Chapter 1

Introduction
1.1 MEDICINAL PLANTS

Medicinal plants constitute an important natural wealth of a country. They play a significant role in providing primary health care services to rural population. They serve as therapeutic agents as well as important raw materials for the manufacture of traditional medicines. Ethnopharmacology is the study of plants used in traditional medicine and is therefore heavily reliant on interactions between researchers and indigenous communities who passed on the traditional knowledge over generations. Whilst in the main, ethnopharmacology focuses on the presence or absence of evidence for specific therapeutic responses through the use of herbal remedies, the field also extends into phytochemistry where the aim is to identify the chemical constituent of the plant or plant extract that is responsible for the pharmacological activities inherent to a specific plant (Mulholland et al., 2005).

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 less side effects. Many traditional medicines in use are derived from medicinal plants, minerals and organic matter (Sangeeta et al., 2011). WHO has listed 21,000 plants, which are used for medicinal purposes around the world (Maurya and Srivastava 2011).

Therefore, with the rising number of diseases lately, many researchers have evaluated the medicinal plants as alternative therapeutic agents. The effectiveness and safety of drugs derived from the medicinal plants require scientific evaluation to establish the profiles of therapeutic effectiveness and toxicity of plant products. One example of such products is antihyperglycemic agents for use in the treatment of diabetes mellitus.

Importance of medicinal plants and traditional medicines

Medicinal plants, since time immemorial, have been used in virtually all cultures as a source of medicine. It has been estimated that about 80 - 85% of population both in developed and developing countries rely on traditional medicine for their primarily health care needs and it is assumed that a major part of traditional therapy involves the use of plant extracts or their active principles (Ignacimuthu et al., 2006, Elujoba et al., 2005, Tomlinson and Akerele 1998).

Due to lack of organized health care systems in developing countries like Ethiopia, people with chronic diseases like diabetes are among the worst suffers in
their communities today. Hence, majority of the populations still have limited access or no access, especially those in remote areas, to modern medicines. Instead they use traditional medicines for a range of diabetic complications (Kochhar and Nagi 2005, Zibula and Ojewole 2000).

1.2 DIABETES MELLITUS

Diabetes mellitus is described as metabolic disorder which resulting from defects in insulin secretion or insulin action or both. Diabetes mellitus could cause long term damage, dysfunction and failure in many organs. Patients with diabetes can develop heart disease, kidney disease, blindness, vascular or neurological problems that can lead to amputation and can suffer increased rates of mortality. Moreover, the death rate in patients with diabetes is much higher than in persons without the disease. According to the estimation of International Diabetes federation (IDF) (IDF Diabetes Atlas 2011), one among ten adults would have diabetes by 2030. There were 366 million people having diabetes in 2011; this will increase to 552 million people by 2030.

The number of people got type 2 diabetes is increasing every year and many people remain undiagnostic. In the demand of preventing and treating Diabetes Mellitus, there are many synthetic drugs have been researched and developed such as Sulphonylureas, Thiazolidinediones, Glinide, Metformin etc. However, they are not optimum solution especially for developing country. They retain many side effects and relatively expensive. There is a need to investigate herbal drug based medicine, which has available resources, easy to use, cheap and less side effects.

Pathophysiology of diabetes mellitus

The pancreas plays a primary role in the metabolism of glucose by secreting the hormones insulin and glucagon (Figure 1.1). The islets of Langerhans secrete insulin and glucagon directly into the blood. Insulin is a protein that is essential for proper regulation of glucose and for maintenance of proper blood glucose levels (Worthley 2003). Glucagon is a hormone that opposes the action of insulin. It is secreted when blood glucose level falls. It increases blood glucose concentration partly by breaking down stored glycogen in the liver by a pathway known as glycogenolysis. Gluconeogenesis is the production of glucose in the liver from non-carbohydrate precursors such as glycogenic amino acids (Sowka et al., 2001).

- **Type I diabetes**: Insulin dependent or childhood onset, is characterized by a lack of insulin production.
- **Type II diabetes**: Non insulin dependent or maturity/adult onset diabetes.
- **Type III or Gestational diabetes**: This type of diabetes first occurs during pregnancy.
- **Secondary diabetes**: Diabetes may develop as a consequence of other diseases or medication.

Prevalence and incidence of diabetes mellitus

Globally, the prevalence of diabetes, without type distinction, was estimated to be 4% in 1995. According to WHO, it is estimated that 3% of the world’s population
have diabetes and the prevalence is expected to double by the year 2025 to 6.3% (Andrade - Cetto and Heinrich 2005, Attele et al., 2002).

There will be a 42% increase from 51 to 72 million in the developed countries and 170% increase from 84 to 228 million, in the developing countries. Thus, by the year 2025, over 75% of all people with diabetes will be in the developing countries, as compared to 62% in 1995 (Ramachandran et al., 2002).

**Management of diabetes mellitus**

Diet, exercise, modern medication including insulin and oral administration of hypoglycaemic drugs such as sulfonylureas and biguanides manage the pathological process of diabetes mellitus. Insulin plays a key role in aldohexose equilibrium along the side of a counter regulative hormone, glucagon, which raises serum glucose. Carrier proteins (GLUT1-5) are essential for glucose uptake into cells. In people with type II diabetes, a standard sequence of medical aid starts with diet treatment and exercise followed by oral antihyperglycemic agents. In general, insulin therapy has been considered to be the last therapeutical option when diet, exercise and oral antihyperglycemic agent therapies have failed. Oral agents acting as indicated in Figure 1.2 are used in type II diabetic patients who fail to meet glycemic goals with medical nutrition therapy and exercise. Traditionally plants are also used for the treatment of diabetes throughout the world (Koski 2006, Cheng and Fantus 2005).

Management of diabetes without any side effect remains a challenge for the medical system. This leads to an increasing search for improved antidiabetic drugs.

**Diabetes mellitus and phytotherapy**

Natural products and their derivatives have been a successful source of bioactive molecules in medicines much before the advancement of other modern therapeutics in the post genomic era. Medicinal plants have been used virtually in all cultures as a source of medicine (Sofowora 1996). The use of medicinal plants for treatment of diabetes mellitus dates back from the Ebres papyrus about 1550 B.C (Kesari et al., 2005, Gupta et al., 2005, Kako et al., 1991, Shruthi et al., 2012).
TZD = thiazolidinedione; FFA = free fatty acid; AGI = α-glucosidase inhibitor

**Figure 1.2:** Major target organs and mechanism of actions of orally administered antihyperglycemic agents in type II diabetes mellitus

Traditional medicines derived mainly from plants play major role in the management of diabetes mellitus. World Health Organization (WHO) has recommended the evaluation of traditional plant treatments for diabetes as they are effective, non-toxic, with less or no side effects and are considered to be excellent candidates for oral therapy (Sunil Kumar *et al.*, 2012, Khan *et al.*, 2010, Virendra Singh and Mohan Lal Kori 2014, Ahmed *et al.*, 2004, Patel and Srinivasan 1997, Day 1998).

To date, over 400 traditional plant for diabetes have been reported, although only a small number of these have received scientific and medical evaluation to assess their efficacy (Ajithadas Aruna *et al.*, 2014). The importance of phytotherapy in treatment of type 2 diabetes mellitus seems to gradually increase in coming years. Phytotherapy can be effective in prevention of diabetes and its complications as well as optimization of the treatment and life standards. As in case of many chronic metabolic diseases, the mechanism is closely related, particularly in diabetes, to oxidative stress and inflammation in the body. Therefore, due to the antioxidant
properties herbs should be considered for both prevention and treatment of diabetes (Kato et al., 1995).

The use of medicinal plants has flourished as an alternative for the treatment of diabetes because modern medicines are tagged with several side effects and are also expensive. A multitude of herbs and medicinal plants and some compounds purified from them have been studied for the treatment of diabetes throughout the world as they might provide a basis of new synthetic antidiabetic analogues with potent activity. Indeed, the widely prescribed insulin - sensitizer metformin was derived from guanidine, a molecule isolated from Galega officinalis L. (French lilac) (Witters 2001, Bailey and Day 2004, Eddouks et al., 2003).

Ethanopharmacological surveys indicate that more than 1200 plants are used in traditional medicine for their allied hypoglycemic activity. In diabetes, some herbal alternatives are proven to provide symptomatic relief and assist in the prevention of the secondary complication of the disease.

Many new bioactive drugs isolated from plants having hypoglycaemic effects showed anti-diabetic activity equal and sometimes even more potent than known oral hypoglycaemic agents. However, many other active agents obtained from plants have not been well characterized. More investigations must be conducted to evaluate the mechanism of action of medicinal plants with anti-diabetic effect. Consequently, it is necessary to perform toxicological investigation of all plants empirically used in order to avoid the risk of the side effects related to phytotherapy.

1.3 LIVER DISEASES AND MEDICINAL PLANTS

Liver plays a vital role in regulation of physiological processes of the human body. It is involved in several vital functions such as metabolism, secretion and storage. Furthermore, detoxification of a variety of drugs and xenobiotics occur in liver. The bile secreted by the liver has an important role in digestion of fat. Liver diseases are amongst the most serious ailments may be classified as acute or chronic hepatitis (inflammatory liver diseases), hepatosis (non inflammatory diseases) and cirrhosis (degenerative disorder resulting in fibrosis of the liver) (Kobayashi and Yoshikawa 1998).

Liver diseases are mainly caused by toxic chemicals (certain antibiotics, chemotherapeutics, peroxidised oil, aflatoxin, carbon tetrachloride, chlorinated hydrocarbons, etc.,), excessive consumption of alcohol, infections and autoimmune
disorders. Most of the hepatotoxic chemicals damage liver cells primarily by inducing lipid peroxidation and other oxidative stress in liver (Bickel et al., 1991). Plant drugs are known to play a vital role in the management of liver diseases. There are numerous plants and polyherbal formulations claimed to have hepatoprotective activities.

**Drug metabolism in liver and hepatotoxicity**

The central role played by liver in the clearance and transformation of chemicals also makes it susceptible to drug induced injury. Drug metabolism is usually divided into two phases: Phase 1 and Phase 2. Drug metabolism in liver takes place by means of transferases, glutathione, sulfate, acetate, glucoronic acid and cytochrome P - 450 enzymes. Three different pathways are depicted for three types of drugs, A, B and C as shown in Figure 1.3.

![Drug metabolism in liver](image)

**Figure 1.3:** Drug metabolism in liver

Phase 1 reaction involves processes such as oxidation, reduction, hydrolysis and hydration. These processes tend to increase water solubility of the drug and can generate metabolites which are more chemically active and potentially toxic. Most of the phase 2 reactions take place in cytosol and involve conjugation with endogenous compounds via transferase enzymes. Chemically active phase 1 products are rendered relatively inert and suitable for elimination by this step (Skett et al., 2001).
A group of enzymes located in the endoplasmic reticulum, known as cytochrome P - 450, is the most important family of metabolizing enzymes in the liver. Cytochrome P - 450 is the terminal oxidase component of an electron transport chain. It is not a single enzyme, but rather consists of a family of closely related 50 iso forms; six of them metabolize 90% of the available drugs (Lynch and Price 2007).

There is a tremendous diversity of individual P-450 gene products and this heterogeneity allows the liver to perform oxidation on a vast array of chemicals (including almost all drugs) in phase 1.

Mechanism of liver damage

Several mechanisms are responsible for either inducing hepatic injury or worsening the damage process. Many chemicals damage mitochondria, an intracellular organelle that produces energy. Its dysfunction releases excessive amount of oxidants which in turn injures hepatic cells. Activation of some enzymes in the cytochrome P-450 system such as CYP2E1 also leads to oxidative stress (Jaeschke et al., 2002). Injury to hepatocyte and bile duct cells lead to accumulation of bile acid inside liver. This promotes further liver damage (Patel et al., 1998). Non-parenchymal cells such as Kupffer cells, fat storing stellate cells and leukocytes (i.e. neutrophil and monocyte) also have important role in the damage mechanism.

Chemicals also produce a wide variety of clinical and pathological hepatic injury. Biochemical markers (i.e. level of alanine transferase (ALT), alkaline phosphatase (ALP) and bilirubin) in blood samples are often used as indicators of the level of liver damage. Liver injury is said to exist when there is a rise in either (a) alanine transferase (ALT) level more than three times of upper limit of normal (ULN), (b) alkaline phosphatase (ALP) level more than twice upper limit of normal (ULN), or (c) total bilirubin level more than twice upper limit of normal (ULN). (Benichou 1990, Keeffe Emmet and Friedman Lawrance 2004). Specific histopathological patterns of liver injury from drug induced damage are discussed below.

Zonal Necrosis

This is the most common type of drug induced (Paracetamol, Carbon tetra chloride) liver cell necrosis where the injury is largely confined to a particular zone of the liver lobule. It may manifest as very high level of alanine transferase (ALT) and severe disturbance of liver function leading to failure.
Hepatitis

In this pattern hepatocellular necrosis is associated with infiltration of inflammatory cells. There can be three types of drug induced hepatitis:

- Viral hepatitis, which is the commonest, where histological features are similar to acute viral hepatitis, (halothane, isoniazide, phenytoin).
- In the focal or non specific hepatitis scattered foci of cell necrosis may accompany lymphocytic infiltrate (aspirin).
- Chronic hepatitis type, which is very similar to autoimmune hepatitis clinically, serologically as well as histologically (methyl dopa, diclofenac sodium)

Cholestasis

Liver injury leads to impairment of bile flow and the clinical picture is predominated by itching and jaundice. Histology may show inflammation (cholestatic hepatitis) or it can be bland without any parenchymal inflammation. In rare occasions it can produce features similar to primary biliary cirrhosis due to progressive destruction of small bile ducts (Vanishing duct syndrome).

**Causes include:** (a) Bland: Oral contraceptive pills, anabolic steroid, androgens (b) Inflammatory: Allopurinol, co-amoxiclav, carbamazepine (c) Ductal: Chlorpromazine, Flucloxacillin.

Granuloma

Drug induced hepatic granulomas are usually associated with granulomas in other tissues and patients typically have features of systemic vasculitis and hypersensitivity. More than fifty drugs have been implicated.

**Causes include:** Allopurinol, phenytoin, isoniazid, quinine, penicillin, and quinidine.

**Acetaminophen toxicity**

![Figure 1.4: Structure of Acetaminophen](image)
Acetaminophen (Paracetamol, also known by the brand name Tylenol and Panadol) shown in Figure 1.4 is usually well tolerated in prescribed dose, but overdose chronic application is the most common cause of drug induced liver disease and acute liver failure worldwide (Keeffe Emmet and Friedman Lawrance 2004), which is one of the most painful experiences patients report. Reports of death from acute hepatotoxicity have been reported to arise from a dose as low as 2.5 gm over a 24 hour period. Damage to the liver is not due to the drug itself, but to a toxic metabolite (N-acetyl-p-benzoquinone imine NAPQI) of it which is produced in the liver (Wallace 2004).

In normal circumstances this metabolite is detoxified by conjugating with glutathione in phase 2 reaction. In conditions of overdose, large amounts of N-acetyl-p-benzoquinone imine (NAPQI) are generated which overwhelm the detoxification process itself and consequently leads to damage to liver cells. Nitric oxide also plays a role in inducing hepatic toxicity (James et al., 2003).

The risk of liver injury is influenced by several factors including the dose ingested, concurrent alcohol or other drug intake, time interval between ingestion and antidote, etc. The dose toxic to liver is quite variable and is lower in chronic alcoholics. Measurement of biochemical markers in blood samples is important in assessing prognosis, higher levels predicting worse prognosis. Administration of Acetylcysteine, a precursor of glutathione, can limit the severity of the liver damage by capturing the toxic N-acetyl-p-benzoquinone imine (NAPQI). Those who develop Paracetamol induced acute liver failure can still recover spontaneously, but may require transplantation even if a poor prognostic sign such as encephalopathy or coagulopathy is present.

1.4 PHYTOPHARMACEUTICALS IN THE TREATMENT OF PAIN, INFLAMMATION AND FEVER

Traditional medicaments chiefly obtained from plants have played a vital role in sustaining disease free human existence in the planet. Over the centuries, phytopharmaceuticals have been utilized by different communities of the world (Sumanta Mondal et al., 2013, Naveed et al., 2012).

Pain, inflammation and fever are very common complications in human beings. Several plants and their products are claimed and proved to possess analgesic, anti-inflammatory and antipyretic property (Manoj Kumar et al., 2012).
As a result of adverse effects such as gastric lesions caused by non-steroidal anti-inflammatory drugs (NSAID), tolerance and dependence induced by opiates, the use of these drugs as anti-inflammatory and analgesic agents have not been successful in all cases. Attention is being focused on the investigation of the efficacy of plant-based drugs used in the traditional medicine because they are cheap, have little side effects and according to WHO, about 80% of the world population still rely mainly on herbal remedies (Dharmasiri et al., 2003, Park et al., 2004, Kumara 2001).

In recent times, focus on plant research has increased and non-steroidal anti-inflammatory drugs (NSAID) constitute one of the most widely used classes of drugs. Herbal drugs are being proved as effective as synthetic drugs with lesser side effects. Herbal medicines are in line with nature, with less hazardous reactions (Sahu et al., 2011).

Plants have long been a very important source of drugs and many plant species have been screened to see if they contain substances with potential therapeutic activity. Several reviews are available in the literature pertaining to approaches for selecting plants as candidates for drug discovery programs. The study of natural products has many advantages over synthetic drug design. The former leads to materials having new structural features with novel biological activity. In this context not only do plants continue to serve as possible sources for new drugs, but chemicals derived from the various parts of these plants can also be extremely useful as lead structures for synthetic modification and optimization of bioactivity. Hence in the present study two plants have been selected based on the literature review. They are *Andrographis echioides* (AE) and *Gynocardia odorata* (GO).

Since ancient times, *Andrographis paniculata* (Kalmegh) is used in traditional, siddha and ayurvedic systems of medicine as well as in tribal medicine in India and some other countries for multiple clinical applications. The therapeutic value of “Kalmegh” extract is due to its mechanism of action which is perhaps by enzyme induction. Kalmegh is also reported to possess antihepatotoxic (Chander 1995), immunostimulatory (Vedavathy and Rao 1991, Madav 1995), antimalarial (Misra 1992), antipyretic (Deng W 1982), anti-snake venom, (Nazimudeen 1978), anti-inflammatory (Coon and Ernst 2004), antidiarrhoeal (Gupta 1993), anti-human immunodeficiency virus (HIV) [Otake 1995] and antibacterial (Leelarasamee 1990) activities. One of the species of *Andrographis* i.e., *Andrographis echioides* is stated to have properties similar to that of *Andrographis paniculata* (Anonymous 1995).
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Andrographis echioides is a species of Andrographis commonly known as kalmegh in Hindi, belonging to the family Acanthaceae, is a dense herb found in plains and waste lands which fruits throughout the year. Andrographis echioides has been reported anti-inflammatory, antimicrobial, anthelmintic, antioxidant and larvicidal properties (De - Yang et al., 2013, Padma et al., 2012, Premkumar et al., 2010, Sankaran et al., 2012). Andrographis panniculata has been reported to possess antidiabetic activity (Yaman et al., 2013).

Pharmacological study on antidiabetic activity of Andrographis echioides has not been reported till now. Therefore the present study was aimed to investigate the antidiabetic effects of methanol extract of Andrographis echioides (MEAE) against streptozotocin (STZ) - induced diabetes in Wistar albino rats. The plant AE selected for the present study is available locally in the Erode district, Tamilnadu and has been used as local folklore medicine for the treatment of diabetes.

Gynocardia odorata roxb. is also known as Chaulmoogra plant, belongs to the family of Flacourtiaaceae, which is indigenous to parts of India, Malaysia and tropical countries of the world, contain fatty acids chaulmoogric acid, hydnocarpic acid. Chaulmoogra oil is an important therapeutic agent in certain medical traditions (Roxburgh and Coromandel 1820). The seeds of Gynocardia odorata roxb are most commonly used. The fruits are hot anthelmintic and used in bronchitis, skin diseases, small tumor’s leprosy, and as an analgesic. It is reported to contain antioxidant properties (Jagan Mohan et al., 2013) and have its antiulcer activity because of its active constituents like flavonoids and especially quercetin (Khan et al., 2013, Shrish Kumar et al., 2014). It was reported that Gynocardia odorata roxb could be a natural medication alternative of thrombolytic agents as well as source of potent bioactive compounds (Faisal et al., 2014).

The above mentioned activities have been reported but there is no evidence of antidiabetic activity is established yet now. In the present study an attempt was made to establish the antidiabetic potential of methanol leaf extracts of Gynocardia odorata roxb, based on folklore applications in the Erode district.

Experimental evidences demonstrate that the complication of diabetes is associated with oxidative stress induced by generation of free radicals. In the diabetic state lipid peroxidation can be induced by protein glycation and glucose auto-oxidation that can lead to formation of free radicals. The main free radicals that occur in this state are superoxide, hydroxyl and peroxyl radicals. All these free radicals
might play a role in DNA damage, glycation, protein modification reactions, and in lipid oxidative modification in diabetes. In diabetic state, simultaneous oxidation and glycerol processes are closely correlated with oxidized low density lipoproteins (LDL). In addition, flavonoids and phenolic compounds possessing both antioxidant and antidiabetic activity are effective in preventing the formation of reactive oxygen induced diseases (Mirunalini and Arulmozhi 2011).

Based on the medicinal applications and literature review, the plants *Andrographis echioides* (AE) and *Gynocordia odorata* (GO) were subjected to evaluate for possible antidiabetic, antioxidant and hepatoprotective activity. Antioxidants are believed to act by inhibiting free radical generations. Free radicals are said to generated in a number of diseases include liver damage and inflammation. Hence the plants were also subjected to evaluate analgesic, anti-inflammatory and anti-pyretic activity.

1.5 DESCRIPTION AND LITERATURE REVIEW OF THE INVESTIGATED PLANTS

**Plant profile of Andrographis echioides (AE) Nees**

*Figure 1.5: Andrographis echioides (AE) Nees plant*
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**Botanical Name**  : *Andrographis echioides* Nees  
**Family**  : Acanthaceae  

**Vernacular Names**  
Bengali  : Kalmegh  
Hindi  : Birkubat  
Tamil  : Gopuram thangi.  
Malayalam  : Pitumba  
Kannada  : Sivamballi  
**Habitat**  : Tropical India in the drier districts, Ceylon.

**Literature review of *Andrographis echioides* (AE) Nees**

- **Ethnopharmacology**
  
  *Andrographis echioides* is a species of *Andrographis* commonly known as kalmegh in Hindi, belonging to the family *Acanthaceae*, is a dense herb found in plains and waste lands which fruits throughout the year (Figure 1.5). *Andrographis echioides* has been reported anti-inflammatory, antimicrobial, anti-helmintic, antioxidant and larvicidal activities (De-Yang *et al.*, 2013, Padma *et al.*, 2012, Premkumar, *et al.*, 2010, Sankaran *et al.*, 2012).

  Pharmacological study on antidiabetic activity of *Andrographis echioides* has not been reported till now. This plant is locally available in the Erode district, Tamilnadu, India and has been used for long a time in local folklore medicine for the treatment of diabetes.

- **Phytochemistry**

  1. Echioidin has been isolated from the leaves of *Andrographis echioides*. On the basis of spectral, degradative and synthetic evidence, echioidinin is shown to be 5, 2′-dihydroxy-7-methoxyflavone (Govindachari *et al.*, 1965).

  2. Chemical examination of leaves of *Andrographis echioides* – II: structure and synthesis of echioidin has been reported. On the basis of degradative and spectral evidence and synthesis, echioidin, the new flavone glucoside isolated from *A.echioides*, is shown to be 5-hydroxy-2′-β-glucosidoxy-7-methoxyflavone (echioidinin-2′-β-glucoside) (Govindachari *et al.*, 1965a).

  3. Isolation of a new chalcone glucoside, androechin, and a known flavone glucoside, echioidinin 5-O-glucoside, from the whole plant of *Andrographis*
*echioides* has been reported. Androechin was characterized as 2, 2’, 6’-trihydroxy-4’-methoxychalcone 2’-O-beta-D-glucopyranoside by spectral and chemical studies (Damu et al., 1998).

4. It has been investigated and reported that the presence of new flavanone, Dihydroechioidinin together with four known flavones in the whole plant of *Andrographis echioides*. The structure of dihydroechioidinin was established as (2S)-5, 2’-dihydroxy-7-methoxyflavanone on the basis of spectral and chemical evidence (Jayaprakasam et al., 1999).

**Plant profile of *Gynocardia odorata* (GO) Roxb**

![Plant profile of *Gynocardia odorata* (GO) Roxb](image)

**Figure 1.6: Gynocardia odorata (GO) Roxb plant**

<table>
<thead>
<tr>
<th>Botanical Name</th>
<th><em>Gynocardia odorata</em> Roxb</th>
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<tbody>
<tr>
<td>Family</td>
<td>Flacourtiaeae</td>
</tr>
<tr>
<td>Vernacular Names</td>
<td>Chhal Mora, Chaulmoogra</td>
</tr>
<tr>
<td><strong>Habitat:</strong></td>
<td>Indigenous to parts of India, Malaysia and tropical countries</td>
</tr>
</tbody>
</table>

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Literature review of *Gynocardia odorata* (GO) Roxb

- **Ethnopharmacology**

  *Gynocardia odorata* roxb is a very large East Indian tree (Figure 1.6). The leaves are glossy, entire, and alternate. The flowers are yellow and sweet-scented. The fruit is round, ash-coloured, and when mature, average in weight from 10 to 20 pounds. The numerous seeds are imbedded in its pulps, and contain oil, which according to Roxburgh, is mixed with fresh butter, and used by the natives as a remedy for cutaneous diseases. It is known as Chaulmoogra and is said, when powdered, to have been used with advantage in scrofula, skin diseases, and rheumatism, the dose being about 6 grains. The seeds are greyish, irregularly ovoid, compressed, and angular and smooth, a little over an inch long, and have an oily taste. (Bailey and Day 1989, Lee Witters 2001, Khare 2007, Arolkar *et al*., 1992, Sambamurthy 2006, Gloria *et al*., 2003).

  *Gynocardia odorata* roxb is also known as chaulmoogra plant, belongs to the family of Flacourtiaceae, contain fatty acids chaulmoogric acid, hydnocarpic acid. Chaulmoogra oil is an important therapeutic agent in certain medical traditions (Roxburgh and Coromandel 1820). The seeds of *Gynocardia odorata* roxb are most commonly used. The fruits are hot anthelmintic and used in bronchitis, skin diseases, small tumor’s leprosy, and as an analgesic. *Gynocardia odorata* roxb is reported to contain antioxidant properties (Jagan Mohan *et al*., 2013). *Gynocardia odorata* roxb may have its antiulcer activity because of its active constituents like flavonoids and especially quercetin (Khan *et al*., 2013, Shrish Kumar *et al*., 2014). It was reported that *Gynocardia odorata* roxb could be a natural medication alternative of thrombolytic agents as well as source of potent bioactive compounds (Faisal *et al*., 2014).

- **Phytochemistry**

  Drevogenin D has been isolated from seeds; hydrolysate of seed extract yielded drevogenins B, D, and P, D-cymarose, (+) methyl pachybioside, oleandrose, pachybiose and digitoxose. A new glycoside - dregoside A along with drevogenin A and drebbysogenin G has also been isolated from this plant (Khare 2007).

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Khan H., Gupta N., Mohammed M. S., Meetu A., Khan G., Mohan G., 2013. Antiulcer activity of seed extracts of Gynocardia odorata roxb on pylorus ligation and
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