I. INTRODUCTION
The history of cultural man dates back to two or three million years when he struggled for his existence as a hunter and gatherer. Thousands of year’s trial and error experimentation must have taught him to distinguish between useful and harmful plants. The history of the herbal medicine started unfolding from this period. Since then, the use of medicinal plants was practiced by all cultures as a source of medicine (Lanfranco, 1999). The earliest record of human civilization and cultures of China, Egypt, Assyria and Indus Valley reveals that the wise and elders of those times used herbal medicines to treat various diseases. It is available in the old literature, folklore, mythological stories, epic poems, medicinal treatises and old manuscripts, palm leaves, copper plates and other records on these cultures which are preserved. The excavation of Shanidar cave in Iraq in 1963 belonging to Naenderthal man buried sixty thousand years ago, revealed the presence of many flowers and plants, which were later identified to have various medicinal properties (Baquar, 1995).

One of the earliest testimonies ‘Pharmacopoeia of the Emperor of China’ recorded between 2730 and 3000 BC revealed the use of Chaulmoogra oil from *Hydnocarpus gaertn* as an effective treatment for leprosy. Similarly, the seeds of Opium poppy (*Papaver somniferum*) and Castor (*Ricinus communis*) were excavated from some ancient Egyptian tombs, which indicated their use in that part of Africa in 1500 BC. The records available in “Ebers Papyrus” also confirm that medicinal plants were used in Egypt at that time (Baquar, 1995).

The historic contribution of Sushrutha, the ancient surgeon of India, is well recognized for his methods of rhinoplasty (Eisengerg, 1982), extracapsular lens extraction in cataract (Kansupada and Sassani, 1997), anal and dental surgeries (Deshpande *et al.* 1975). Sushrutha was the famous surgeon of Kashi, used to teach and practice medicine around 600 BC. He was a disciple of Dhanwantri and his work is presently available in a treatise called “Sushrutha Samhitha”. This contains 184 Chapters, description of 1120 illnesses, 700 medicinal plants and 64 preparations from mineral sources as well as 57 preparations from animal sources (Dwivedi and Dwivedi, 2007).

The Chinese herbal history started with Shen Nong (Supernatural farmer), who lived about 4700 years ago (Chan, 1939). He studied the effect of several medicines, someday he was poisoned for 70 times and he used several plants as medicine to
detoxify and survived. The first book of Chinese herbal medicine “Shen Nong Ben Cao Jing” (Ben means root and Cao means shoot) was written about 2500 years after the death of Shen Nong, which recorded 365 medicines (252 plants, 67 animal and 46 mineral origin). Most of these medicines are still being used today with same name as used in ‘Shen Nong Ben Cao Jing’.

Another Chinese book on disease treatment, Huang Di Nei Jing’s “The Yellow Emperor’s Classic of Internal Medicine”, was written at about the same time as Shen Nong Ben Cao Jing. The book used Yin Yang and five elements theory to explain diseases. Other important book in Chinese herbal medicine is “Shang Han Lun-Discussion of cold induced diseases” which was written by Zhang Zhong-Jing around 1800 years ago. He devoted his life to study fever related diseases that killed many of his family members (Tayler, 1965).

An overview of traditional medicinal system

By definition, ‘traditional’ use of herbal medicines implies substantial historical use and this is certainly true for many products that are available as ‘traditional herbal medicines’. In many developing countries, a large proportion of the population relies on traditional practitioners and their armamentarium of medicinal plants in order to meet health care needs. Although modern medicine may exist with such traditional practice, herbal medicines have often maintained their popularity for historical and cultural reasons. Such products have become more widely available commercially, especially in developed countries.

According to the World Health Organization (WHO), traditional medicine refers to health practices, approaches, knowledge, and beliefs incorporating plant, animal, and mineral based medicines, spiritual therapies, manual techniques, and exercises, applied singularly or in combination, to diagnose and treat illnesses. If the material being used is of plant origin, then it is called traditional herbal medicine.

Various traditional medicines are widely applied in Asia, Africa, and Latin America to meet primary health-care needs. Traditional medicine has maintained its popularity in most regions of the developing world. The application is also rapidly spreading in industrialized countries, where adaptations of traditional medicines are often termed “complementary” or “alternative”. The term complementary and alternative medicine are used to refer to a broad set of healthcare practices that are not
part of country’s own tradition, or not integrated into the dominant healthcare system. Based on this broad definition it may be hard to find a region without some form of TCAM (Traditional Complementary and Alternative medicine) practice. As per the context in which it is practiced or the form of knowledge, often it is called in various ways such as traditional medicine, alternative medicine, complementary medicine, natural medicine, herbal medicine, phytomedicine, non-conventional medicine, indigenous medicine, folk medicine, ethno medicine etc. Chinese medicine, Ayurveda, Herbal medicine, Siddha, Unani, Kampo Jamu, Thai, Homeopathy, Acupuncture, Chiropractic, Osteopathy, bone-setting and spiritual therapies are some of the popular established systems.

In the United States, the National Institutes of Health (NIH) uses the name complementary and alternative medicine (CAM) to cover health systems, practices, and products that are not considered part of conventional medicine. For example, the medicinal herb, *Artemisia annua*, used in China for almost 2000 years has been found to be effective against malaria and could create a breakthrough in preventing almost one million deaths annually, most of them among children due to severe malaria. Over one-third of the population in developing countries lack access to essential medicines. The provision of safe and effective TM/CAM therapies could become an important tool to increase access to health care.

Among all the different traditional medicine systems followed worldwide, traditional Chinese medicine (TCM) is currently the most popular, followed by Indian medicine. In Western terminology, the name “Oriental medicine” covers Chinese, Japanese, and Korean medicines preferred by immigrants from Korea, while “Asian medicine” is often used to include TCM, Indian (Ayurveda), and Tibetan medicine. Among all treatment methods in traditional medicine systems, medicinal herbs are the most widely applied.

Medicine has been revolutionized in Europe by advances in chemistry, laboratory techniques and equipments since Robert Koch discovered the transmission of disease by bacteria, followed by the discovery of antibiotics in the early 1900. Thus modern medicine is commonly called Western medicine even though there are also traditional medicines in Western countries. It is also called conventional medicine. Other terms for Western medicine or conventional medicine include allopathy and allopathic medicine, mainstream medicine, orthodox medicine, regular medicine, and
biomedicine. Although conventional medicine is the mainstream medicine in Western countries, application of traditional medicine including herbal medicines is growing worldwide for many reasons, in particular, the side effects. The following data are provided by the WHO, (2007)

- In Africa, up to 80 percent of the population uses traditional medicine for primary health care.
- In China, traditional herbal preparations account for 30–50 percent of the total medicinal consumption.
- In Europe, North America, and other industrialized regions, over 50 percent of the population has used complementary or alternative medicine at least once.
- In Germany, 90 percent of the population has used a natural remedy at some point in their lives.

Since the last century, scientists from the fields of chemistry, biology, pharmacology, toxicology, and clinical trials have studied the herbal medicines. In addition to screening out new drug candidates, investigators also expect to explore the preventative and therapeutic mechanism of herbal medicines that play very important roles in most of the traditional medicine systems, such as TCM and Ayurveda medicine.

In this modern setting, ingredients are sometimes marketed for uses that were never contemplated in the traditional healing systems from which they emerged. An example is the use of ephedra for weight loss or athletic performance enhancement (Shaw, 1998). While in some countries, herbal medicines are subject to rigorous manufacturing standards, this is not so everywhere. In Germany, for example, where herbal products are sold as ‘phytomedicines’, they are subject to the same criteria for efficacy, safety and quality as are other drug products. In the USA, by contrast, most herbal products in the marketplace are marketed and regulated as dietary supplements, a product category that does not require prior approval of products on the basis of any of these criteria.

**Forms of Traditional Medical Knowledge**

In countries such as India, China and many other parts of Asia, one can observe traditional medical knowledge in various forms such as codified medical systems, folk systems, allied disciplines and new systems of knowledge.
1. Codified Medical Systems

These are also known as great traditions. Ayurveda, Siddha and Unani medical systems in Indian subcontinent or Traditional Chinese medicine and Acupuncture in China, have evolved in a historical period spanning over 3-4 millennia with their own unique worldviews, conceptual, theoretical frameworks and elaborate codified literature. For example, the oldest medical text of Ayurveda, Charaka samhita is estimated to be written in various versions from 1,500 BC to 200 AD. Such codified medical traditions have unique understanding of physiology, pathogenesis, pharmacology and pharmaceuticals, which is different from Western biomedicine (Unnikrishnan, 2009). These medical systems have been professionalized since last millennia and have been integrated into the national health programs.

Traditional Chinese medicine has been used by Chinese people from ancient times. More than half the population regularly uses traditional remedies, with the highest prevalence of use in rural areas. Although animal and mineral materials have been used, the primary source of remedies is plants. Of the more than 12,000 items used by traditional healers, about 500 are in common use (Li, 2000). Botanical products are used only after some kind of processing like stir-frying or soaking in vinegar or wine. In clinical practice, traditional diagnosis may be followed by the prescription of a complex and often individualized remedy. Many herbal remedies found their way from China into the Japanese systems of traditional healing. During ninth century, herbs native to Japan were classified in the first pharmacopoeia of ‘Japanese traditional medicine’ (Saito, 2000).

2. Folk Medicine

The folk knowledge traditions which are mostly orally transmitted, are more diverse, ecosystem and ethnic community specific with household level health practices (home remedies for primary health care, food recipes, rituals, customs), specialized healing traditions like bone setting, poison healers, birth attendants, veterinary healers, general healers etc. These are generated over centuries by communities and use components of ecosystems (plants, animal and mineral/metal derivatives) that are primarily locally available, easily accessible and often cost effective. It varies hugely based on social, ecological and historical circumstances.
Hence, countries with similar ecosystems are often found to nurture similar health practices indicating the strong linkages between environment and health.

Folk medicine is also known as indigenous medicine, ethno medicine, little traditions etc. In most countries where traditional medicine is not formalized, it largely remains in the non-codified folk knowledge form. Diversity, collective ownership guided by customary laws, adaptability to changing contexts and oral transmission are some of the prominent characteristics of this knowledge. Unlike common understanding, it is highly dynamic thus contemporary and not pertaining to a period in time. While knowledge generation and transmission might vary with cultures, there are several similarities in the value systems and modes of transmission of knowledge among communities. Often it is not recognized as valid knowledge by scientists as it is combined with beliefs and values.

3. Allied Forms of Health Knowledge

There are allied forms of health knowledge such as Yoga, Tai-chi, Qigong, Kalari, Judo seifuku, various forms of meditations, breathing techniques, and massage techniques, among many others which are related to well being. Though these are not purely medical systems, they have been adapted as health applications and contribute to health sector immensely.

4. New Forms of Alternative Health Knowledge

There is also new knowledge generated in the west and other developed countries with a mix of ancient and contemporary scientific knowledge such as phytomedicine, health supplements and macrobiotics among many others which are of relatively recent origin. There are other therapies such as reiki or shiatsu (the term and form as it is practiced today) which are of 20th century origin. Often some of these are also a blend of one or more of older medical knowledge systems. Some consider homeopathy and chiropractic systems not as traditional medical systems as they were developed in Europe post 18th century after the introduction of modern medicine (WHO, 2002). Many other new forms of TCAM therapies can be grouped under this category since some of the new forms of alternative health knowledge are often guided by modern knowledge issues related to their acceptance may be different.
Traditional medicine in India

The Indian Systems of Medicine and Homoeopathy (Ayurvedic, Yoga & Naturopathy, Unani, Siddha and Homeopathy i.e. AYUSH) cover both the systems which originated in India and abroad, but which got adopted in India in the course of time. In the past decade, there has been renewed attention and interest in the use of traditional medicine in India and globally. It is estimated that 65 percent of the population in rural India use Ayurveda and medicinal plants to meet primary health care needs (Satakopan, 1994). India has 15 agro-climatic zones, 47,000 plant species and 15,000 medicinal plants that include 7,000 plants used in Ayurveda, 700 in Unani medicine, 600 in Siddha medicine and 30 in modern medicine. This makes India one among 12 mega bio-diverse countries of the world. The Indian systems of medicine have identified 1,500 medicinal plants, of which 500 species are mostly used in preparation of drugs. More than 150 plant species have been categorized as endangered.

Use of plants in ayurvedic drugs

Ayurvedic medicines mainly based on plants enjoy a respective position today, especially in the developing countries, where modern health services are limited. Safe, effective and inexpensive indigenous remedies are gaining popularity among the people of both urban and rural areas especially in India and China. Information from ethnic groups or indigenous traditional medicines has played vital role in the discovery of novel products from plants as chemotherapeutic agents.

The Ayurvedic concept appeared and developed between 2500 and 500 BC in India. The literal meaning of Ayurveda is “Science of life” because ancient Indian system of health care focused views of man and his illness. It is pointed out that the positive health means metabolically well-balanced human beings. The practice of Ayurveda therapeutics consisted of 8 sections divided into 180 chapters and listed 314 plants, which are used as medicines in India (Subhose and Narain, 2005). Four thousand years ago, the medical knowledge of the Indian subcontinent was termed as Ayurveda.

Ayurveda remains an important system of medicine and drug therapy in India. Plant alkaloids are the primary active ingredients of Ayurvedic drugs. Today the
pharmacologically active ingredients of many Ayurvedic medicines are being identified and their usefulness in drug therapy being determined.

The Indian subcontinent is a vast repository of medicinal plants that are used in traditional medical treatments (Ballabh and Chaurasia, 2007). In India, around 15000 medicinal plants have been recorded (Dev, 1997); however traditional communities are using only 7,000-7,500 plants for curing different diseases (Perumalswamy and Ignacimuthu, 1998 and 2000 and Kamboj, 2000). The medicinal plants are listed in various indigenous systems such as Siddha (600 species), Ayurveda (700 species), Amchi (600 species), Unani (700 species) and Allopathy (30 species) for different ailments (Rabe and Staden, 1997). According to another estimate, around 17,000 species of medicinal plants have been recorded, out of which nearly 3,000 species are used in medicinal field (Nayar, 1987).

Chemical principles from natural sources have become much simpler and have contributed significantly to the development of new drugs from medicinal plants (Calixto, 2000). The valuable medicinal properties of different plants are due to presence of several constituents i.e. saponins, tannins, alkaloids, alkenyl phenols, glycol-alkaloids, flavonoids, sesquiterpenes, lactones, terpenoids and phorbol esters (Tiwari and Singh, 2004). Among them, some act as synergistic and enhance the bioactivity of other compounds.

Artemisinin produced by Artemisia annua plant is very effective against Plasmodium falciparum, P. vivax and also drug resistant parasites. The main active constituents of Artemisia annua are sesquiterpenoid lactone and endoperoxides named as artemisinin and artemisinic acid respectively. For more than a century, quinine, an alkaloid obtained from the bark of various species of cinchona trees, has been used in the treatment of Malaria and interestingly was one of the first agents used for the treatment of amoebic dysentery.

Reserpine isolated from raw plant extract of Rauvolfia serpentina is used as tranquilizer and in control of high blood pressure. From 2000 years, the powdered root of Rauvolfia serpentina has been used in treatment of mental illness in India. Although synthetic drugs are often used in the treatment of certain diseases, a remarkable interest and confidence on plant medicine is still continuing (Tiwari, 2008).
<table>
<thead>
<tr>
<th>No</th>
<th>Botanical name</th>
<th>Major components</th>
<th>Therapeutic uses</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td><em>Adhatoda vasaica</em> Nees</td>
<td>Vasicine, Total alkaloids</td>
<td>Anti-asthmatic, Bronchodilator, Cold remedy</td>
</tr>
<tr>
<td>2</td>
<td><em>Boswellia serrata</em> Roxb</td>
<td>Boswellic acid, Sennosides</td>
<td>Antiarithmetic, Antiinflammatory and laxative action</td>
</tr>
<tr>
<td>3</td>
<td><em>Capsicum annum</em> (L)</td>
<td>Capscicin</td>
<td>Pain reliever</td>
</tr>
<tr>
<td>4</td>
<td><em>Centella asiatica</em> Urb.</td>
<td>Total triterpenes</td>
<td>Skin, health and weight management</td>
</tr>
<tr>
<td>5</td>
<td><em>Coleus forskohlii</em> Briel Syn</td>
<td>Forskohlin</td>
<td>Antihypertensive, weight management</td>
</tr>
<tr>
<td>6</td>
<td><em>Curcuma longa</em> Linn.</td>
<td>Curcumin C3, Curcuminoinds</td>
<td>Antioxidant, anti-viral, anti-inflammatory, anticarcinogenic</td>
</tr>
<tr>
<td>7</td>
<td><em>Emblica officinalis</em> Gaertn.</td>
<td>Tannins</td>
<td>Detoxification, Rejuvenating agent</td>
</tr>
<tr>
<td>8</td>
<td><em>Garcinia cambogia</em> Desr.</td>
<td>(-) HCA (Ca)</td>
<td>Weight management</td>
</tr>
<tr>
<td>9</td>
<td><em>Garcinia indica</em> Choisy.</td>
<td>Citrin crystalline powder (-) HCA</td>
<td>Beverages, naturally Red in colour</td>
</tr>
<tr>
<td>10</td>
<td><em>Glycrrhiza glabra</em> Linn.</td>
<td>Glycorrhizinic acid &amp; Lutein</td>
<td>Eyesight, age related, Muscular degeneration</td>
</tr>
<tr>
<td>11</td>
<td><em>Camellia sinensis</em> (Linn.) Kuntze</td>
<td>Catechins, Caffeine</td>
<td>Antioxidant</td>
</tr>
<tr>
<td>12</td>
<td><em>Commiphora mukul</em> Engl.</td>
<td>Gulgulipid, Guggulsterones Z&amp;E</td>
<td>Cholesterol, Management</td>
</tr>
<tr>
<td>13</td>
<td><em>Momordica charantia</em> Linn.</td>
<td>Charantin</td>
<td>Antidiabetic</td>
</tr>
<tr>
<td>14</td>
<td><em>Mucuna pruriens</em> Baker</td>
<td>Catecholamines</td>
<td>Nerve tonic</td>
</tr>
<tr>
<td>15</td>
<td><em>Phyllanthus amarus</em> Linn.</td>
<td>Phyllanthine</td>
<td>Anti-hepatitis</td>
</tr>
<tr>
<td>16</td>
<td><em>Picrorhiza kurroa</em> Royle</td>
<td>Kutkin</td>
<td>Hepatoprotectant</td>
</tr>
<tr>
<td>17</td>
<td><em>Piper nigrum</em> Linn.</td>
<td>Piperine</td>
<td>Nutrient bio-availability Enhancer</td>
</tr>
<tr>
<td>18</td>
<td><em>Rubia cordifolia</em> Linn.</td>
<td>Concentration</td>
<td>Skin disorders</td>
</tr>
<tr>
<td>19</td>
<td><em>Sida cordifolia</em> Linn.</td>
<td>Ephedrine, Isoflavones</td>
<td>Bronchodilator, anti-carcinogenic</td>
</tr>
<tr>
<td>20</td>
<td><em>Terminalia arjuna</em> W. &amp; A.</td>
<td>Arjunolic acid</td>
<td>Revitalizing, blood circulation</td>
</tr>
<tr>
<td>21</td>
<td><em>Tinospora cordifolia</em> Miers</td>
<td>Bitter principles</td>
<td>Diuretic</td>
</tr>
<tr>
<td>22</td>
<td><em>Tribulus terrestris</em> Linn.</td>
<td>Steroidal saponins</td>
<td>Muscle building, Anabolic alternative</td>
</tr>
<tr>
<td>23</td>
<td><em>Ocimum sanctum</em> Linn.</td>
<td>Ursolic acid</td>
<td>Antidiabetic Stress management</td>
</tr>
<tr>
<td>24</td>
<td><em>Tylophora asthmatica</em> W &amp; A.</td>
<td>Total alkaloids</td>
<td>Anti-asthmatic</td>
</tr>
<tr>
<td>25</td>
<td><em>Withania somnifera</em> (Linn.) Dunal</td>
<td>Withanolides, alkaloids, withaferin</td>
<td>Herbal adaptogen</td>
</tr>
<tr>
<td>26</td>
<td><em>Zingiber officinale</em> (Willd.) Rosc.</td>
<td>Gingerols</td>
<td>Digestive aid, Ginger soft extract</td>
</tr>
</tbody>
</table>
Indian Vedas describe the widespread use of herbal products and aqueous extract of different plant parts for curing different diseases. Roots are the extensively used plant part (30%) in Ayurvedic medicine (Ved et al. 1998). The pharmacological properties of some Ayurvedic crude drugs in support for their therapeutic claims are listed in Table 1.1

**Global market of herbal medicine**

Several important modern drugs are extracted directly from plants. It has been estimated that only 6 percent of all described species have been analysed chemically and only a small fraction analysed pharmacologically (Choudhary, 2002). In USA, the process of synthetic drug discovery and development takes an average of 12 years, and any new drug requires the investment of an average of US$ 230 million. It is seen that plant based drugs take a comparatively much less time and expenses than synthetic drugs. Hence plant based medicines would be cheaper, unless the market price are inflated by other considerations (Ramakrishnappa, 2002).

Currently even the developed countries are relying upon the herbal drugs and remedies and hence the demand for plant-derived products has increased worldwide. The demand is estimated to grow in the years to come fuelled by the growth of sales of herbal supplements and remedies according to several surveys. This means that scientists, doctors and pharmaceutical companies will be looking at countries like China, India *etc* for their requirements, as they have the most number of medicinal plant species and are the top exporters of medicinal plants. Out of around 4,22,000 plant species available worldwide, around 52,885 species are believed to be of medicinal importance (Table 1.2). China and India are the major repositories of these medicinal plants.

The value of medicinal plants as a source of foreign exchange for developing countries depends on the use of plants as raw materials in the pharmaceutical industry. It provides numerous opportunities for developing nations to advance rural well being. Export statistics available between 1992 and 1995 indicate that India exported about 32,600 tonnes of crude drugs valued at $US 46 million (Dhar *et al*. 2002).
Table 1.2. Countrywise use of medicinal plants (Schippmann et al. 2002).

<table>
<thead>
<tr>
<th>Country</th>
<th>Plants species (No)</th>
<th>Medicinal species (No)</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>China</td>
<td>26,092</td>
<td>4,941</td>
<td>18.9</td>
</tr>
<tr>
<td>India</td>
<td>15,000</td>
<td>3,000</td>
<td>20.0</td>
</tr>
<tr>
<td>Indonesia</td>
<td>22,500</td>
<td>1000</td>
<td>4.4</td>
</tr>
<tr>
<td>Malaysia</td>
<td>15,500</td>
<td>1,200</td>
<td>7.7</td>
</tr>
<tr>
<td>Nepal</td>
<td>6,973</td>
<td>700</td>
<td>10.0</td>
</tr>
<tr>
<td>Pakistan</td>
<td>4,950</td>
<td>300</td>
<td>6.1</td>
</tr>
<tr>
<td>Philippines</td>
<td>8,931</td>
<td>850</td>
<td>9.5</td>
</tr>
<tr>
<td>Sri Lanka</td>
<td>3,314</td>
<td>550</td>
<td>16.6</td>
</tr>
<tr>
<td>Thailand</td>
<td>11,625</td>
<td>1,800</td>
<td>15.5</td>
</tr>
<tr>
<td>USA</td>
<td>21,641</td>
<td>2,564</td>
<td>11.8</td>
</tr>
<tr>
<td>Vietnam</td>
<td>10,500</td>
<td>1,800</td>
<td>17.1</td>
</tr>
<tr>
<td>Average</td>
<td>13,366</td>
<td>1,700</td>
<td>12.5</td>
</tr>
<tr>
<td>World</td>
<td>422,000</td>
<td>52,885</td>
<td></td>
</tr>
</tbody>
</table>

China with exports of over 120,000 tons per annum (US$ 264.5 million) and India with over 32,000 tons per annum dominate the international market. The annual export of medicinal plants from India is valued at Rs. 1200 million (Ramakrishnappa, 2002).

The global market for herbal medicines currently stands at over $60 billion annually. The sale of herbal medicines is expected to get higher at 6.4 percent average annual growth rate (Inamdar et al. 2008). Due to the contribution of numerous significant factors, the market of herbal medicines has grown at an expressive rate worldwide. Some of them are: preference of consumers for natural therapies; concern regarding undesirable side effects of modern medicines and the belief that herbal drugs are free from side effects, since millions of people all over the world have been using herbal medicines for thousands of years; great interest in alternative medicines; preference of populations for preventive medicine due to increasing population age; the belief that herbal medicines might be of effective benefit in the treatment of certain diseases where conventional therapies and medicines have proven to be inadequate; tendency towards self-medication; improvement in quality, proof of efficacy and safety of herbal medicines and high cost of synthetic medicines (Calixto, 2000).

According to World Health Organization, herbal medicines are lucrative globally and they represent a market value of about US$ 43 billion a year (Christie,
According to an estimate in 1991, the herbal medicine market in the European countries was about $6 billion, with Germany accounting for $3 billion, France $1.6 billion and Italy $0.6 billion while in other countries was 0.8 billion. In 1996, the herbal medicine market in the European countries was about $10 billion, in USA about $4 million, in India about $1.0 billion and in other countries was $5.0 billion (Prajapati et al. 2003). In 1997, the European market alone reached about $7.0 billion. The German market corresponds to about 50 percent of the European market *i.e.* about $3.5 billion. This market is followed by France-$1.8 billion; Italy-$700 million; the United Kingdom-$400 million; Spain-$300 million and the Netherlands about $100 million (Calixto, 2000).

**Indian herbal market**

The importance of medicinal plants in the national economy and their potential for the rapid growth of herbal products, perfumery and allied industry in India has been emphasized from time to time (Kokate et al. 2005). New trends are emerging in the standardization of herbal raw materials whereby it is carried out to reflect the total content of phytoconstituents like polyphenols, which can be correlated with biological activity (Sapna and Ravi, 2007). The major traditional sector pharmas, namely Himalaya, Zandu, Dabur, Hamdard, Maharishi *etc.* are standardizing their herbal formulations by Chromatography techniques like TLC/ HPTLC finger printing *etc.* (Borris, 1996).

India has 2.4 percent of world’s area with 8 percent of global biodiversity. It is one of the 12 mega-diversity hot-spot regions of the world, other countries being Brazil, Colombia, China, South Africa, Mexico, Venezuela, Indonesia, Ecuador, Peru, USA and Bolivia. Across the country, the forests of India are estimated to harbour 90 percent of India’s medicinal plants diversity in the wide range of forest types that occur. Only about 10 percent of the known medicinal plants of India are restricted to non-forest habitats. The estimated numbers of plant species and those used for medicinal purpose vary. According to Schippmann *et al.* (2002), one fifth of all the plants found in India are used for medicinal purpose. The world average stands at 12.5 percent while India has 20 percent plant species of medicinal value and which are in use. But according to Hamilton (2003), India has about 44 percent of flora, which is used medicinally. Although it is difficult to estimate the number of medicinal and
aromatic plants present worldwide, the fact remains true that India with rich biodiversity ranks first in percent flora, which contain active medicinal ingredient.

There are over 1.5 million practitioners of traditional medicinal system using medicinal plants in preventive, promotional and curative applications. It is estimated that there are about 8000 medicinal drug-manufacturing units in India (Ramakrishnappa, 2002). The market for ayurvedic medicines is estimated to be expanding at 20 percent annually. Sales of medicinal plants have grown by nearly 25 percent in India in past ten years (1987-96), the highest rate of growth in the world (Masood, 1997). But the per capita expenditure in India on medicines per annum is amongst the lowest in the world.

The annual turnover of the Indian herbal medicinal industry is about Rs. 2,300 crore as against the pharmaceutical industry’s turnover of Rs. 14,500 crore with a growth rate of 15 percent (Krishnan, 1998). The export of medicinal plants and herbs from India has been quite substantial in the last few years. India is the second largest producer of castor seeds in the world, producing about 1,25,000 tonnes per annum. The major pharmaceuticals exported from India in the recent years are isabgol, opium alkaloids, senna derivatives, vinca extract, cinchona alkaloids, ipecac root alkaloids, solasodine, Diosgenine, menthol, gudmar herb, mehdileaves, papian, rauvolfia, guar gum, Jasmine oil, agar wood oil, sandal wood oil etc. (Kokate, 2005). The turnover of herbal medicines in India as over-the-counter products, ethical and classical formulations and home remedies of traditional systems of medicine is about $ one billion and export of herbal crude extract is about $ 80 million (Kamboj, 2000).

All the major herbal-based pharmaceutical companies are showing a constant growth of about 15 percent or more, next only to Information Technology industry (Kumar, 2000). The turnover of herbal medicines in India as ethical, classical formulations and home remedies of Ayurveda, Unani, and Siddha systems of medicine is about US$1 billion with a meagre export of about US$ 80 million (Kamboj, 2000).

**NEED OF STANDARDIZATION**

While centuries of use in traditional settings can be used as testimony that a particular herbal ingredient is effective or safe, several problems must be addressed as these ingredients are incorporated into modern practice. One problem is that
INGREDIENTS once used for symptomatic management in traditional healing are now used in developed countries as part of health promotion or disease prevention strategies; thus, acute treatment has been replaced by chronic exposure (e.g. herbal products used for weight loss, Allison et al. 2001). This means that a statement about ‘thousands of years of evidence that a product is safe’ may not be valid for the way the product is now being used. This does not mean that an ingredient is unsafe, but it does mean that safety in the modern context cannot be assumed.

A second problem is that efficacy and effectiveness have rarely been demonstrated using modern scientific investigations. An evidence-based approach to this issue has only recently been implemented, and the results reveal that for most herbal products, considerable gaps in knowledge need to be remedied before one can be convinced about their efficacy.

Current policy in herbal medicine is that, every herbal formulation must be standardized as per WHO guidelines (WHO, 2008). The objective of WHO guidelines is to define basic criteria for the evaluation of quality, safety and efficacy of drugs herbal medicines (Phillipsion, 1989). To be a global supplier of herbal medicines conforming to international specification, the following aspects are still demanding the attention:

- Proper botanical identification of all medicinal plants in Indian System of Medicine. All herbal ingredients in preparation to be specified by their botanical names besides their popular/common names.
- Processing of medicinal plants in a scientific, economic and safe way using similar ones used for modern drugs.
- Isolation and chemical characterization of acute ingredients including inorganic constituents, wherever possible.
- Pharmacological and clinical studies to ascertain their efficacy and safety.
- Standardization to ensure uniformity. The use of medicinal plants in combination to be limited to facilitate analysis and to apply quality control and standardization parameters to herbal drug preparations.
- Documentation of research.
Conservation of Medicinal Plants

India has been identified as one of the top twelve mega bio-diversity centres of the world. This is because India has a vast area with wide variation in climate, soil, altitude and latitude. India with its biggest repository of medicinal plants in the world may maintain an important position in the production of raw materials either directly for crude drugs or as the bioactive compounds in the formulation of pharmaceuticals, cosmetics etc. Medicinal plant based drug industries are progressing very fast in India but associated with a number of problems. Most alarming problem the industry has started facing and will face in future is the demanding supply of plant material from natural resources. A national policy on medicinal plants with a view to pressure endangered species and promoting cultivation of plants which are being extensively used by industry will help in solving the major problem of the industry.

Many of the ancestor plants are highly endangered and urgently need to be maintained in their native habitats. Unless we preserve genetic material for propagation from these species now, many will be extinct before we can protect and restore habitats for their long term recovery. Surveying, monitoring and collecting material for propagation from populations of these species are the primary activities of individual. The viable plant material, living plant collections and long term seed storage can be preserved in order to maximize their potential for future use in our restoration efforts. To ensure accurate accession records, especially necessary for future restoration work, collection of highly accurate GPS location data for individual plants and populations is essential, as is creation of high quality species distribution and survey maps.

The global craving for more herbal ingredients creates possibilities for the local cultivation of medicinal crops as well as for the regulated and sustainable harvest of wild. The expanding trade in medicinal plants has serious implications on the survival of several plants species, with many under serious threat to become extinct. According to an all India ethnobiological survey carried out by the Ministry of Environment and Forests, Government of India, out of 8000 species of plants being used, 90-95 percent collection of Medicinal plants is from the forests (wild-collected) and few are cultivated. The biodiversity loss is not only a threat to ecology of the planet but also a more immediate threat to the livelihood security of rural communities. Data on threatened species are rare but national studies show 120
medicinal plants are rare or endangered in India. Open access to medicinal plants in the wild is perhaps one of the main reasons for the current unsustainable levels of harvesting. As the prices paid to the gatherers tend to be very low, commercial plant gatherers often ‘mine’ the natural resources rather than manage them, as their main objective is to generate an income resulting in destructive harvesting (Sandhya, 2004).

Other factors contributing to non-sustainability include lack of sufficient data on wild plant populations, marketing, and trading; inadequate regulations and legal protection (including intellectual property rights for local practitioners with local knowledge); and poor access to appropriate technology for sound harvesting and plantation development. Interaction between social, economic and ecological systems is most essential to conserve the medicinal plants making its sustainable use. A need-based research is essential for screening of plants for biological activity and focus on environmental and bio-diversity conservation aspects of forests, which continue to be primary habitats of medicinal plants. Training to the collectors and growers proves very useful in improving the quality of the material and plummeting the wastage. There is an urgency to have clearly defined policies to regulate medicinal plant conservation, cultivation quality control standards, processing and preservation, marketing and trade including domestic and export, and a well-coordinated information network effort.

Little or no attention is paid in India to the socio-economic and conservation of medicinal plant resources, probably due to the relatively small volumes involved and the specialist nature of the informal trade in them. Conservation is essential to retain the natural balance, diversity and evolutionary changes in the environment. Conservation is a protective measure taken

- to prevent the loss of genetic diversity of a species
- to save a species from extinction
- to protect an ecosystem from damage

**HCA (Hydroxycitric Acid) and its role in obesity management**

Obesity is emerging as a major global problem and is becoming an important contributor of chronic disease and disability. Currently more than one billion adults are overweight worldwide and at least 300 million of them are clinically obese (WHO, 2009). A person is defined as overweight if his body mass index (BMI) is
more than 25 Kg/m² and said to be obese if it exceeds 30 Kg/m². Obesity may lead to type-2 diabetes, cardiovascular disease, hypertension and stroke, and certain forms of cancer. In the recent days, losing weight has become a modern-day obsession. Regardless of the personal reasons to lose weight, there is a need for wider concern about obesity and being overweight.

Without adequate prevention and treatment of obesity, government agencies have suggested that the direct and indirect costs associated with obesity may be of concern to the healthcare system (Joyal, 2004). Obesity places an enormous financial burden on the health service, with the direct costs being at least £500 million per year (NAO, 2001). The cost of obesity related healthcare varies with the degree of obesity. Overall, the healthcare costs for a person whose BMI is >40 kg/m² are double those of a person of normal weight (Andrereya et al. 2004).

Many diets have been proposed to induce weight loss. For those unable to stick to a diet, there are several pharmacological active compounds that promote weight loss. For example, sibutramine blocks the re-uptake of serotonin and norepinephrine, regulating the sense of fullness, and these results in reduced food intake (Callins, 2006). Orlistat is an inhibitor of gastrointestinal lipases. It acts in the lumen of the stomach and small intestine by forming a covalent bond with the active serine residue sites of gastric and pancreatic lipases. Thus, the inactivated enzymes are unavailable to hydrolyse dietary fat (i.e. triglycerides) into absorbable free fatty acids and monoglycerides, which may have a positive effect on weight control. However, many other compounds that induce weight loss are illegal (amphetamines), dangerous (fenfluramine, ephedra), addictive (phentermine, clobenzorex), experimental (opioid antagonists, amylin) or are indicated for other conditions (fluoxetine [Prozac]-an antidepressant) (Callins, 2006).

Few detailed studies on the safety or efficacy of other potentially useful compounds are available. One of the better-studied compounds is hydroxycitric acid (HCA), the laevorotatory optical isomer (L-hydroxycitric acid or [-]-hydroxycitric acid) of which has been discussed as a potentially safe and effective pharmacological intervention for obesity for at least 30 years (Bray and Greenway, 1976).
**Hydroxycitric acid**

Hydroxycitric acid is found to be one of the active components in various weight-loss formulations and appetite-suppressor products. It is obtained from the rind of the fruits of *Garcinia indica* and *Garcinia cambogia*. After harvesting and drying, the rind contains up to 30 percent by weight of HCA. Hydroxycitric acid is an extremely popular dietary supplement. Between March 2000 and September 2003, 225 tonnes of HCA, *G. cambogia* and *G. cambogia* extract were imported into the United States (NCI extract, 2006).

The organic acids present in the fruit rinds of the two species were misidentified earlier as tartaric acid and citric acid (Kuriyan and Pandya, 1931). Later Lewis and Neelakantan (1965) isolated the principal acid and identified it as (-)-HCA on the basis of chemical and spectroscopic studies. The isolated HCA is unstable leading to the formation of (-) Hydroxy citric acid lactones (HCAL). The sour taste components are due to HCA (Lewis and Neelakantan, 1965). Hydroxycitric acid (1,2 dihydroxy propane-1,2,3-tricarboxylic acid) has two asymmetric centres, hence four different isomers are possible (Fig.1.1). Martius and Maue (1943) have synthesized the four possible stereo-isomers and one of these occurs in *Garcinia* (I) and another in *Hibiscus* sp. (II).

**Properties of (-)-HCA and Lactones**

The physical properties of (-)-HCA and lactones of *Garcinia* is presented in Table 1.3 (Lewis and Neelakantan, 1965). The equivalent weight of pure lactones is 69. The structure of the (-)-HCA lactones was further established by IR and HNMR spectroscopy. The (-)-HCA lactones displayed strong IR bands at 3200,1760 and 1680 cm\(^{-1}\). HNMR spectra of the lactones showed two protons at the $\gamma$-carbon, which give an AB quartet at $\delta$ 2.53 and $\delta$ 2.74 with $J=17.1$ HZ, and one proton at the $\alpha$-carbon showing a singlet at $\delta$ 5.15 (Jayaprakasha and Sakariah, 2000).
Fig 1.1: Four different isomeric forms of (-)-Hydroxycitric acid and their Lactones
Table 1.3. Physical properties of (-)-HCA and lactones from *Garcinia*

<table>
<thead>
<tr>
<th>Property</th>
<th><em>Garcinia</em></th>
</tr>
</thead>
<tbody>
<tr>
<td>Melting point (°C)</td>
<td>178</td>
</tr>
<tr>
<td>Crystal shape</td>
<td>Needles</td>
</tr>
<tr>
<td>Hygroscopicity</td>
<td>Slight</td>
</tr>
<tr>
<td>Solubility</td>
<td>High in alcohol &amp; water: fair in ether</td>
</tr>
<tr>
<td>Paper chromatography (R_f)</td>
<td></td>
</tr>
<tr>
<td>Butanol/formic acid / H₂O</td>
<td>0.24</td>
</tr>
<tr>
<td>Propanol/acetic acid / H₂O</td>
<td>0.26</td>
</tr>
<tr>
<td>Metavandate spray (5%)</td>
<td>Yellow</td>
</tr>
<tr>
<td></td>
<td>Reddish orange</td>
</tr>
</tbody>
</table>

Biochemistry of (-)-HCA

Hydroxycitric acid has several proposed actions that may be useful in promoting weight loss, including inhibition of fatty acid synthesis, appetite suppression and the increase of thermogenesis/fat oxidation.

Inhibiting fatty acid synthesis

Hydroxycitric acid is a potent competitive, reversible inhibitor of ATP-citrate lyase (also known as ATP citrate synthase, citrate cleavage enzyme) *in vitro*, and an inhibitor of fatty acid synthesis in rat liver *in vivo* (Watson *et al.* 1969 and Lowenstein, 1971). ATP citrate lyase is a cytosolic enzyme required for the synthesis of fatty acids and catalyses the following reaction:

\[
\text{Citrate} + \text{CoA} + \text{ATP} \rightarrow \text{oxaloacetate} + \text{acyetyl-CoA} + \text{ADP} + \text{phosphate}
\]

Acetyl-CoA is the basic building block of fatty acids. It is produced by oxidation of glucose obtained from carbohydrates in the diet *via* the tricarboxylic acid (TCA) cycle or by oxidation of fatty acids. Both activities take place in the mitochondria and cytoplasm. Acetyl-CoA is ultimately derived from citrate exported across the mitochondrial membrane. Inhibiting production of acetyl-CoA would also be expected to deplete the concentrations of subsequent metabolites in the fatty acid synthetic pathway. The second metabolite in the pathway, formed from acetyl-CoA, is malonyl-CoA. This is an inhibitor of the enzyme carnitine acetyl transferase, which is needed for the oxidation of fat. Therefore, it is proposed that reducing malonyl-CoA formation with HCA might stimulate fat metabolism.
Numerous animal studies have demonstrated that HCA can reduce weight gain and that inhibiting fat synthesis is the likely mechanism for the observed effect.

**Appetite suppression**

Regulation of appetite is a complex process that is not fully understood. It consists of both central and peripheral elements and involves the integration of a variety of signals by the brain from peripheral organs transmitted through neurotransmitters, peptides, hormones and metabolites (Sullivan and Green, 1985). Most anorectic drugs act by central mechanisms and have many disadvantages that include limited effectiveness, side effects on the central nervous system, development of tolerance, abuse potential, and rebound hyperphagia (over-eating) on discontinuation of treatment.

Several appetite-modulating agents have been tested in animals that act by peripheral mechanisms and do not produce tolerance or rebound hyperphagia, which suggests that peripherally acting anorectic drugs may provide new therapeutic approaches to disorders of appetite regulation in humans. A patent for the use of HCA as an appetite suppressant and an inducer of weight loss was issued in 1998.

**Thermogenesis**

Thermogenesis is the metabolism of fat or other compounds to produce heat rather than metabolic energy in the form of ATP. Thermogenesis occurs in specialised fatty tissue known as brown adipose tissue (brown fat). However, it is unclear how HCA exerts any stimulatory effect on brown fat (Wheeler, 2006). Proposed mechanisms have not been validated and detailed metabolic studies on this interesting hypothesis have not been conducted.

In the present study, the two species of *Garcinia* have been selected which have proven to contain significant content of hydroxycitric acid.

**Garcinia species**

*Garcinia* is an economically important genus belonging to the family Clusiaceae (Guttiferae), tribe *Garcinieae* consisting of about 400 species. These species are distributed in tropical Asia, Africa and Polynesia. Around thirty species occur in India distributed in Andaman Islands, North East Hill region, West Bengal,
Orissa, Bihar, Western Ghats covering Maharashtra, Goa, Karnataka and Nilgiri hills (Rema and Krishnamurthy, 2000).

Some of the important species are (Akhtar Hussain, 1992)

3. *Garcinia mangostana* L. (Mangosteen, Dodol)
4. *Garcinia Morella* (Gaertn.) Desr.: Syn; *Garcinia pictoria* Roxb.
5. *Garcinia xanthochymus* HK.f.ex. T. And.: Syn: *Garcinia tinctoria*-the egg tree.

*Garcinia indica* (Thouars) Choisy: Syn. Kokum

**Morphology and Distribution**

*Garcinia indica* (Thouars) Choisy (2n=54) is a moderate dioecious evergreen tree with spreading or drooping branches. It is seen throughout the Western Ghats in evergreen and lower shola forests up to 1800 m. It is a crop of oriental origin preferring warm and moderately humid tropical climate with a total rainfall range of 2500-5000 mm (Chandran, 1996).

Bark is dark brown and smooth, young twigs are cylindrical with four elevated glabrous lines. Leaves are opposite on long petioles, blade oblong-lanceolate or oblong-oval, 2-4 inches long, obtuse or acute at the apex, tapering at the base. This reddish young leaves turn bright green later. Flowers are small, unisexual, sub-dieious. The staminate flowers are on short glabrous pedicels arranged in threes at the end of branchlets. The pistillate flowers are sessile, solitary or in a bunch of 2-3 in the leaf axils. Male flowers have four round sepals, four petals twice the length of sepals, numerous stamens and filaments are fused. Ovoid anthers, two celled and dehisce longitudinally. Female or sub-bisexual flowers have petals and sepals similar to that of male flower, androecium represented by 4 groups opposite to the sepals, small stamens in one or two rows about the length of the ovary. Ovary is globular, 2-12 loculed, fleshy and smooth with large, spreading and papillose stigma. Fruit is as
the size of a small orange with persistent calyx, dull red or red in color, depression at the apex. Pericarp is thick and soft, indehiscent, entirely filled with a firm juicy dark purplish-red pulp. Seeds are 5-8 in number, large, oblong, and enclosed in a pulpy axils. There is a mention of white variety which is not subjected to detailed study (CSIR The wealth of India, 1956). The flowers appear between November-December and the fruit ripens in hot season i.e. April to June (Chandran, 1996) (Fig 1.2 a and b).

**Traditional Uses**

*Garcinia indica* is a potential oilseed tree and is traditionally used as an acidulant in Karnataka, Kerala and Maharashtra. The fruit has sweetish acid taste and used as a garnish to give an acid flavor to curries. Fruit is used to prepare cooling syrup and juice. The soup prepared out of dried rinds, called ‘Solkadi’, spiced and sweetened to serve in marriage feast and functions in Uttara Kannada District. It is considered to promote digestion, stabilize liver function and also used to prepare pickles (NOVODB, 2009).

The kokum fruit is antihelminthic, cardio tonic and is used in treatment of piles, dysentery, tumours, pains and heart complaints. The seeds contain 23-26 percent oil; remain solid at room temperature and yields valuable edible oil known as ‘Kokum butter’. It is suitable to use as confectionary butter. The butter is nutritive, demulcent, astringent and emollient. It is used in ointments, suppositories and other pharmaceutical preparations, soaps and candle making. It is used for local application to ulcerations and fissures of lips, hand etc. The cake is used as manure. Kokum butter is preferred over cocoa as an intensive skin moisturizer as it has soothing and healing properties. It is useful in treating mouth sores, relieving joint pain and correcting digestion imbalance (NOVODB, 2009). Many value added products are prepared out of fruit juice and rind.

**Phytochemistry**

The fruit rind is a rich source of Garcinol, Isogarcinol and (-)-hydroxycitric acid-an anti-obesity compound. Kokum rind is a natural colorant for acid foods (Nawale et al.1997).
Morphological variability

Abundant variation in natural spread population of Kokum was reported with respect to tree form, tree height, fruit size and yield (Korikantimath and Desai, 2005) and anthocyanin pigmentation (Joshi et al. 2004).

Pharmacological properties

_Garcinia indica_ fruit rind extract has exhibited the antimicrobial and cytotoxic effect on mouse fibroblasts. _G. indica_ extract has both antifungal and antibacterial properties and has a potential for use as a bio-preservative in food applications and therapeutic agent in cancer treatment (Varalakshmi et al. 2010).

Garcinol present in the fruit rind (Kirshnamurthy et al. 1981) has anti-oxidant property (Sang et al. 2002) and is a glycation inhibitor (Yamaguchi et al. 2000). HCA has been reported to reduce cholesterol synthesis, food consumption and weight gain (Greenwood and Robinson, 1999 and McCarty, 1994).


It is distributed throughout the Western Ghats in evergreen and lower shola forests of Western Ghats from Coorg to Travancore. In Kerala, it is very popular in Central Travancore and Kerala seems to be one of the centres of origin where maximum diversity is seen (Muthulakshmi et al. 1999). It is a medium sized evergreen diecious tree with rounded crown and horizontal or drooping branches generally attaining to a height of 18 m. The bark is almost black and rough, wood is moderately hard, pale grey, uniform and close grained. Leaves are 5-12 cm X 2.5-5 cm, dark green and shining above, yellow beneath and narrowed to base. The flowers are yellowish white and fleshy. Staminate flowers are 4 to 12 in number, smaller in size found in axils of withered leaves. Pistillate or dioecious flowers are larger in size, one to three together from axils of terminal leaves. Fruits are sub-globose berries, four lobed, fleshy, deeply 8-10 grooved and sour taste. Fruits are yellow to light red colour with tough rind and with six to eight seeds (Thomas, 1965). The fruit may vary in size weighing 50-180 g (Fig 1.3).

It flowers in February-March and the fruits are harvested in July-August. Fruits are eaten raw, seeds are about eight to nine in number and juice is pale yellow colour which serves as a raw material for varnish.
The species is categorized as ‘near threatened globally’. As per the IUCN classification, it is in the ‘endangered’ category (Myers et al. 1988 and 1990, Koen Kusters and Brian Belcher, 2004).

**Traditional Uses**

The fruits of *Garcinia gummi-gutta* have excellent therapeutic value and the dried rind is a popular fruit spice used in curries in place of tamarind or lime (Lewis et al. 1964) and hence it is commonly termed as ‘Malabar tamarind’. The fruits are rich in non-volatile acids. Decoction made from ripe fruits and the seed is given for rheumatism and bowel complaints. In cattle, it is used as a wash for mouth diseases. The dried rind has excellent therapeutic value against obesity. It is used to treat respiratory infections such as sore throat and cough (Oluyemi et al. 2007).

**Phytochemistry**

The dried rind of *Garcinia gummi-gutta* which is of commercial value contains citric acid, tartaric acid, phosphoric acid and reducing sugars (Kennedy et al. 1999). Leaf extract of *Garcinia gummi-gutta* found to contain alkaoloid, terpenoid, steroid, catechin and Phenol, which in turn responsible for anti-bacterial activity (Maridass et al. 2010) while stem bark collected from Nigeria found to contain tannins, phlobatannins, flavonoids, cardiac glycosides and alkaloids (Kagbo, 2010).

**Pharmacological Studies**

Leaf extracts of *Garcinia gummi-gutta* have shown significant antibacterial activity (Maridass et al. 2010). Methanol extract of the fruits in selective in vivo model system using Wister albino rats proved that there was a significant improvement of antioxidant enzyme levels and the efficacy was found to be dose dependent (Selvam et al. 2011). Oral administration of (-)-hydroxycitrate depressed significantly the weight, body lipid, and appetite in in-vivo lipogenic rats (Sullivan et al. 1974).

It is evident from the foregoing account that the plants are used for treating several diseases and particularly of special significance in anti obese management studies. In view of the increasing dependence on plants as a source of natural oxidants, pharmaceuticals and anti-obesity safe drugs, the two *Garcinia* species viz. *Garcinia*
indica (red) and Garcinia gummi-gutta were selected for the present study. Garcinia indica which are found naturally growing and cultivated in some homesteads, the available type was with pedicellate flowers and bigger sized red to dark red fruits yielding red colour juice. But in literature, there is a mention of white type which is believed to have better medicinal values. Therefore present study also explores the White type of Garcinia indica along with differentiating characters from that of normally existing red type. As these two species are over-exploited, a thorough study envisaging their morphometric traits is of paramount importance for the conservation in their natural habitat, which was not systematically analysed in earlier studies. In this context, the present investigation was undertaken with the following objectives

- Morphometric evaluation of elite trees of Garcinia indica (Thouars) Choisy and Garcinia gummi-gutta (L) Robson in two ranges of Western Ghats namely Agumbe and Nagara range

- Identifying the female trees of Garcinia indica and Garcinia gummi-gutta

- Qualitative analysis for phytoconstituents in leaves and bark of the two species

- Quantitative estimation of Protein and HCA (Hydroxycitric acid) content in fruits

- To assess the therapeutic properties of leaf extracts namely antioxidant activity, wound healing and antimicrobial activities

- Molecular characterization of elite lines of two species by RAPD analysis
Fig 1.2 a *Garcinia indica* tree, leaves and fruits
Fig 1.2 (a) White Kokum (Garcinia indica White) and (b) Red Kokum (Garcinia indica Red)

Fig 1.2 b  *Garcinia indica* flower

Tree

Leaves

Fig 1.3 *Garcinia gummi-gutta* tree, leaves, flowers and fruits

Flowers

Fruits