I. INTRODUCTION
INTRODUCTION

From the moment man evolved on earth, plants which had evolved before humans played an indispensable role in his struggle to survive. Dependency of living beings for food, clothing and shelter, have made plants a rich source for existence of life and have played a vital role in sustaining life on earth without which the earth would have been a barren and lifeless world of deserts (Anonymous, 1975). Medicinal plants, since times immemorial, have been used in virtually all cultures as a source of medicine. The widespread use of herbal remedies and healthcare preparations, as those described in ancient texts such as the Vedas and the Bible, and obtained from commonly used traditional herbs and medicinal plants, has been traced to the occurrence of natural products with medicinal properties (Lucy and Edgar, 1999). Since last few decades continuous efforts are being made to improve medicinal plants or produce their products in high amounts through various technologies. Such attempts resulted in the identification of about 2,00,000 natural products of plant origin and many more are being identified from higher plants and microorganisms. Some plant-based drugs have been used for centuries and there is no alternative medicine for many drugs, such as cardiac glycosides (Ramawat, 2008c).

The use of traditional medicine and medicinal plants in most developing countries, as a normative basis for the maintenance of good health, has been widely observed. Furthermore, an increasing reliance on the use of medicinal plants in the industrialized societies has been traced to the extraction and development of several drugs and chemotherapeutics from these plants as well as from traditionally used rural herbal remedies (UNESCO, 1998). Moreover, in these societies, herbal remedies have become more popular in the treatment of minor ailments, and also on account of the increasing costs of personal health maintenance. Indeed, the market and public demand has been so great that there is a great risk that many medicinal plants today, face either extinction or loss of genetic diversity (Lucy and
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Edgar, 1999). Further, interest in medicinal plants as a re-emerging health aid has been fuelled by the rising costs of prescription drugs in the maintenance of personal health and well-being, and the bioprospecting of new plant-derived drugs. Based on current research and financial investments, medicinal plants will, seemingly, continue to play an important role as a health aid.

The Role of Plants in Human History

Medicine, in several developing countries, using local traditions and beliefs, is still the mainstay of health care. As defined by WHO (2006), health is a state of complete physical, mental, and social well being and not merely the absence of disease or infirmity. Herbalism is a traditional medicinal or folk medicine practice based on the use of plants and plant extracts. Herbalism is also known as botanical medicine, medical herbalism, herbal medicine, herbology, phytomedicine and phytotherapy (Acharya, 2008).

People on all continents have used hundreds to thousands of indigenous plants for treatment of ailments since prehistoric times. There are evidences that suggest that Neanderthals, living 60,000 years ago in present day Iraq used *Althea rosea* which is still in ethnomedical use around the world today. The practice of organized herbal medicine dates back to the earliest periods of known human history (Nudrat and Usha, 2004). The first generally accepted use of plants as healing agents was depicted in the cave paintings discovered in the Lascaux caves in France, which have been radiocarbon-dated to 13,000-25,000 B.C. Medicinal herbs were found in the personal effects of an "ice man", whose body was frozen in the Swiss Alps for more than 5300 years. These herbs appear to have been used to treat the parasites found in his intestines.

Ancient Egyptian medicine of 1000 B.C. are known to have used garlic, opium, castor oil, coriander, mint, indigo, and other herbs for medicine
and the Old Testament also mentions herb use and cultivation, including mandrake, vetch, caraway, wheat, barley, and rye. Indian Ayurveda medicine has been using herbs such as turmeric possibly as early as 1900 B.C. (Aggarwal, 2007). The *Sushruta Samhita* attributed to Sushruta in the 6th century B.C. describes 700 medicinal plants, 64 preparations from mineral sources, and 57 preparations based on animal sources (Girish and Shridhar, 2007).

The first Chinese herbal book, the *Shennong Bencao Jing*, compiled during the Han Dynasty but dating back to a much earlier date, possibly 2700 B.C. lists 365 medicinal plants and their uses - including ma-Huang, the shrub that introduced the drug ephedrine to modern medicine. Greek and Roman medicinal practices, as preserved in the writings of Hippocrates and especially Galen, provided the patterns for later western medicine. Hippocrates advocated the use of a few simple herbal drugs - along with fresh air, rest, and proper diet. Galen, on the other hand, recommended large doses of drug mixtures - including plant, animal, and mineral ingredients. The Greek physician compiled the first European treatise on the properties and uses of medicinal plants, *De Materia Medica*. In the first century A.D. Dioscorides wrote a compendium of more than 500 plants that remained an authoritative reference into the 17th century. Similarly important for herbalists and botanists of later centuries was the Greek book that founded the science of botany, Theophrastus’ *Historia Plantarum*, written in the fourth century B.C.

The uses of plants for medicine and other purposes changed little in early medieval Europe. Many Greek and Roman writings on medicine, as on other subjects, were preserved by hand copying of manuscripts in monasteries. The monasteries thus tended to become local centers of medical knowledge, and their herb gardens provided the raw materials for simple treatment of common disorders. Medical schools known as Bimaristan began to appear from the 9th century in the medieval Islamic world, which was
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generally more advanced than medieval Europe at the time. Muslim botanists and muslim physicians significantly expanded on the earlier knowledge of materia medica (Fahd and Toufic, 1996).

The fifteenth, sixteenth and seventeenth centuries were the great age of herbals, many of them available for the first time in English and other languages rather than Latin or Greek. The first herbal to be published in English was the anonymous *Grete Herball* of 1526. The two best-known herbals in English were *The Herball or General History of Plants* (1597) by John Gerard and *The English Physician Enlarged* (1653) by Nicholas Culpeper. The second millennium, however, also saw the beginning of a slow erosion of the pre-eminent position held by plants as sources of therapeutic effects. This began with the introduction of active chemical drugs (like arsenic, copper sulfate, iron, mercury, and sulfur), followed by the rapid development of chemistry and the other physical sciences, led increasingly to the dominance of chemotherapy - chemical medicine - as the orthodox system of the twentieth century. The use of herbs to treat disease is almost universal among non-industrialized societies in spite of tremendous development in the field of allopathy as medicinal plants and their derivatives still remain one of the major sources of drugs in modern and traditional systems throughout the world playing a major role in medicinal therapy at the end of the twentieth century.

Traditional Medicine in Healthcare

Over the centuries humans have relied on plants for variety of purposes. Plants have also been utilized for additional purposes, namely as arrow and dart poisons for hunting, poisons for murder, hallucinogens used for ritualistic purposes, stimulants for endurance, and hunger suppression, as well as inebriants and medicines (Bisset, 1989).
Traditional medicine is the synthesis of therapeutic experience of generations of practicing physicians of an indigenous system of medicine. While traditional preparations utilize medicinal and aromatic plants, minerals and other organic matter, herbal drugs constitute only those traditional medicines that use primarily medicinal plant preparations for therapy (Anonymous, 2001). According to a WHO estimate, the majority of population in developing countries depends upon traditional and herbal medicines as their primary source of health care and estimates that 80 percent of the world's population presently uses herbal medicine for some aspect of primary health care (Akerele, 1993). The global demand for herbal medicine is not only large, but also growing. The market for Ayurvedic medicine is estimated to be expanding at 20% annually in India, while the quantity of medicinal plants obtained from just one province of China has grown by 10 times in the last 10 years (Pei, 2002). Factors contributing to the growth in demand for traditional medicine include the increasing human population and the frequently inadequate provision of Western (allopathic) medicine in developing countries.

In developed countries, non-conventional medical modalities, also designated as complementary and alternative medicines (CAM), are often used concomitantly with conventional medicine in medical treatment, including cancer therapy. The popularity of CAM in the USA is reflected in a survey, which showed its use increased from 34% in 1990 to 42% in 1997. The same survey showed that American consumers spent US$ 27 billion on alternative treatments and an estimated US$ 5.1 billion on herbal medicines in 1997. A large percentage with life-threatening disorders uses alternative medical therapies. This may be because of the poor prognosis that many of these patients face despite the use of the full spectrum of conventional medical approaches (Einsberg, 1998).
In developing countries, patients are brought to hospitals at a very late stage when treatment cannot cure the disease. At this juncture, these patients turn to alternative therapies and paranormal treatments. Worsening physical symptoms, troubling side effects from prescription drugs and diminishing hope may further add to the allure of less orthodox approaches. There are several examples where patients with chronic diseases like cancer and HIV have tried one or other form of alternative medicine (Crone, 1998).

The industrial uses of medicinal plants are many. These range from traditional medicines and health foods such as nutraceuticals to galenicals, phytopharmaceuticals and industrially produced pharmaceuticals. Herbal tablets, herbal tonics, herbal soaps, herbal shampoos, herbal talcum powder, herbal toothpastes and herbal cosmetics have become popular consumer items. The very word “herbal” has become symbol of safety for these products in contrast to the “synthetic” ones which has become highly unsafe for human consumption once science revealed their adverse effects on human health and the environment (Swaminathan, 1994). Furthermore, medicinal plants constitute a source of valuable foreign exchange for most developing countries, as they are a ready source of drugs such as quinine and reserpine; of galenicals like tinctures and of intermediates (e.g. diosgenin from Discorea sp.) in the production of semi-synthetic drugs. The world market for plant-derived chemicals pharmaceuticals, fragrances, flavours, and colour ingredients, alone exceeds several billion dollars per year. Classic examples of phytochemicals in biology and medicine include taxol, vincristine, digoxin, opium, aspirin, quinine vinblastine, colchicines as well as the Chinese antimalarial - artemisinin, and the Indian ayurvedic drug-forkolin.

Global Market of Herbal Medicine

Herbal medicine is a major component in all traditional medicine systems, and a common element in siddha, ayurvedic, homeopathic, naturopathic, traditional chinese medicine, and native American medicine. In
several industrialized societies, plant-derived prescription drugs constitute an element in the maintenance of health. Pharmacologists, microbiologists, botanists, and natural-products chemists are combing the Earth for phytochemicals and leads that could be developed for treatment of various diseases. Medicinal plants are an integral component of research developments in the pharmaceutical industry. Such research focuses on the isolation and direct use of active medicinal constituents, or on the development of semisynthetic drugs, or still again on the active screening of natural products to yield synthetic pharmacologically-active compounds. Pharmaceuticals are prohibitively expensive for most of the world's population, half of which lives on less than $2 U.S. per day (Aggarwal, 2007 and Girish and Shridhar, 2007). In comparison, herbal medicines can be grown from seed or gathered from nature for little or no cost. Furthermore, the absence of modernized socio economic and public healthcare systems reinforces reliance of rural and lower-income urban populations on the use of traditional medicinal herbs and plants as complementary aids to routine pharmaceutical market products.

The world market for herbal medicine, including herbal products and raw materials has been estimated to have an annual growth rate between 5 and 15%. Worldwide market of herbal medicines is estimated to be around 80 to 100 billion US $ and this market is expected to reach 2500 billion dollars by the year 2010 (Mathur, 2003). In the West, the demand for herbal drugs has reached a new high in recent years. Since 1999, the global market for herbal supplements exceeded US $15 billion, with a US $7 billion market in Europe, US $2.4 billion in Japan, US $2.7 in the rest of Asia and US $3 billion in North America (Wakdikar, 2004). The results of a nationwide survey indicated a marked increase in the number of individuals using alternative therapies between 1990 and 1997 estimating total out-of-pocket expenditures for alternative therapies at $27 billion (Eisenberg, 1998). In India the value of botanicals related trade is about US $10 billion per annum with annual export
of US $1.1 billion, (Singh, 2003) while China’s annual herbal drug production is worth US $48 billion with export of US $3.6 billion (Handa, 2004). In the U.S., which has just 4% of the world’s population, 106,000 patients died and 2.2 million were seriously injured by adverse effects of pharmaceuticals in the year 1994 (Lai, 2004). In fact, according to the World Health Organisation, approximately 25% of modern drugs used in the United States have been derived from plants. Nonetheless, millions of people in the United States use herbal products to treat a wide variety of ailments or to enhance health. Presently, the United States is the largest market for Indian botanical products accounting for about 50% of the total exports. Japan, Hong Kong, Korea and Singapore are the major importer of herbal medicine taking 66% share of China’s botanical drugs export (Patwardhan, 2005). The WHO considers phytotherapy in its health programs and suggests basic procedures for the validation of drugs from plant origin in developing countries (Vulto, 1988). Eastern countries, such as China and India, have a well-established herbal medicines industry and Latin American countries have been investing in research programs in medicinal plants and the standardisation and regulation of phytomedicinal products, following the example of European countries, such as France and Germany. In Germany, 50% of phytomedicinal products are sold on medical prescription, the cost being refunded by health insurance (Gruenwald, 1997). In North America, where phytomedicinal products are sold as health foods (Brevoort, 1997 and Calixto, 2000), in 1997, the market for products of plant origin reached US$ 2 billion (Brevoort, 1997).

It is difficult to assess how many medicinal aromatic plants are traded commercially, either on a national or even on an international level. The bulk of the plant material is exported from developing countries, while major markets are in the developed countries. An enumeration of the WHO from the late 1970s listed 21,000 medicinal species (Penso, 1980); however, in China alone 4,941 of 26,092 native species are used as drugs in Chinese traditional medicine (Duke, 1985) an astonishing 18.9%. If this proportion is calculated
for other well-known medicinal florae and then applied to the global total of 4, 22,000 flowering plant species (Bramwell, 2002 and Govaerts, 2001), it can be estimated that the number of plant species used for medicinal purposes is more than 50,000.

**India and its medicinal wealth**

India is well known as an Emporium of medicinal plants and is the largest producer of medicinal plants and is rightly called the "Botanical garden of the World". India is tenth among plant rich countries of the world and fourth among the Asian countries. In India about 2,500 plant species belonging to more than 1000 genera are used in indigenous system of medicine. Knowledge of medicinal use of plants in India is amassed over millennia by tribals. For thousands of years Indian plants have been attracting attention of foreign countries. People from countries like China, Cambodia, Indonesia and Baghdad used to visit ancient universities of India like Takshila (700 B. C.) and Nalanda (500 B. C.) to learn health science of India (Anonymous, 1994). Dioscorides mentions many plants in India including datura smoke for treating asthma, nux vomica for paralysis and indigestion and croton as purgatives. Over one and a half million practitioners of the Indian System of Medicine in the oral and codified streams use medicinal plants in preventive, promotive and curative applications. There are estimated to be around 25,000 effective plant based formulations available in the indigenous medical text used in folk medicine and known to rural communities all over India (Ramakrishnappa, 2002). Medicinal plants provide raw material of different parts of plants for use in all indigenous systems of medicine in India namely Ayurveda, Unani, Siddha, and Tibetan medicines (Fig. 1.1 and 1.2). The Siddha system of medicine uses about 600, Ayurveda 700, Unani 700 and modern medicine about 30 medicinal plants for treating a variety of diseases in man and animal. Only few medicinal plants have attracted the interest of scientists, to investigate them for a remedy. (Anonymous, 2000).
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In recent years, the growing demand for herbal product has led to a quantum jump in volume of plant materials traded within and across the countries. Though India has a rich biodiversity, the growing demand is putting a heavy strain on the existing resources. While the demand for medicinal plants is growing, some of them are increasingly being threatened in their natural habitat.

![Pie chart showing the breakdown of medicinal plants by their parts utilized]

Fig. 1.1 Breakup of medicinal plants by their parts utilized

![Bar chart showing plants being used by various systems of medicines]

Fig. 1.2 Plants being used by various systems of medicines
Distribution of Medicinal plants in India

India has 16 agro-climatic zones and medicinal plants are distributed across diverse habitats and landscapes. Nearly 70% of India’s medicinal plants are found in the tropical areas mostly in the various forest types across the Western and Eastern ghats, the Vindhyas, Chota Nagpur plateau, Aravalis and Himalayas. Nearly 30% of medicinal plants occur in temperate and alpine region which include plants of high medicinal values. Of the 386 families and 2200 genera in which medicinal plants are recorded the families Asteraceae, Euphorbiaceae, Lamiaceae, Fabaceae, Rubiaceae, Poaceae, Acanthaceae, Rosaceae and Apiaceae share the larger proportion of medicinal plant species with the highest number of species being under Asteraceae (Fig. 1.3). Analyses of habits of medicinal plants indicate that they are distributed across various habitats. One third is trees and equal portion shrubs and the remaining one third herbs, grasses and climbers (Fig. 1.4). A very small proportion of the medicinal plants are lower plants like lichens, fern algae, etc. (Anonymous, 2000).

![Fig. 1.3 Distribution of medicinal plants by families](image-url)
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Fig. 1.4 Distribution of medicinal plants by habit

Trade of Medicinal plants in India

The market in medicinal plants in India is very large and complex. According to data compiled by the International Trade Centre, Geneva, India is ranked second amongst the exporting countries with an annual export of 3,26,000 tonnes with a value of Rs 45.95 million during 1992-95. Recently the economic value of medicinal plant related trade in India is of the order of Rs 5.5 billion per year. Thus India earns a substantial foreign exchange from supplying raw drugs to the international market. India is a major exporter of raw plants and processed plant based drugs. Exports of crude drugs from India in 1994-95 were valued at US$ 53,219 million. Important crude drugs included *Plantago ovata*, *Panax spp*, *Cassia spp*, *Catharanthus roseus*. In addition to the international trade, there is a substantial volume of internal trade in medicinal plants in India. The domestic market of Indian System of Medicine and Homeopathy is of the order of Rs 4,000 crores in 2000 which is expanding day by day. The Ayurveda drug market alone is of the order of Rs 3500 crores in 2000. Besides this there is also a growing demand for natural products including items of pharmaceuticals, food supplements and cosmetics in both domestic and international markets (Nudrat and Usha, 2004).
Indian System of Medicine - Ayurveda

Ayurveda means life of Science in sanskrit and aims at holistic management of health and disease. It remains one of the most ancient medical systems widely practiced in the Indian subcontinent and has sound philosophical, experiential and experimental basis. Ayurveda originated in India way back in the pre-vedic period. “Rigveda” and “Atharva-veda” (5000 years B.C.), the earliest documented ancient Indian treatise, have references on health and diseases (Ramawat, 2008a). Charaka Samhita and Sushrut Samhita (100-500 B.C) are main Ayurvedic classics, which describe over 700 plants along with their Classification, pharmacological and therapeutic properties. It deals elaborately with measures for healthful living during the entire span of life and its various phases. In addition, dealing with principles for maintenance of health, it has also developed a wide range of therapeutic measures to combat illness. These principles of positive health and therapeutic measures relate to the physical, mental, social and spiritual welfare of human beings. Thus, Ayurveda is one of the oldest systems of health care, dealing with both the preventive and curative aspects of life in a most comprehensive way, and presents a close similarity to the World Health Organization’s concept of health propounded in the modern era. Rasyana therapy is one of the eight branches of Ayurveda and generally consists of nourishing and rejuvenating drugs with multiple applications of longevity, memory enhancement, immunomodulation and adaptogenic. Many researchers have supposed the neuro-endocrine immune axis theory to explain Rasyana activity and they have considered it to be an innovative source of immunodrugs (Patwardhan, 2005a and b).

A considerable amount of research on pharmacognosy, chemistry pharmacology and clinical therapeutics has been carried out on ayurvedic medicinal plants (Patwardhan et al. 2004) and resulted in the establishment of modern medicine from Ayurveda-based medicine (Dev, 1999 and Dahanukar, 2000). These includes indole alkaloids for hypertension from Rauwolfia
serpentina, psoralens for leucoderma from *Psoralea corylifolia*, alkaloids against amoebiasis from *Holarrhena antidysenterica*, guggulsterones as hypolipidaemic agents from *Commiphora wightii*, l-Dopa (dihydroxy phenylalanine) from *Mucuna pruriens* for Parkinson's disease, piperidines as bioavailability enhancers, baccosides from *Bacopa monnieri* for memory enhancement, picrosides from *Picrorhiza kurroa*, in hepatic protection, curcumin from *Curcuma longa* as an anti-inflammatory agent and withanolides and many other steroidal lactones as immunomodulators (Patwardhan, 2000).

India has moved forward in popularizing global usefulness of Ayurveda in health care through global networks. As a result, many foreign countries have began looking to India for an understanding of Ayurveda and incorporating it through education, research and practice to meet the overwhelming desire of consumers to access complementary and alternative medicine. Indian Missions in the USA, UK, Russia, Germany, Hungary and South Africa have played an effective role in channelling information regarding Ayurveda and opening up new opportunities for the spread of this Indian medicine in to foreign institutions; general public awareness building about Ayurveda in foreign countries has been identified as an important thrust area (Ramawat, 2008b).

**Biological background of herbal medicine**

All plants produce chemical compounds as part of their normal metabolic activities. These include primary metabolites, such as sugars and fats, found in all plants, and secondary metabolites (SMs) which are derived biosynthetically from plant primary metabolites and are not directly involved in the growth, development, or reproduction of plants. The content of SMs varies hugely among plant species; some may contain as little as 1% or up to a one third of their dry weight. Generally, tropical and sub-tropical plant species contain much greater amounts of extractives than the ones in the
temperate regions. Furthermore, the concentration of SMs in all parts of a plant is not uniform, and different amounts may be present in leaves, flowers, fruits, bark, heartwood, roots, branch bases and wound tissues. Variations in the content of SMs have also been found among species, between plant of a given species, and between different seasons (John and Daniel, 2001 and John, 2004).

The functions of secondary metabolites are varied. For example, some secondary metabolites are toxins used to deter predation, and others are pheromones used to attract insects for pollination. Phytoalexins protect against bacterial and fungal attacks. Allelochemicals inhibit rival plants that are competing for soil and light. However, it was the potential use of plant SMs in health care and personal care products, and as lead compounds for the development of novel drugs, that led to a huge interest in their isolation and characterization from major plant species over the past few decades. At present, the array of compounds reported is daunting, and the total number of identified SMs exceeds 100,000 (Winks, 1999) with wide ranging chemical, physical and biological activities.

Plants synthesize a bewildering variety of secondary metabolites - phytochemicals but most are derivatives of a few biochemical motifs and some major groups are explained below.

- **Nitrogen-containing alkaloids and sulphur-containing compounds:**
  Alkaloids contain a ring with nitrogen; with over 10,000 known structures, but they are only found in 20% of the angiosperms. Alkaloids are generally present in higher concentrations in bark, seeds, roots and leaves than in wood. All alkaloids contain nitrogen heterocycles and are mainly present in plants as salts of carboxylic acids. Alkaloids have a wide variety of chemical structures and are classified according to the type of ring viz. pyrrolidine (Hygrines, Stachydrine), piperidine (Arecoline, Lobeline), purines (Caffeine,
Theophylline) etc, and their biosynthetic origin. Alkaloids amines often affect neuroreceptors, or modulate other steps in the signal transduction e.g. ion channels- and enzymes (Winks & Schimmer, 1999). This is because alkaloids are derived from the same amino acid precursors as neurotransmitters, and their structures often mimic those of neurotransmitters. Furthermore, alkaloids may affect the function of ion channels by inhibiting neurotransmitter-degrading enzymes (such as acetylcholinesterase) or by modulating enzymes involved in signal transduction (such as adenyl cyclase, protein kinase) (Winks, 1999). Alkaloids are well known for potent pharmacological activities, such as analgesics (morphine, papavarine), antimalarial (quine) antispasmodics, and for treatment of hypertension (reserpine), mental disorders and tumours (vincrystine).

The major sources of sulphur-containing plant compounds are derived from the cruciferous crops such as cabbages, and Allium crops such as garlic (A. sativum), onions (A. cepa). Epidemiological studies with both cruciferous crops and Allium crops suggest that they provide health benefits, particularly with regard to a reduction in risk of cancer. Experimental approaches with animal and cell models suggest that the sulphur-containing compounds of these crops may be the major bioactive agent. Additionally, these compounds may also protect against atheroelsclerosis and other inflammatory diseases (Crozier, et al. 2006).

- Phenolics: These contain phenol rings. The anthocyanins that give grapes their purple color, the isoflavones, the phytoestrogens from soy and the tannins that give tea its astringency are phenolics. These organic compounds are characterized by the presence of a hydroxyl (-OH) group, attached to a benzene ring or to other complex aromatic ring structures. Phenols with more than one hydroxyl group per aromatic ring are known as polyhydric phenols (e.g. catechol, and
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hydroquinone). Phenolic compounds range from simple phenol (found in essential oil of *Pinus sylvestris*) to polyphenols such as anthocyanin pigments and tannins. Tannins are mainly found in bud and foliage tissues, but bark and heartwood often contain the highest levels. The tannins have been reported to possess essential pharmacological properties such as wound healing, antioxidant, antimicrobial, antifungal, antiviral, antitumor, antifeedant, anthelminthic, anti-inflammatory, cytotoxic *etc* (Harborne, 1991).

Another important type of polyphenolic compounds is water-soluble pigments, flavonoids that have useful antioxidant properties. Of the 8000 known phenolic compounds, around 4000 are flavonoids (Harborne, 1991). Flavonoids commonly occur in foliage, bark, sapwood and heartwood in trees. The other properties reported for flavonoids include anti-inflammatory, antihistaminic, antiviral and antidiabetic. For example, quercetin (found in bark of *Quercus spp.*) has been reported to block the sorbitol pathway, which is linked to certain problems associated with diabetes.

Some phenolics occur as glycosides and lignans *etc.* and display a wide range of biological activities including fungal growth inhibition, fish toxicity, insect antifeedant and juvenile hormone functions (Gottlieb & Yoshida, 1989).

- **Terpenoids (Terpenes):** Terpenoids are built up from terpene building blocks. Terpenes are the largest group of natural products from plants with over 20,000 known structures, comprising essential oils, flavours, fragrances, and lipid-soluble plant pigments. These hydrophobic compounds are usually stored in plants in resin ducts, oil cells or glandular trichomes (Winks and Schimmer, 1999). Terpenes are derived from 5-carbon isoprene units \([\text{CH}_2=\text{C}\left(\text{CH}_3\right)-\text{CH}=\text{CH}_2]\), such as \(\text{C}_5\) hemiterpenes, \(\text{C}_{10}\) monoterpenes, \(\text{C}_{15}\) sesquiterpenes, \(\text{C}_{20}\) diterpenes, \(\text{C}_{25}\) sesterpenes, \(\text{C}_{30}\) triterpenes, \(\text{C}_{40}\) tetraterpenes, and \(\text{C}_{50}\)
polyterpenes. While lower terpenoids are found in volatile emissions and essential oils, higher terpenes are mainly present in plant's lipid soluble pigments. The fragrance of rose and lavender is due to monoterpenes. The carotenoids produce the reds, yellows and oranges of pumpkin, corn and tomatoes.

Sterols and steroids are modified triterpenes, and are found in woods of a number of gymnosperms and angiosperms including Larix, Pinus, Fagus, and Quercus spp. Phytosterols are different from animal sterols in that they have an extra methyl or ethyl substituent in the side chain.

Terpenes are widely used in the food, pharmaceutical and perfume sectors, as well as in a wide range of pharmacological applications. Menthol, a monoterpene (10 carbons) isolated from various mints, is a topical pain reliever and antipuretic (relieves itching). Most terpenes disturb fluidity of membranes and efflux of ions, while some may cause cell death (cytotoxic, antimicrobial). Saponins are haemolytic, while others can inhibit the vital enzyme Na⁺/K⁺ ATPase in the pests to deter herbivory. Steroids, such as cortisone, are most often used as anti-inflammatory agents, but many have other uses such as in birth control pills. Ruminants are known to avoid high terpene diets because they kill microbial populations in their gut that are needed to digest cellulosic materials.

- Glycosides: These consist of a glucose moiety attached to an aglycone. The sugars found in glycosides may be monosaccharide such as glucose, rhamnose and fucose or, more rarely deoxy sugars such as the cymarose found in cardiac glycosides. The aglycone is a molecule that is bioactive in its free form but inert until the glycoside bond is broken by water or enzymes. Some pharmacologically important glycosides are Salicin, Populin, Digoxin, Diosgenin, Sennosides, etc.
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The fore going account clearly illustrates the importance of plants in human health care, not only when plant constituents are used directly as therapeutic agents but also when they are used as basic material for the synthesis of drugs or as model for pharmacologically active compounds. It is an undisputed fact that ancient and folklore knowledge coupled with scientific principles can come to the forefront and provide us with powerful remedies to eradicate the diseases. According to one estimate, only 20% of the plant flora has been studied, of these, 15% have been evaluated phytochemically and a reported 6% have been screened for biologic activity (Verpoorte, 2000). This necessitates continuous exploration and rigorous experimentation of plant products for plant derived drugs in addition to new pharmaceuticals for many of the human ailments. Hence the present research programme has been envisaged.

The present study explores the medicinal potentialities of two plants, viz. *Azima tetracantha* Lam. and *Cocculus hirsutus* L. and are claimed to possess several medicinal properties in folklore systems.

*Azima tetracantha* Lam (Fig. 1.5) belongs to the family of Salavodraceae, which is grown as hedgegrow or ornamental plant in gardens. It is a xerophytic plant found in India, Africa and Madagascar. In India the plant grows in deccan, Ceylon and coramendal coast. The plant is known by various names in different languages.

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<th>English</th>
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<td>Marathi</td>
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**Traditional uses:** In traditional systems, the root bark is used in muscular rheumatism. The leaves are used as stimulant and are given to puerperal woman immediately after confinement (Kirtikar and Basu, 2001a). The leaves are also used for rheumatism and their juice used to relive cough; as diuretic and in treating chronic diarrhea dyspepsia (Nadkarni, 1976a). Further, the leaves mixed with stem bark and made into a semisolid liquid are given to cattle for a week as anti rinderpest (CSIR, 2004). It has been also reported that the leaf powder is used in toothache (Hebbar et al. 2004).

**Phytochemistry:** Several phytochemical investigations in plant resulted in the isolation of dimeric piperidine alkaloids like azimine, azacarpine and carpine (Rall et al. 1967). Venkatarao and Prasadrao, (1978) have reported the isolation of triterpenoids from leaf and root. Further, Bennet et al. (2004) have reported the presence of glucosinalates, flavonoids, alkaloids and other secondary metabolites in the tissues of *Azima tetracantha*. Vasikaran, (1987) and Daulatabad, (1991) reported isorhamnetin 3-rutinoside and novel fattyacids.

**Pharmacology:** The aqueous and alcoholic extracts of *Azima tetracantha* have proved to posses diuretic effect in rats (Senthmarai et al. 1996). Syed Ismail et al. (1997) have reported the powder of leaf posses' anti-inflammatory effect. The Plant has been also screened for its anti-fungal activity (Mahmaod Al Fatimi, 2007) and antiulcer activities (Muthusamy, 2009).

*Cocculus hirsutus* L (Fig. 1.6) is a scandent creeper, which belongs to the family Menispermaceae. The plant grows in fields along the hedgerow. It is found growing in tropical and subtropical India from the foot of Himalayas to south India, Ceylon, China Arabia and tropical Africa. The plant is known by various names in different languages.
Traditional uses: The juice of the leaves is used externally as cooling and soothing application in pruriga (skin itching), eczema (scabies), impetigo (skin eruption) *etc*. It is used in the treatment of gonorrhea; the decoction of root is given in chronic rheumatism, stomachache, dyspepsia and syphilitic cachixia (Nadkarni, 1976b). It is used in tribal medicine for treating leucorrhoea and menorrhagia (Hemadri *et al.* 1983). The roots are bitter acrid thermogenic, laxative, alterant, digestive, carminative, diuretic, aphrodisiac, expectorant, antipyretic and tonic (Kirtikar and Basu, 2001b). It is useful in poisonous bites, leprosy, skin diseases, colic, strangury (painful urination) and gout (Vaidyaratanam, 1994).

Phytochemistry: The alkaloids present specifically in the leaves of *C. hirsutus* are D-trilobine and DL-Coclaurine (Jagannadha and Ramachandra, 1961). The whole plant of *C. hirsutus* has been reported to contain essential oil, Beta-Sitosterol, Ginnol (Merchant *et al.* 1962), glycosides, sterols and alkaloids (Das *et al.* 1964). Two resins and unknown alkaloids also have been reported (Nadkarni, 1976). The alkaloids reported to be present are Hirsutine, Shaheenine (Rasheed *et al.*1991a and b.), Jamtine-N-Oxide, Cohirsinine, jamtinine, (Viquaruddin *et al.* 1987a, 1991 and 1993a), Cohirsine, Corsitinine and Haiderine (Viquaruddin, *et al.* 1987b, 1992 and 1993b), Corsutine (Yadav, 2005).

Pharmacological Studies: The plant has been subjected to several pharmacological screening *viz.* hypoglycemic and cardiotonic activities in
roots of *Cocculus hirsutus* (Kokate, 2001); diuretic and laxative activities (Ganapathy *et al.* 2002); anti-inflammatory, analgesic and antimicrobial activities in roots (Nayak *et al.* 1993 and 2003). Recently antihyperglycemic activity in leaves has been reported (Badole *et al.* 2006).

It is evident from the foregoing account that the plants are used for various ailments in folklore system and such medicinal claims of the plants are largely remain unexplored, therefore warrants systematic pharmacological evaluation. Further, phytochemical investigation documented the rich source of alkaloids and other important secondary metabolites which attracts any investigator to exploit the plants for rigorous screening for pharmacological activities. Therefore, in the present research programme the two plants are subjected to experimentation with following objectives.

1. **Pharmacognostic study**
   - To establish the identification of the plants through Macroscopy, Microscopy and Proximate values.

2. **Phytochemical Investigation**
   - To extract leaf material utilizing solvent extraction method.
   - Qualitative chemical analysis of the extracts.
   - Isolation of chemical constituents and identification.

3. **Pharmacological studies to screen activities *viz.***
   - Hepatoprotective
   - Antioxidant
   - Antipyretic
   - Anti-inflammatory
   - Analgesic
   - Cardiovascular
   - Anthelmintic
   - Antimicrobial
Fig. 1.5 *Azima tetracantha* Lam. Habit

Fig. 1.6 *Cocculus hirsutus* L. Habit