I. Introduction
Plants provide a variety of resources that contribute to the fundamental needs of food, clothing and shelter. Among plants of economic importance medicinal and aromatic plants have played a vital role in alleviating human sufferings (Baquir, 2001). According to the World Health Organization (WHO, 1977) “a medicinal plant” is any plant, which in one or more of its organ contains substances that can be used for the therapeutic purposes or which, are precursors for the synthesis of useful drugs. This definition distinguishes those plants whose therapeutic properties and constituents have been established scientifically and plants that are regarded as medicinal but which have not yet been subjected to thorough investigation.

Medicinal plants, since times immemorial, have been used in virtually all cultures as a source of medicine. The widespread use of herbal remedies and health care 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. Further more, plant-based drugs have been used for centuries and there is no alternative medicine for many drugs, such as cardiac glycosides (Ramawat, 2008).

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 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.

Herbs are staging a comeback and herbal ‘renaissance’ is happening all over the globe. The herbal products today symbolize safety in contrast to the synthetics that are regarded as unsafe to human and environment. Although herbs had been priced for their medicinal, flavouring and aromatic qualities for centuries, the synthetic products of the modern age surpassed their importance, for a while. However, the blind dependence on synthetics is over and people are returning to the naturals with hope of safety and security (Joy et al, 2001).

**Medicinal Plants and Human History**

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. (Agarwal, 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 Shenmong 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 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 Health care**

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, herbolology, phytomedicine and phytotherapy (Acharya, 2008). The term “herbal drug” determines the part/parts of a plant (leaves, flowers, seeds, roots, barks, stems, etc.) used for preparing medicines (Anonymous, 2007).

The traditional medicine (Indigenous medicine or folk medicine) describes medical knowledge systems, which developed over centuries within various societies before the era of modern medicine; traditional medicines include practices such as herbal medicine, Ayurvedic medicine, Unani medicine, acupuncture, spinal manipulation, Siddha Medicine, traditional Chinese medicine, South African Muti, as well as other medical knowledge and practices all over the globe.

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. 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. The ancient record is evidencing their use by Indian, Chinese, Egyptian, Greek, Roman and Syrian dates back to about 5000 years. About 500 plants with medicinal use are mentioned in ancient texts and around 800 plants have been used in indigenous systems of medicine. Indian subcontinent is a vast repository of medicinal plants that are used in traditional medical treatments which also forms a rich source of knowledge (Chopra et al. 1956). The various indigenous systems use several plant species to
treat different ailments (Rabe and Staden, 1997). In India around 20,000 medicinal plant species have been recorded recently (Dev, 1997), but more than 500 traditional communities use about 800 plant species for curing different diseases (Kamboj, 2000). Plants are important sources of medicines and presently about 25% of pharmaceutical prescriptions in the United States contain at least one plant-derived ingredient. In the last century, roughly 121 pharmaceutical products were formulated based on the traditional knowledge obtained from various sources (Anesini and Perez, 1993).

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 (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 *Dioscorea 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 ayurdevic drug *forkolin* (Abdin *et al.* 2003 and Maruthi Ekbote, 2010).

**Global Market of Herbal Medicine**

Medicinal plants continue to play a central role in the healthcare system of large proportions of the world’s population. Over the past decade, herbal medicine has become a topic of global importance, making an impact on both world health and international trade. In several industrialized societies, plant-derived prescription drugs constitute an element in the maintenance of health and hence allure pharmacologists, microbiologists, botanists, and natural-products chemists 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 (Agarwal, 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 health care 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%. 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 (Einsberg, 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 $3.6 billion (Handa, 2004). In the U.S., which has just 4% of the world’s population, 106,000 patients died and 2.2 million were seriously injured by adverse effects of pharmaceuticals in the year 1994 (Lai, 2004). In fact, according to the World Health Organization, approximately 25% of modern drugs used in the United States have been derived from plants. Nonetheless, millions of people in the United States use herbal products to treat a wide variety of ailments or to enhance health. Presently, the United States is the largest market for Indian botanical products accounting for about 50% of the total exports. Japan, Hong Kong, Korea and Singapore are the major importer of herbal medicine taking 66% share of China’s botanical drugs export (Patwardhan, 2005a). The WHO considers phytotherapy in its health programs and suggests basic procedures for the validation of drugs from plant origin in developing countries (Vulto, 1988). Eastern countries, such as China and India, have a well-established herbal medicines industry and Latin American countries have been investing in research programs in medicinal plants and the
standardisation and regulation of phytomedicinal products, following the example of European countries, such as France and Germany. In Germany, 50% of phytomedicinal products are sold on medical prescription, the cost being refunded by health insurance (Gruenwald, 1997). In North America, where phytomedicinal products are sold as health foods (Brevoort, 1997 and Calixto, 2000), in 1997, the market for products of plant origin reached US$ 2 billion (Brevoort, 1997). Over three-quarters of the world population relies mainly on plants and plant extracts for health care. More than 30% of the entire plant species, at one time or other was used for medicinal purposes. It is estimated that world market for plant derived drugs may account for about Rs.2,00,000 crores. Presently, Indian contribution is less than Rs.2000 crores. Indian export of raw drugs has steadily grown at 26% to Rs.165 crores in 1994 - 95 from Rs.130 crores in 1991- 92. The annual production of medicinal and aromatic plant’s raw material is worth about Rs.200 crores. This is likely to touch US $5 trillion by 2050.

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 floras and then applied to the global total of 4, 22,000 flowering plant species (Govaerts, 2001 and Bramwell, 2002), 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 has an over 3000 year-old medicinal heritage based on herbs. The sacred Vedas and other ancient Indian treaties give many references of these
medicinal plants. One of the remotest record in traditional herbal medicine is 'Vrikshayurveda' compiled by Parashara which formed the basis of medical studies in ancient India. More detailed accounts are in 'Atharvanaveda' (1200 B.C.). Later, the concept of Ayurveda was appeared and developed between 2500 and 500 B.C. It has a vast literature in Sanskrit covering all aspect of diseases, pharmacy and therapeutics and remains one of the most ancient medical systems widely practiced in the Indian subcontinent and has sound philosophical, and experimental basis. The Vedic and Post-Vedic periods roughly from 4500 B.C. to 500 A.D. had celebrated Indian physicians and herbalists. Atreya, Nagarjuna, Vagbhatha, Sushruta and the Hindu hippocrates, Charaka were the legendary figures of the traditional Indian medicine (Ramawat, 2008). Charaka Samhita and Sushrut Samhita 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. Rasayana 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).
India is well known as an emporium of medicinal plants. Knowledge of medicinal use of plants in India is amassed over millennia by tribal. 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 Takshashila (700 B.C.) and Nalanda (500 B.C.) to learn health science of India. It is documented that the Indian people have a tremendous passion for medicinal plants and use them for a wide range of health related applications from common cold to memory improvement and treatment of poisonous snake bites to a cure for muscular dystrophy and the enhancement of body’s general immunity. 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. There are more than 15000 species of higher plants occur in India of which 9000 are economically important. Of these about 7500 are of medicinal value; 3900 are of food value; 700 are culturally important; 525 used for fiber; 400 for fodder; 300 for pesticide and insecticides; 300 for gum, resin and dyes and 100 provide incense and perfume (Anonymous, 1994). Out of the above, over, 9,500 wild plant species are used by tribal societies of India for their varied requirements (GOI, 1995).

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 Muccuna pruriens for Parkinson’s disease, piperidines as bioavailability enhancers, baccosides from Bacopa monnieri for memory enhancement,
picrosides from *Picrohiza 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, 2008).

**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. and *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).

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

Although plant secondary products have been defined as chemicals that do
not appear to have a biochemical role in the process of building and maintaining
plant cells, recent research has shown a pivotal role of these chemicals in the eco-
physiology of plants. Accordingly, secondary products have both a defensive role
against herbivory, pathogen attack and inter-plant competition and an attractant
role towards beneficial organisms such as pollinators or symbionts (Winks and
Schimmer, 1999). Plant secondary products also have protective actions in relation
to abiotic stresses such as those associated with changes in temperature, water
status, light levels, UV exposure and mineral nutrients. Furthermore, recent work
has indicated potential roles of secondary products at the cellular level as plant
growth regulators, modulators of gene expression, and in signal transduction
(Kaufman et al. 1999).

Secondary products can have a variety of functions in plants; it is likely that
their ecological function may have some bearing on potential medicinal effects for
humans. For example, secondary products involved in plant defense through
cytotoxicity towards microbial pathogens could prove useful as antimicrobial
medicines in humans, if not too toxic. Likewise, secondary products involved in
defense against herbivores through neurotoxin activity could have beneficial
effects in humans (i.e. as antidepressants, sedatives, muscle relaxants or
anesthetics) through their action on the central nervous system. To promote the
ecological survival of plants, structures of secondary products have evolved to
interact with molecular targets affecting the cells, tissues and physiological
functions in competing microorganisms, plants and animals (Winks and
Schimmer, 1999). In this respect, some plant secondary products may exert their
action by resembling endogenous metabolites, ligands, hormones, signal
transduction molecules or neurotransmitters and thus have beneficial medicinal
effects on humans due to similarities in their potential target sites (e.g. central
nervous system, endocrine system, etc.) (Kaufman et al. 1999).

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.

In contrast to synthetic pharmaceuticals based upon single chemicals, many medicinal and aromatic plants exert their beneficial effects through the additive or synergistic action of several chemical compounds of secondary metabolites acting at single or multiple target sites associated with a physiological process. As pointed out by Tyler (1999), these synergistic pharmacological effects can be beneficial by eliminating the problematic side effects associated with the predominance of a single xenobiotic compound in the body. Kaufman et al. (1999) extensively documented how synergistic interactions underlie the effectiveness of a number of Phytomedicines. Most of these phytochemical constituents are potent bioactive compounds found in medicinal plant parts, which are precursors for the synthesis of useful drugs (Sofowora, 1993).

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 (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 (quinine) antispasmodics, and for treatment of hypertension (reserpine), mental disorders and tumours (vincristine).

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 atherolosclerosis 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 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 and 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 \([CH_2=C(CH_3)-CH=CH_2]\), such as C₅ hemiterpenes, C₁₀ monoterpenes, C₁₅ sesquiterpenes, C₂₀ diterpenes, C₂₅ sesterpenes, C₃₀ triterpenes, C₄₀ tetraterpenes, and C₅₀ 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.

The foregoing 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 study explores the medicinal potentialities of plant, *Anogeissus latifolia* which is claimed to possess several medicinal properties in folklore systems.

*Anogeissus latifolia* (Roxb.) is a medium sized deciduous tree belonging to the family combretaceae and it is commonly known as *Dhava*. It attains height of about 30-40 feet (Orwa, 2006). Leaves are opposite or sub-opposite. Bark is smooth with grey- white colour and exfoliating in irregular thin scales (Warrier, 1994). Flowers sessile, in dense heads, fruit small, compressed, winged with beak, seed ovoid (Fig 1a, b and 2a). Tree flowers and fruits in the month of Sept-March (Yadav and Sardesai, 2002). It is distributed throughout India (Warrier, 1994) and Ceylon (Kirtikar and Basu, 1975). The plant is common in dry deciduous forest, except E. Bengal and Assam. It is found in Sub-Himalayan tract, from the Ravi to Nepal, Bihar, Chota Nagpur and ascends to south India (Chopra *et al*. 1956). The plant is known by various names in different languages.

<table>
<thead>
<tr>
<th>Language</th>
<th>English</th>
<th>Sanskrit</th>
<th>Kannada</th>
<th>Telugu</th>
<th>Hindi</th>
<th>Marathi</th>
<th>Malayalam</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Axlewood</td>
<td>Dhava</td>
<td>Dinduga</td>
<td>Shirimanu</td>
<td>Bakli</td>
<td>Dhaura</td>
<td>Malakanniram</td>
</tr>
</tbody>
</table>

Traditional uses: It is important timber and the leaves and bark are used for tanning. The bark is effective in anemic conditions, urinary discharges and piles (Kirtikar and Basu, 1975). Stem bark is astringent, haemostatic, constipating, depurative and useful in vitiated conditions of *kapha* and *vata* (Warrier, 1994). According to Jain (1991) stem bark is useful in diarrhea, dysuria, cough, colic,
liver complaints, snakebite and skin diseases. Tribals in Udaipur District of Rajasthan, use the bark of this tree in the treatment of fever (Nag et al. 2007). Bark is remedy for chronic cough called ‘Dangya Khokala’ (Patil, 2011). Tribal people residing in the forest of Gundlabranhmeswaram wild life sanctuary apply paste of stem bark on scorpion sting (Venkata Ratan et al. 2008). Leaf decoction is reported to be effective in epileptic fits (Pawar and Patil, 2008). Gum ghatti (Fig 2b) is used as tonic and generally consumed after delivery (Pawar and Patil, 2008). According to Jagtap et al. (2009) pawara tribes of Satpura hills, use the gum with a cup of water or milk during early morning for lactation.

**Phytochemistry**

Reddy et al. (1965) reported tannin, (+) leucocyanidin and ellagic acid from the bark, sapwood and heart wood, whereas, Deshpande et al. (1976) isolated 3,3’-di-O-methyle ellagic acid-4’-β-D-Xyloside and 3,4,3’-tri-O-methylflavellagic acid-4’-β-D-glucoside from stem bark. Steroid, β-sistosterol and a triterpenoid, 3-β-hydroxy-28-acetytaraxaren were isolated from the ethyl acetate fractions of stem bark of *A. latifolia* (Rahman et al. 2007).

**Pharmacology**

Wound healing potentiality was evaluated by using ethanolic extract of *Anogeissus latifolia* bark for the treatment of dermal wounds in rats. The ethanolic extract was also found inhibitory against human pathogenic bacteria *Staphylococcus aureus, Pseudomonas aeruginosa, Klebsiella pneumoniae* and *Escherisia coli* due to the presence of ellagic acid. Antiulcer activity of *Anogeissus latifolia* was found effective against induced ulcers. Antioxidant potential of ethanolic extract of *A. latifolia* was also evaluated and reported dose dependent inhibition of nitric oxide, DPPH radical, hydrogen peroxide, and superoxide radicals (Govindarajan et al. 2004a, 2004b and 2006).
It is obvious 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 provides an opportunity for systematic pharmacological evaluation. Further, phytochemical investigation documented the rich source of important secondary metabolites which attracts any investigator to exploit the plant for rigorous screening for pharmacological activities. Therefore, in the present research programme, plant is 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 and bark utilizing solvent extraction method.
   - Qualitative chemical analysis of the extracts.
   - Isolation of chemical constituents and identification.

3. **Pharmacological studies to screen activities**

   - Hepatoprotective
   - Antihyperglycemic
   - Hypolipidemic
   - Anti-inflammatory
   - Analgesic
   - Anthelmintic
FIGURE 1

a. *Anogeissus latifolia* Habit

b. Flowering twig of *Anogeissus latifolia*
FIGURE 2

a. Seeds of *Anogeissus latifolia*

b. Gum ghatti (a translucent exudate) of *Anogeissus latifolia*