim made by the traditional Indian system of medicine regarding the use of leaf extracts of these plants in the treatment of diabetes stands confirmed.

Among the tested three plants, i.e, *C. tamala, M. oleifera* and *S. dulcis* showed good antioxidant activity, but *C. tamala* showed the maximum, followed by *M. oleifera*. Similarly, when tested for hypoglycemic activity, *C. tamala* was the most effective, followed by *M. oleifera*. *C. tamala*, or bay leaves, is one of the common ingredients of Indian cooking.The high medicinal potential of the leaves point to the fact that this is also a case where age old practice is based on preliminary knowledge. Similarly, *M. oleifera*, also consumed as vegetable has high potential. On the other hand, *Clerodendrum viscosum*, a weed showed minimum beneficial activity.

It is known that oral antidiabetic agents produce hypoglycemic effect through various mechanisms of action. This ranges from suppressing hepatic gluconeogenesis, stimulating glycolysis and inhibition of glucose absorbtion from the intestine (biguanides), stimulation of insulin release (sulphonylureas); inhibition of conversion of dietary disaccharides to

monosacchrides (alpha-glucosidase inhibitors); and exerting transcription of fatty acids by activating a specific sub-class of perioxisome proliferators-activated receptor (phiazolidine-diones) (Hardy and McNutty, 1997).

It is therefore probable that these modes of action may also be present in the aqueous leaves extracts of *C. tamala, M. oleifera, S. dulcis* in which the presence of several bioactive constituents have been demonstrated. It is not known which of the recorded groups of biologically active compounds are responsible for this observed hypoglycemic effect. Neither is the mechanism of action clearly understood. However, this work has clearly brought out the importance of common plants in medicine, which if used properly, can be as good as any other forms of medicine. The involvement of several biochemical components in their action has also been established. Several lines of action are still open for further research which can pinpoint the actual component(s) involved and their specific modes of action.