1. INTRODUCTION

1.1 Definition of Diabetes

Diabetes mellitus is a group of metabolic disorders affecting many people world wide. It is mainly characterized by chronic hyperglycemia, resulting from defects in insulin secretion or insulin action. Diabetes mellitus consists of a group of syndromes characterized by hyperglycemia, altered metabolism of lipids, carbohydrates, proteins, and also increased risk of complications of vascular disease (Patel et al., 2012). The basis of the abnormalities in carbohydrate, fat, and protein metabolism in diabetes is deficient action of insulin on target tissues. Deficient insulin action results from inadequate insulin secretion and/or diminished tissues responses to insulin at one or more points in the complex pathways of hormone action. Impairment of insulin secretion and defects in insulin action frequently coexist in the same patient, and it is often unclear which abnormality, if either alone, is the primary cause of the hyperglycemia. Symptoms of marked hyperglycemia include polyuria, polydipsia, weight loss, sometimes with polyphagia, and blurred vision (ADA, 2013).

Long-term complications of diabetes include retinopathy with potential loss of vision; nephropathy leading to renal failure; peripheral neuropathy with risk of foot ulcers, amputations, and Charcot joints; and autonomic neuropathy causing gastrointestinal, genitourinary, cardiovascular symptoms and sexual dysfunction. Patients with diabetes have an increased incidence of atherosclerotic cardiovascular, peripheral arterial and cerebrovascular disease. Hypertension and abnormalities of lipoprotein metabolism are often found in people with diabetes (ADA, 2013).
1.2 Epidemiology of diabetes

The number of people with diabetes is increasing due to population growth, aging, urbanization, and increasing prevalence of obesity and physical inactivity. Quantifying the prevalence of diabetes and the number of people affected by diabetes, now and in the future, is important to allow national planning and allocation of resources (Sarah Wild et al., 2004).

1.2.1 Diabetes – World scenario

Diabetic mellitus occurs throughout the world, but it is more common (especially type 2) in the more developed countries. The greatest increase in prevalence is seen in Asia and Africa. The increase in incidence in developing countries follows the trend of urbanization and lifestyle changes, perhaps most importantly a "Western-style" diet (Wild et al., 2004). According to World Health Organization projections, the prevalence of diabetes is likely to increase by 35%. Currently there are over 150 million diabetic patients worldwide. Recent estimates project that the number of diabetic patient will more than double to 300 million before 2025 (Sikarwar et al., 2010).

Almost one Chinese adult in ten has diabetes. A 2010 study estimated that more than 92 million Chinese adults have the disease; with another 150 million showing early symptoms (China faces, 2010). India has more diabetics than any other country in the world; this disease affects more than 50 million Indians, 7.1% of the nation's adults - and kills about 1 million Indians a year. The average age on onset is 42.5 years (Gale and Jason 2012). The high incidence is attributed to a combination of genetic susceptibility plus adoption of a high calorie, low-activity lifestyle by India's growing middle class (Kleinfield, 2012). About 3.8 million people in the United Kingdom have diabetes mellitus, but the charity Diabetes U.K. have made predictions that could become high as 6.2 million by 2035/2036. In 2010, nearly 26 million people had diabetes in the United States, of whom 7 million people
remained undiagnosed. Another 57 million people are estimated to have prediabetes (Number of Americans, 2011).

1.2.2 Diabetes – Indian scenario

Diabetic mellitus is a real problem of public health in developing countries, where its prevalence is increasing steadily. India has become the diabetic capital of the world with over 20 million diabetics and this number will increase nearly to 57 million by 2025 (King et al., 1998).

According to the statistics of the International Diabetes Federation, in India, there will be nearly 50 million diabetic patients by the year 2025. As the incidence of diabetes is on the rise, there is a proportionate rise in the complications that are associated with diabetes. It is very essential, that people should be made aware and educated about their health and fitness level to reduce the number of diabetic patients in India. India leads the world with the largest number of diabetic subjects earning the dubious distinction of being termed the "Diabetes Capital of the World ".

1.3 Classification of diabetes mellitus

The American Diabetes Association (ADA), recognizes three main forms of diabetes mellitus namely type 1, type 2, and gestational diabetes (occurring during pregnancy), which have similar signs, symptoms and consequences but different causes and population distributions. Ultimately all forms are due to the inability of the pancreas being unable to produce sufficient insulin to prevent hyperglycemia (ADA, 2008).

1.3.1 Type 1 or Insulin dependent diabetes mellitus (IDDM)

Type 1 diabetes mellitus (IDDM or juvenile diabetes) is characterized by beta cell destruction caused by an autoimmune process, usually leading to absolute insulin deficiency. The onset is usually acute, developing over a period of few days to weeks. Over 95% of
patients with type 1 diabetes mellitus develop the disease before the age of 25, with an equal incidence in both sexes. Diabetes mellitus is an endocrine disease. Most of the patients have the "immune- mediated form" of type 1 diabetes mellitus with islet cell antibodies and often have other autoimmune disorders.

- Caused by the immune destruction of the beta cells of the pancreas.
- Antibodies to islet cells and insulin are present at diagnosis.
- Insulin secretion gradually diminishes.
- May present at any age, but most common in childhood and adolescence.
- Insulin by injection is necessary for survival

1.3.1.1 Immune-mediated diabetes

This form of diabetes, which accounts for only 5–10% of those with diabetes, previously encompassed by the terms insulin-dependent diabetes, type I diabetes, or juvenile-onset diabetes, results from a cellular-mediated autoimmune destruction of the β-cells of the pancreas. In this form of diabetes, the rate of β-cell destruction is quite variable, being rapid in some individuals (mainly infants and children) and slow in others (mainly adults). Some patients, particularly children and adolescents, may present with ketoacidosis as the first manifestation of the disease.

1.3.1.2 Idiopathic diabetes

Some of these patients have permanent insulinopenia and are prone to ketoacidosis, but have no evidence of autoimmunity, although only a minority of patients with type 1 diabetes fall into this category. This form of diabetes is strongly inherited, lacks immunological evidence for β-cell autoimmunity.
1.3.2 Type 2 or non-insulin dependent diabetes mellitus (NIDDM)

Type 2 diabetes mellitus is a group of disorders characterized by hyperglycemia and associated with micro vascular (i.e., retinal, renal, neuropathic), macro vascular (i.e., coronary, peripheral vascular), and neuropathic (i.e., autonomic, peripheral) complications. Unlike type 1 diabetes mellitus, patients are not absolutely dependent upon insulin for life, even though many of these patients are ultimately treated with insulin.

- Caused by insulin resistance in the liver and skeletal muscle, increased glucose production in the liver, over production of free fatty acids by fat cells and relative insulin deficiency.
- Insulin secretion decreases with gradual beta cell failure.
- Reductions in blood glucose levels often can be achieved with changes in food intake and physical activity patterns. Oral medication and/or insulin injections are eventually required.

1.3.3. Gestational diabetes mellitus (GDM)

Gestational diabetes mellitus is carbohydrate intolerance resulting in hyperglycemia of variable severity with onset or first recognition during pregnancy. It does not exclude the possibility that the glucose intolerance may antedate pregnancy. In Gestational diabetes mellitus, babies born to mothers with untreated gestational diabetes are typically at increased risk of problems such as being large for gestational age (which may lead to delivery complications), low blood sugar, and jaundice. If untreated, it can also cause seizures. Gestational diabetes is a treatable condition and women who have adequate control of glucose levels can effectively decrease these risks. The food plan is often the first recommended target for strategic management of GDM (ADA, 2004).
1.3.4. Other types of diabetes

Genetic defects of the β-cell: Several forms of diabetes are associated with monogenetic defects in β-cell function. These forms of diabetes are frequently characterized by onset of hyperglycemia at an early age (generally before age 25 years).

Genetic defects in insulin action: There are unusual causes of diabetes that result from genetically determined abnormalities of insulin action. The metabolic abnormalities associated with mutations of the insulin receptor may range from hyperinsulinemia and modest hyperglycemia to severe diabetes.

Diseases of the exocrine pancreas: Any process that diffusely injures the pancreas can cause diabetes. Acquired processes include pancreatitis, trauma, infection, pancreatectomy, and pancreatic carcinoma. With the exception of that caused by cancer, damage to the pancreas must be extensive for diabetes to occur; adrenocarcinomas that involve only a small portion of the pancreas have been associated with diabetes. This implies a mechanism other than simple reduction in β-cell mass.

Endocrinopathies: Several hormones (e.g., growth hormone, cortisol, glucagon, epinephrine) antagonize insulin action. Excess amounts of these hormones can cause diabetes. This generally occurs in individuals with preexisting defects in insulin secretion, and hyperglycemia typically resolves when the hormone excess is resolved.

Drug or chemical-induced diabetes: Many drugs can impair insulin secretion. These drugs may not cause diabetes by themselves, but they may precipitate diabetes in individuals with insulin resistance. In such cases, the classification is unclear because the sequence or relative importance of β-cell dysfunction and insulin resistance is unknown. Examples include nicotinic acid and glucocorticoids. Patients receiving α-interferon have been reported
to develop diabetes associated with islet cell antibodies and, in certain instances, severe insulin deficiency.

Infections: Certain viruses have been associated with β-cell destruction. Most of the patients with congenital rubella may develop type1 diabetes. In addition, coxsackievirus B, cytomegalovirus, adenovirus, and mumps have been implicated in inducing certain cases of the disease.

Other genetic syndromes sometimes associated with diabetes: Many genetic syndromes are accompanied by an increased incidence of diabetes. These include the chromosomal abnormalities of Down syndrome, Klinefelter syndrome, and Turner syndrome (Diabetes care, 2013).

1.4. Diabetic Complications

Diabetic patients have a high risk of developing long term diabetic complications because they develop poor glycemic control and vascular complications. The health care outcome among diabetic patients in many Asian countries is far from optimum (Gerstein et al., 2010).

Diabetes is associated with debilitating micro and macro vascular complications. As Asian populations develop diabetes at a young age, they live long enough to develop the complications too, resulting in high rates of morbidity and early mortality. The risk of cardiovascular disease increases by 3-4 folds in a diabetic person. More than 75% of all mortality among diabetic persons occurs due to cardiovascular disease. In diabetic patients, several stronger risk factors other than the classic risk factors exist, such as elevated low-density lipoprotein (LDL) cholesterol or oxidized LDL, which confer a higher risk in diabetic than in non-diabetic individuals with elevated LDL. The process of atherogenesis in diabetes is complex and consists of interrelated multiple factors. The chronic hyperglycemia activates
the mechanisms related to atherogenesis. The cardiovascular pathology is related to a combination of both micro and macrovascular dysfunction (Geiss et al., 1995). Few population based data on prevalence of diabetic complications are available from developing countries. However, it is been estimated that nearly 30% of type 2 diabetic patients in Asian countries have retinopathy. The prevalence of diabetic end stage renal disease is also higher than among the white populations. The prevalence of neuropathy and foot complications was also high among the Asian patients (Ambady Ramachandran et al., 2012).

The theory that hyperglycemia is the cause of diabetic complications has been challenging, because 40% of diabetics who carefully control their blood sugar nevertheless develop neuropathy and also because some of those with good blood sugar control still develop nephropathy (Rich, 2006). It has been discovered that the serum of diabetics with neuropathy is toxic to nerves even if its blood sugar content is normal (Pittenger and Vinik, 1993).

1.5. Pancreas

The pancreas is an elongated, tapered organ located across the back of the abdomen, behind the stomach. In human, the pancreas is a yellowish organ about 7 inches (17.8 cm) long and 1.5 inches (3.8 cm) wide. The pancreas is made up of two types of glands:

- **Exocrine gland-** It secretes pancreatic juice containing digestive enzymes that pass to the small intestine. These enzymes help to further breakdown the carbohydrates, protein, and fat.

- **Endocrine gland-** It produce several important hormones, including insulin, glucagon, and somatostatin.
1.5.1 Functions of pancreas

1.5.1.1. Exocrine function

The pancreas contains exocrine glands that produce enzymes important to digestion. When food enters the stomach, these pancreatic juices are released into a system of ducts that culminate in the main pancreatic duct. The pancreatic duct joins the common bile duct to form the ampulla of vater which is located at the first portion of the small intestine, called the duodenum. The common bile duct originates in the liver and the gallbladder and produces another important digestive juice called bile. The pancreatic juices and bile that are released into the duodenum help the body to digest fats, carbohydrates, and proteins.

1.5.1.2. Endocrine function

The endocrine component of the pancreas consists of islet cells that secrete and release important hormones directly into the bloodstream. Two of the main pancreatic hormones are insulin, which acts to lower blood sugar, and glucagon, which acts to raise blood sugar. Maintaining proper blood sugar levels is crucial to the functioning of key organs including the brain, liver, and kidneys.
1.6. Insulin and its role in diabetes mellitus

Human insulin is a polypeptide hormone, having a molecular weight of about 6000 Dalton, consisting of two amino acid chains A and B, which are linked by two disulphide (-S-S-) linkages. Normal human pancreas contains about 8-10 mg of insulin. Insulin is not suitable for oral administration due to inactivation by digestive enzymes. 80% of exerted insulin is normally degraded in the liver and kidneys. The amount of insulin secreted per day in a normal human is about 40 units. The dose of insulin required to control the diabetes varies from patient to patient and from time to time in the same patient (Warjeet Singh, 2011). Insulin is produced by beta cells of the pancreas, and is central to regulating carbohydrate and fat metabolism in the body. In liver and skeletal muscles, the insulin helps to absorb glucose from the blood and store it as glycogen, and in fat tissue (adipocytes) it is stored as triglycerides.

![Insulin Structure]

**Fig. 2. Structure of Insulin**

Insulin prevents the use of fat as an energy source by inhibiting the release of glucagon. In case like diabetes mellitus, insulin is provided within the body in a constant proportion to remove excess glucose from the blood, which otherwise would be toxic. When blood glucose levels fall below a certain level, the body begins to use stored sugar as an energy source through glycogenolysis, which breaks down the glycogen stored in the liver.
and muscles into glucose, which can then be utilized as an energy source. In addition, it has several other anabolic effects throughout the body (American Society of Health, 2009).

When control of insulin levels fails, diabetes mellitus can result. As a consequence, insulin is used medically to treat some forms of diabetes mellitus. Patients with type 1 diabetes depend on external insulin (most commonly injected subcutaneously) for their survival because the hormone is no longer produced internally. Patients with type 2 diabetes are often insulin resistant and, because of such resistance, may suffer from a "relative" insulin deficiency. Some patients with type 2 diabetes may eventually require insulin if other medications fail to control blood glucose levels adequately. Over 40% of those with Type 2 diabetes require insulin as part of their diabetes management plan (American Society of Health, 2009).

1.7. Pharmacological therapy

Pharmacologic therapy is associated with improved glycemic control and reduced long-term complications in type 2 diabetes. Metformin, Sulfonylureas, Meglitinide derivatives, Thiazolidinediones (TZDs) are used for the treatment of type 2 diabetes.

Metformin is the only biguanide in clinical use. Another biguanide, phenformin, was taken off the market in the United States in the 1970s because of its risk of causing lactic acidosis and associated mortality (rate of approximately 50%). Metformin has proved effective and safe. Metformin lowers basal and postprandial plasma glucose levels. Its mechanisms of action differ from those of other classes of oral antidiabetic agents; metformin works by decreasing hepatic gluconeogenesis production. It also decreases intestinal absorption of glucose and improves insulin sensitivity by increasing peripheral glucose uptake and utilization. Unlike oral sulfonylureas, metformin rarely causes hypoglycemia (Scarpello and Howlett, 2008). Metformin is associated with a low risk of mortality in
patients who have diabetes and experience heart failure compared with treatment that includes a sulfonylurea or insulin (Andersson et al., 2010).

Sulfonylureas (eg, glyburide, glipizide, glimepiride) are insulin secretagogues that stimulate insulin release from pancreatic beta cells and probably have the greatest efficacy for glycemic lowering than any of the oral agents. The sulfonylurea group of oral agents is the chief cause of cardiovascular death in diabetic patients admitted with acute myocardial infarction (Zeller et al., 2010).

Meglitinide derivatives (eg, repaglinide, nateglinide) are considerably more expensive than sulfonylureas, they are similar in their glycemic clinical efficacy. Meglitinides may be used in patients who have allergy to sulfonylurea medications (Bellomo Damato et al., 2011).

Thiazolidinediones (TZDs) (eg, pioglitazone, rosiglitazone) act as insulin sensitizers; thus, they require the presence of insulin to work. The use of TZDs may cause inflammation of blood vessels, edema and weight gain. These effects may induce heart failure in patients (Dormandy et al., 2005).

1.8. Studies on experimental diabetes

To understand the pathogenesis, complications, and testing of various therapeutic agents appropriate experimental models are needed. Diabetes animal models can be obtained through spontaneously, chemical induced or dietary or surgical manipulations. In recent years large numbers of new genetically modified animals have been used for the screening of antidiabetic drugs (Fröde and Medeiros, 2008). The use of experimentally induced diabetes in rats is a convenient method for screening of new drugs. The alloxan model of diabetes was first described in rabbits by Dunn, Sheehan and McLetchie in 1943 (Dunn et al., 1943). Alloxan was originally isolated in 1818 by Brugnatelli and was named in 1838 by Wöhler and Liebig.
The administration of alloxan to the animals selectively destroys the insulin producing β- cells in the pancreas and causes an insulin dependent diabetes mellitus (called "Alloxan Diabetes") in these animals, with characteristics similar to type 1 diabetes in humans. The beta cell toxic action of alloxan is initiated by free radicals formed in this redox reaction. One study suggests that alloxan does not cause diabetes in humans (Lenzen, 2008). Alloxan is used to induce diabetes in laboratory animals. This occurs most likely because of selective uptake of the compound due to its structural similarity to glucose as well as the beta-cell's highly efficient uptake mechanism. Some studies have shown that alloxan is not toxic to the human beta-cell, even in very high doses, probably because of differing glucose uptake mechanisms in humans and rodents. Alloxan is, however, toxic to the liver and the kidneys in high doses (Tyrberg et al., 2001 and Eizirik et al., 1994).

When alloxan is given intraperitonealy or subcutaneously its effective dose must be 2-3 times higher. A survey of literature revealed different workers using doses of alloxan varying from 80-200 mg/kg of body weight (Venkatesh et al., 2003; Virdi et al., 2003; Nagappa et al., 2003). The manifestation of diabetes state as evaluated by the blood glucose levels also therefore varies from 150-750 mg dL.
1.9. Management of diabetes

The treatment of diabetes mellitus is considered as the main global problem and a successful treatment is yet to be discovered. Even though insulin therapy and oral hypoglycemic agents are the first line of treatment for diabetes mellitus they have some side effects and fail to significantly alter the course of diabetic complications (Venkatesh et al., 2010).

Herbal medications have been used for the treatment of variety of ailments; a huge number of the world’s population is entirely dependent on traditional medicines. A number of medicinal plants and their formulations are used for treating diabetes in the ayurvedic medicine system as well as in ethnomedicinal practices. About 800 plants which may possess antidiabetic potential have been found. Several plants have been used as dietary adjuvant and in treating a number of diseases even without any knowledge of their proper functions and constituents. This practice may be due to its fewer side effects compared to the synthetic hypoglycemic agents and because of their safety, effectiveness, and availability (Patel et al., 2012).

1.10. Scope of medicinal plants

In the last few years there has been an exponential growth in the field of herbal medicine and these drugs are gaining popularity both in developing and developed countries because of their natural origin and lesser side effects. Many traditional medicines in use are derived from medicinal plants, minerals and organic matter (Grover et al., 2002). A number of medicinal plants, used for over 1000 years and traditionally called rasayana in herbal preparations of Indian traditional health care systems (Scartezzini and Sproni, 2000). The World Health Organization (WHO) has listed 21,000 plants, which are used for medicinal purposes around the world. Among these, 2500 species are in India, out of which 150 species
are used commercially on a fairly large scale. India is the largest producer of medicinal herbs and is called botanical garden of the world (Seth and Sharma, 2004). The current review focuses on herbal drug preparations and plants used in the treatment of diabetes mellitus, a major crippling disease in the world leading to huge economic losses.

There are about 400 traditional plant treatments for diabetes which have been reported, although only a small number of these have received scientific and medical evaluation to assess their efficacy. The hypoglycemic effect of some herbal extracts has been confirmed in human and animal models of type 2 diabetes. The World Health Organization Expert Committee on diabetes has recommended that traditional medicinal herbs be further investigated. Major hindrance in amalgamation of herbal medicine in modern medical practices is lack of scientific and clinical data proving their efficacy and safety. There is a need for conducting clinical research in herbal drugs, developing simple bioassays for biological standardization, pharmacological, toxicological evaluation, and developing various animal models for toxicity and safety evaluation. It is also important to establish the active components from the plant extracts (Manisha Modak et al., 2007).

1.11. Indian medicinal plants with antidiabetic and related beneficial effects

There are many herbal remedies suggested for diabetic complications. Medicinal plants with antidiabetic and related beneficial effects are:

*Acacia arabica* (Wadood et al., 1989), *Aegle marmelos* (Karunanayake et al., 1984), *Allium cepa* (onion) (Roman-Ramos et al., 1995), *Allium sativum* (garlic) (Mathew and Augusti, 1975 and Sheela and Augusti, 1992), *Aloe vera* and *Aloe barbadensis* (Al-Awadi and Gumaa, 1987), *Azadirachta indica* (Neem) (Biswa et al., 2002), *Caesalpinia bonducella* (Chakrabarti et al., 2003), *Cassia auriculata* (Sivaraj et al., 2010), *Coccinia indica* (Kamble et al., 1998), *Eugenia jambolana* (Indian gooseberry, jamun)
(Acherekar et al., 1991), Mangifera indica (Mango) (Aderigbe et al., 1999), Momordica charantia (bitter gourd) (Khanna et al., 1981), Ocimum sanctum (holy basil) (Vats et al., 2002), Trigonella foenum graecum (fenugreek) (Sauvaire et al., 1998), Hibiscus rosa-sinesis (Sachadeva and Khemani, 1999), and Syzygium alternifolium (Rao and Rao, 2001).

1.12. Medicinal plants selected for the study

In the present study three Indian folklore medicinal plants Momordica charantia (Family- Cucurbitaceae), Aegle marmelos (Family- Rutaceae) and Cassia auriculata L. (Family- Caesalpiniaceae) have been selected for antidiabetic studies.

1.12.1. Momordica charantia (Family: Cucurbitaceae)

It is a tropical household vegetable used as daily food and also as folk medicine especially for diabetes (Fig- 4a). Several studies have examined the antidiabetic potential of bitter gourd, both in humans as well as in experimental animals. Several workers have studied the effects of this plant in diabetic mellitus. Treatment with M. charantia fruit juice reduced blood glucose levels, improved body weight and glucose tolerance. It can also inhibit glucose uptake by the gut and stimulate glucose uptake by skeletal muscle cells. Moreover, the juice of this plant preserves β cell functions in pancreas, normalizes the systolic blood pressure, and modulates xenobiotic metabolism and oxidative stress. M. charantia also has anti-carcinogenic properties. In conclusion, M. charantia has tremendous beneficial values in the treatment of diabetes mellitus (Celia Garau et al., 2003).

1.12.2. Aegle marmelos (Family: Rutaceae)

Aegle marmelos (Family: Rutaceae) is a traditional medicinal plant and widely used to treat diabetes (Fig- 4b). The root is sweet, cures fever, pain in the abdomen, palpitation of the heart and urinary problems. The leaves are astringent, digestive; laxative, when fresh; the flowers allay thirst and vomiting; useful in dysentery. The ripe fruit is a restorative tonic,
astringent, laxative; good for the heart and brain. The leaf extract significantly controlled blood glucose, urea, body weight, liver glycogen and serum cholesterol (Mhaskar et al., 2000). Research has found the essential oil of the *A. marmelos* to be effective against 21 types of bacteria. It is prescribed for smooth bowel movement to patients suffering from constipation and other gastrointestinal problems (Pattnaik et al., 1996).

**1.12.3. *Cassia auriculata* (Family-Caesalpinaceae)**

*Cassia auriculata* (Family-Caesalpinaceae) is a traditional medicinal plant (Fig- 4c). The root of *C. auriculata* cures tumours, skin diseases and asthma; leaves are anthelmintic, good for ulcer and leprosy. The flowers are used in the treatment of urinary discharge, diabetes and dysentery (Sivaraj et al., 2010). This plant is said to contain a cardiac glucoside (sennapicrin) and sap, leaves and bark yield anthraquinones, while the latter contains tannins. The root is used in decoctions against fevers, diabetes, diseases of urinary system and constipation. The leaves have laxative properties. The dried flowers and flower buds are used as a substitute for tea in case of diabetes patients. It is also believed to improve the complexion in women. The powdered seed is also applied to the eye, in case of chronic purulent conjunctivitis. In Africa the bark and seeds are said to give relief in rheumatism, eye diseases, gonorrhea and diabetes. The plant has been shown to have antibacterial activity in the laboratory (Maneemegalai and Naveen 2010).
Fig. 4. Medicinal plants selected for the study

a. *Momordica charantia*  
b. *Aegle marmelos*  
c. *Cassia auriculata*