



Chapter - 1

General introduction and Review of literature

1.1. Medicinal Plants

Throughout the ages, humans depend on Nature for their basic needs such as production of food-stuffs, shelters, clothing, means of transportation, fertilizers, flavours and fragrances and medicines. Plants have formed the basis of sophisticated traditional medicine that have been in existence for thousands of years and continue to provide new remedies for mankind. The first records written on clay tablets in cuneiform are from Mesopotamia and date from about 2600 BC. Among the substances that were used were oils of *Cedrus* spp. (Cedar) and *Cupressus sempervirens* (Cypress), *Glycyrrhiza glabra* (Licorice), *Commiphora* spp. (Myrrh) and *Papaver somniferum* (Poppy juice), all of which are still in use today for the treatment of ailments ranging from cough and cold to parasitic infections and inflammation. Egyptian medicines report on the use of bishop weeds (*Ammi majus*) to treat vitiligo, a skin condition characterized by loss of pigments and a drug, β -methoxypsoralen has been produced from this plant for the treatment of psoriasis and other skin disorders as well as T-cell lymphoma (Gurib-Fakim 2006).

According to WHO, 80% of the world's population, primarily those of developing countries rely on plant derived medicines for their healthcare (Gbile 1986). Across the cultures, traditional medicines are mainly derived from plants. About 25% of the modern drugs are derived from plants which were first used traditionally. The widespread use of herbal medicine is mainly due to its ready availability and affordability (Ikpefan and Ayinde 2013). Natural products and their derivatives represent more than 50% of all the drugs in clinical use in the world. Higher plants contribute not less than 25% of the total. During the last 40 years, at least a dozen number of potent drugs have been derived from flowering plants including reserpine and other anti-hypertensive and tranquilizing alkaloids, laxative agents and cardiotoxic agents etc. Approximately half (125,000) of the world's flowering plant species are present in the tropical forests. Tropical rain forests continue to support a vast reservoir of potential drug species. They continue to provide natural product chemists with invaluable compounds as starting points for the development of new drugs (Gurib-Fakim 2006).

1.2. Indigenous Health Systems in India

The indigenous health systems in India have two social streams: one is folk medicine or Local Health Traditions (LHT), which are oral traditions found in the rural communities. The carriers are millions of housewives with practical knowledge of simple home remedies, traditional birth attendants, local healers, bone-setters, practitioners skilled in acu-pressure, eye diseases, dental care, poisons or veterinary care and village level herbal medicine healers. They constitute an autonomous, self reliant and community-supported system of health delivery at the village level. The folk medicine is based on empirical knowledge and utilises a large proportion (25-60%) of local plant species in various regions, along with many animals and minerals.

The second stream of indigenous health system consists of traditional, organised and codified Indian Systems of Medicine (ISM) such as Ayurveda, Unani, Siddha and Amchi. Unlike folk medicine, these systems have sophisticated theoretical foundations expressed in hundreds of manuscripts covering treatises on all branches of medicine and surgery. Some of the Ayurvedic texts are 3,000 years old. Herbal medicine is dispensed regularly and the recipes are usually quite complicated, comprising 20-30 different plant species each. The total number of plant species used in ISM is much lower than in folk medicine (Singh et al. 2008).

1.2.1. Indian Systems of Medicine

The system of medicines which are considered to be Indian origin or the systems of medicine, which have come to India from outside and got assimilated into Indian culture are known as Indian Systems of Medicine (Prasad 2002). India has the unique distinction of having six recognized systems of medicine in this category. They are- Ayurveda, Siddha, Unani, Yoga, Naturopathy and Homoeopathy. Though Homoeopathy came to India in 18th Century, it completely assimilated into the Indian culture and got enriched like any other traditional system. Hence it is considered as part of Indian System of Medicine (Prasad 2002). In India, around 15000 medicinal plants have been recorded (Dev 1997). But traditional communities are using only 7,000 - 7,500 plants for curing different diseases (Samy, Ignacimuthu, and Sen 1998; Samy and Ignacimuthu 2000; Kamboj 2000). The medicinal plants listed for different ailments in various indigenous

systems such as Siddha (600), Ayurveda (700), Amchi (600), Unani (700) and Allopathy (30) (Rabe and Staden 1997). According to another estimate, 17,000 species of medicinal plants have been recorded of which nearly 3,000 species are only used in medicinal field (Nayar 1987).

1.2.2. Ayurveda

Most of the traditional systems including Ayurveda have their roots in folk medicine. Ayurveda has a well-defined conceptual framework that is consistent throughout the ages. In conceptual base, it was perhaps highly evolved and far ahead of its time. It was amongst the first medical system to advocate an integrated approach towards matters of health and disease. Unlike other systems, Ayurveda developed their conceptual framework based on the results obtained with the use of drugs and therapy. It first provided philosophical framework that determined the therapeutic practice with good effects (Rao 1987). 'Ayurveda' literally means the Science of life. It is presumed that the fundamental and applied principles of Ayurveda got organized and enunciated around 1500 BC. *Atharvaveda*, contains 114 *hymns* related to formulations for the treatment of different diseases. From the knowledge gathered and nurtured over centuries, two major schools and eight specializations got evolved. One was the school of physicians called as '*Dhanvantri Sampradaya*' (Sampradaya means tradition) and the second school of surgeons referred in literature as '*Atreya Sampradaya*'. These schools had their respective representative compilations- Charaka Samhita for the school of Medicine and Sushruta Samhita for the school of Surgery. The former contains several chapters dealing with different aspects of medicine and related subjects. Around six hundred drugs of plant, animal and mineral origin have been mentioned in this treatise (Ravishankar and Shukla 2007).

1.2.3. Siddha

Siddha system of medicine is practiced in some parts of South India especially in the state of Tamil Nadu. It has close affinity to Ayurveda, yet it maintains a distinctive identity of its own. This system has come to be closely identified with Tamil civilization. The term '*Siddha*' has come from '*Siddhi*'- which means achievement. *Siddhars* were the men who achieved supreme knowledge in the field of medicine, yoga or *tapa* (meditation) (Narayanaswamy 1975). The materia medica of Siddha system of medicine

depends on drugs of metal and mineral origin in contrast to Ayurveda of earlier period, which was mainly dependent upon drugs of vegetable origin. A number of plant-based preparations are used in Siddha system of medicine and are quite similar in profile to those mentioned in Ayurveda (Ravisankar and Shukla 2007).

1.3. Other World Systems

1.3.1. Unani

Unani system of medicine is also known as Greco-Arab medicine, is an ancient system of medicine originated from Greece. It is commonly practiced in Indian subcontinent and has an age-old concept and principles of drug management. It has drugs from natural identity and source. Greek medicine covers the millenium from 500BC to 500 AD. The inventor of this medicine is Apollo and Dioscoridius (70AD) who was a successive healer of this medicine and was the first person to write a comprehensive illustrated book enlisting the major medicinal plants (Rahman 2006). Unani medicine is having a holistic approach and it refers to the whole knowledge as a total recognition of the patient's condition. The Unani drugs are of plant, animal and mineral origin which are grouped into four degrees on the basis of their temperament, potentiality (potency) and power of effectiveness (efficacy). "Higher the degree, higher the adverse effects" (Rahman, Khan, and Latif 2008).

1.3.2. Amchi

Amchi system or Tibetan medicine also known as Sowa-Rigpa. It is one of the oldest surviving and well-documented medical traditions of the world. It has been popularly practiced in Tibet, Mangolia, Bhutan, some parts of China, Nepal, Himalayan regions of India and few parts of former Soviet Union. Some scholars believe that it has originated from India, some say it has Chinese origin and as Tibetan origin. Majority of theory and practice of Amchi are similar to the Indian medical system, Ayurveda; followed by few Chinese principles and the Tibetan folklore. In India, this system is practiced in Sikkim, Arunachal Pradesh, Darjeeling (West Bengal), Lahoul and Spiti (Himachal Pradesh), and Ladakh region of Jammu and Kashmir. The word 'Amchi' is derived from Mangolian word Am-rjay, which means superior to all. The practitioners of this medicine are known as Amchis. This system of medicine is a rich accumulation of

science, art and philosophy with a history of more than 2500 years and is based on holistic approach of body and mind for leading a healthy way of life in complete harmony with nature (Gurmet 2004).

1.3.3 Homoeopathy

Homoeopathy, founded by a German physician Samuel Hahnemann in 1790, is based on the idea that ‘like cures like’; that is substances that cause certain symptoms in a healthy person can also cure those same symptom in someone who is sick. This so called law of similar, gives homoeopathy its name ‘homoeo’ for similar and ‘pathy’ designating disease. In this experiment Hahnemann developed a method of ‘potentizing’ homeopathic remedies by diluting them in a water-alcohol solution and then vigorously shaking the mixtures. The result convinced him that a high degree of dilution not only minimizes the side effects of the remedies but also simultaneously enhances their medical efficacy. Most Homeopathic remedies have undergone ‘proving’ or medical observation in which healthy individuals are given doses of undiluted homeopathic substances. Mental, emotional, psychic and other details of the patients are most important. This leads the physician to a better understanding of a remedy that suits a particular set of symptoms the best (Mukerjee 2002).

1.4. Plants as a source of medicines

The Indian subcontinent is an immense storehouse of medicinal plants that are used in traditional treatments (Ballabh and Chaurasia 2007) . Many Westerners have regarded the Indian system of medicine as a rich source of knowledge (Subhose, Srinivas, and Narayana 2005). Major pharmaceutical industries depend on plant products for the preparation of Ayurvedic medicines. In the present context, the Ayurvedic system of medicine is widely accepted and practiced not only in the Indian Peninsula but also in the developed countries such as Europe, United States and Japan. Plant derived medicines have been the first line of defense in maintaining health and combating diseases (John 1984; Veale, Furman, and Oliver 1992).

Biologically active compounds from natural sources have always been of great interest to scientists working on infectious diseases. Detailed research on the chemistry and pharmacology of products of plant origin are much essential and this may eventually lead to the discovery of medicine that can be used in the treatment of several diseases

(Dev 1997). Moreover, if these local Ayurvedic preparations are scientifically evaluated and disseminated properly, our indigenous population can be given better access to efficacious drug treatment and improved health status (Manandhar 1987). 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.

1.5. Herbal Wealth

Chemical principles from natural sources have become much simpler and have contributed considerably to the development of new drugs from medicinal plants (Cox 1990; Cox and Ballick 1994). 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 synergistically and enhance the bioactivity of other compounds. Artemisinin produced by *Artemisia annua* is very effective against *Plasmodium falciparum*, *P. vivax* and also against drug resistant parasite. The main active constituents of *Artemisia annua* are sesquiterpenoid lactone endoperoxide named artemisinin and artemisinic acid. 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. Interestingly, it was one of the first agents used for the treatment of amoebic dysentery. Reserpine isolated from raw plant extract of *Rauwolfia serpentina* is used as a tranquilizer and also in controlling high blood pressure. From over 2000 years, the powdered root of *Rauwolfia serpentina* has been used in treatment of mental illness in India (Tiwari 2008). Indian Vedas describe the widespread use of herbal products and aqueous extract of different plant parts for curing different diseases. Maximum 30% of root part of medicinal plant is used in different practices in comparison to other plant parts (Ved, Mudappa, and Shankar 1998).

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. It is one of the biggest repository of medicinal plants in the world and 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 is progressing very fast in India.

Most alarming problem the industry has started facing and will face in future is the demanding supply of plant material from natural resources (Meena, Bansal, and Kumar 2009).

1.6. The Wild Plant Resource Base of Medicinal Plants

The Indian sub-continent has a very rich diversity of plant species in a wide range of ecosystems. There are about 17,000 species of higher plants, of which approximately 8,000 species, are considered medicinal and used by many communities or in traditional medicinal systems, such as the Ayurveda. Many of the wild plants are endemic and are found only in specific ecological niches. Almost all medicinal plant raw materials in India are collected from wild populations. This has led to the unsustainable exploitation of many of the plants. The growing interest in traditional herbal medicine will lead to a further increase in the demand for medicinal plants (Singh et al. 2008).

1.7. Phytochemicals

Phytochemicals (Greek word 'phyto', meaning plant) are biologically active, naturally occurring chemical compounds found in plants that provide health benefits for humans (Hasler and Blumberg 1999). They protect plants from diseases and damages and contribute to the plant's colour, aroma and flavour. In general, the plant chemicals that protect plant cells from environmental hazards such as pollution, stress, drought, UV exposure and pathogenic attack are called as phytochemicals (Gibson, Wardle, and Watts 1998; Mathai 2000). It is evidently known that they have roles in the protection of human health and hence their dietary intake is significant. More than 4,000 phytochemicals have been cataloged (American Horticulture Society 2000) and are classified according to their protective function, physical characteristics and chemical characteristics (Meagher and Thomson 1999) and about 150 phytochemicals have been studied in detail (American Cancer Society 2000). Phytochemicals accumulate in different parts of the plants, such as in roots, stems, leaves, flowers, fruits or seeds (Costa et al.1999) and have important properties to prevent or to fight some common diseases (Saxena et al. 2013).

Phytochemicals are classified as primary or secondary constituents, depending on their role in plant metabolism. Primary constituents include the common sugars, amino acids, proteins, purines and pyrimidines of nucleic acids, chlorophylls etc. Secondary constituents are the remaining plant chemicals such as alkaloids, terpenes, flavonoids,

lignans, plant steroids, curcumines, saponins, phenolics, flavonoids and glucosides (Hahn 1998). These compounds serve to meet the secondary requirements of organisms. They help them to survive interspecies competition, provide defensive mechanisms and facilitate the reproductive processes. Many secondary metabolites have proved as valuable antimicrobial agents, anticancer drugs, antiparasitic agents, herbicides, diagnostics and tools of research (Vaishnav and Demain 2010).

1.8. Chemotaxonomy

Chemotaxonomy of plant involves the study of chemical variation in different plants and use of this information in their classification. Chemotaxonomy consists of the investigation of distribution of chemical compounds or groups of biosynthetically related compounds in series of related or supposedly related plants. Since ancient times, the essential oil and terpenoids of many aromatic plants have been used as bioactive ingredients in drug, food, perfumery and cosmetic formulations all over the world and so it is worthwhile to study their role in chemotaxonomy (Bhargava, Patel, and Desai 2013).

In order to properly assess the systematic status of a taxon and its phylogeny, the studying of morphological characters alone is not sufficient. So the other branches of study are also taken into account for the correct assessment of the systematic position of a taxon. The taxonomic contributions of chemotaxonomy have made an equally great help to support the ideas of classification and phylogeny. The rise of chemotaxonomy has been due to the development of sophisticated techniques in chemical analysis which can detect even trace of chemical compounds (Kalia 2011).

Presence or absence of essential oils regardless of their compositions provides a very valuable taxonomic character. In fact, the volatile oil constituents of aromatic plants are at present regarded not only as important bioactive ingredients, but also as target metabolites emitted by plants to balance their status in their natural habitat or in agronomic conditions of fixed protocol (Harbone 2011). Terpenoids are one of the important essential oils which are of chemotaxonomic importance which occur mostly in higher plants (Bhargava, Patel, and Desai 2013).

1.9. Molecular taxonomy

To refresh traditional taxonomy and help it rise above the taxonomic crisis, alternative and complementary approaches have been promoted and one of them is

molecular taxonomy (Hebert et al. 2003; Tautz et al. 2003). DNA barcoding (Hebert et al. 2003) has been particularly successful in the identification and delimitation of new species from various groups (Borisenko et al. 2008; Cywinska, Hunter, and Hebert 2006; Hajibabaei, Janzen, et al. 2006; Hajibabaei, Smith, et al. 2006; Hebert et al. 2004; Kerr et al. 2009; Smith et al. 2007; Ward et al. 2005). This method has received increased acceptance because it is simple and affordable (Padial and De La Riva 2007).

In addition to genetic taxonomy and other classical morphological and non-morphological methods, phytochemical taxonomy can also provide supplementary information in species identification (Desjardins 2008). The chemotype of a plant species has traditionally been defined as by profile of natural products, and the genotype has been defined as its genetic constitution or DNA sequence. The classification of plants based on chemotypes can be used as a powerful chemotaxonomic tool that provides a detailed view of the differences and similarities between species (Liu and Liu 2013). Bezić et al. (2009) reported on the essential oil composition and Internal Transcribed Spacer (ITS) sequence variability of four South-Croatian *Satureja* species (Lamiaceae) and this is the first report on the comparison between the phytochemical and DNA sequence data in *Satureja* species which was helpful for understanding the interspecies relationships in this genus.

1.10. The genus *Artemisia* L.

The family Asteraceae, also named Compositae, is the largest family of the angiosperms in terms of number of species, with 1620 genera and 23,600 species (Funk et al. 2005). It comprises about 8-10% of all flowering plants. Majority of members of Asteraceae are herbs and they are identified by a set of characters including fused anthers, a fruit with a single ovule and inflorescence called capitulum (Garcia et al. 2010). The family occurs in all continents except in Antarctica (Funk et al. 2005) and includes many edible, medicinal, noxious, invasive and endangered species.

The genus *Artemisia* is widespread in temperate and subtropical regions of the northern hemisphere and less common in the southern hemisphere (Ling 1994; Ling and Peng 1998; Ling, Humphries and Shultz 2006). The generic name *Artemisia* is derived from 'Artemis', which refers to Diana, a Greek Goddess. The name of the Goddess Artemis was given to the genus because, one of the species *Artemisia vulgaris* L. was used for women's disease in folk remedy (Takeda 1971). The genus *Artemisia* is

economically important and are used medicinally throughout the world in Europe, Middle East countries, Afghanistan, Pakistan, India, China, Korea etc. Most of them are aromatic shrubs and herbs with high medicinal value, due to the presence of monoterpenes, sesquiterpenes, flavonoids, and other compounds (Lao, Fujimoto, and Tatsuno 1984; Ling 1992; Mucciarelli and Maffei 2002). The 500 species of *Artemisia* are mainly found in Asia, Europe and North America. Asia has the greatest concentration of species with 150 accessions in China, 174 in the ex-USSR, about 50 species reported in Japan, and 35 species in Iran. The large genus *Artemisia* from the tribe Anthemideae consists of important medicinal plants which have great phytochemical importance because of their biological and chemical diversity and production of essential oils (Abad et al. 2012).

The genus *Artemisia* L. is one of the extensively distributed genera and the largest genus of the Anthemideae tribe. The genus is predominantly composed of perennial plants (e.g., *Artemisia gmelinii* Stechm., *Artemisia desertorum* Spreng.), but some are known to behave either as annuals (*Artemisia jacutica* Drobow., *Artemisia palustris* L.) or biennials (*Artemisia biennis* L.) (Bremer and Humphries 1993; Ling, Humphries, and Shultz 2006). The genus have variability of biotypes, being primarily considered as herbs (*Artemisia annua* L., *Artemisia vulgaris* L.), sub-shrubs (*Artemisia changaica* Krasch., *Artemisia crithmifolia* L.) and shrubs which may develop highly lignified stems (*Artemisia tridentata* Nutt.). The genus have the capability to inhabit many different ecosystems and environmental conditions ranging from deserts and semi-deserts (steppes, tundras and slope hills), forests and deeply anthropized meadows to humid areas and from sea level to high mountains at almost 4000m (Pellicer, Garnatje, and Vallès 2011).

1.10.1. Geographical Distribution

Current distribution of the genus *Artemisia* is a result of the long period of developmental, evolutionary and migrational consequences. *Artemisia* species are commonly spread in the temperate, cold temperate and subtropical areas of northern hemisphere. Two main centers of the genus diversity are Eurasia and North America. Some species dominate the landscape in different arid climates of the world and are regularly found as the leading type of vegetation in some localized plant communities forming associations with other species in steppe environment. Their occurrence with less

diversity is also recognized in some coastal areas of Northern hemisphere. *Artemisia* is not common in the Southern Hemisphere (Ling 1982; Valles and McArthur 2001).

1.10.2. Economic importance of the genus *Artemisia*

The genus *Artemisia* which constitute about 500 species have high economic values in many fields. They are used as food (absinth, *A. absinthium*, *A. genipi* in the preparation of liquors); as spices (tarragon or estragon, *A. dracuncululus*); in medicine as an antihelminthic (*A. santonicum* and *A. brevifolia*) and anti-malaria biochemicals (*A. annua*); as forage (*A. herba-alba* and *A. scoparia*, *A. tridentate*), as ornamentals (*A. absinthium*, *A. caucasica*, and *A. stelleriana*); and also used as soil stabilizing agents in badly disturbed habitats (*A. ludoviciana* and *A. vulgaris*) (Bailey 1976; Turner and Wassen 1999). Some are invasive weeds in crop fields (*A. verlotiorum*), some are toxic (*A. absinthium*, *A. scoparia*) and while some cause allergy (*A. barrelieri*) (Giner et al. 1999).

1.10.2.1. Importance in Medicine

The genus *Artemisia* has a long medicinal history and various extracts and isolates are used against many diseases. The World Health Organization formally recommended *A. annua* as antimalarials (Zinczuk et al. 2007). *Artemisia* species contain alkaloids, vitamins A, B₁, B₂, C and various minerals which is used in the treatment of gastrointestinal problems, uterine bleeding and asthma (Lee 1965, 1975). They also contain various other substances such as coumarine derivatives, which are used to enhance liver functions (Gilani and Janbaz 1993; Hahn 1966; Kimura et al. 1985) and were used as an effective antioxidant and anticarcinogen (Hoffmann and Herrmann 1982; Hwang et al. 1998; Lee et al. 1999). The anthelmintic activity of *Artemisia herba-alba* has been reported against *Haemonchus* species (Idris, Adam, and Tartour 1982); *Artemisia pallens* against *Pheritima posthuma*, *Taenia* and *Ascaris* species (Nakhare and Garg 1991), *Artemisia maritima* against *Strongyloides*, *Nematodirus* and *Trichostrongylus* species (round worms) (Sharma 1993) and *Dipylidium caninum* (tapeworm) and *Taenia* species (Narayana et al. 1976). The essential oil of *A. herba-alba* Asso inhibited the asexual reproduction of *Aspergillus niger* Tiegh, *Penicillium italicum* Wehmer and *Zygorrhynchus* species (Tantaoui-Elaraki, Ferhout, and Errifi 1993). Valecha et al. (1994) reported the antimalarial activity of *Artemisia japonica*, *Artemisia maritima* and *Artemisia nilagirica*; and Delazar et al. (2007) reported antioxidant activity of the

essential oil from *Artemisia fragrans* and *Artemisia austriaca*. Jeong et al. (2007) reported the effectiveness of extracts of *Artemisia argyi* and *Artemisia asiatica* Nakai against human breast cancer. Iriadam et al. (2006) explained the antidiabetic properties of *Artemisia herba-alba* and Chanphen et al. (1998) isolated antimalarial principles from *Artemisia indica* Willd. Sharif et al. (2006) experimentally established the effect of methanolic extract of *Artemisia aucheri* in wound healing and leishmaniasis.

Artemisia species are used as medicinal plants in folk medicines worldwide. Some species such as *A. absinthium* L., *A. annua* L. and *A. vulgaris* L. have been included in the pharmacopoeias of several European and Asian countries (Proksch 1992). Ko et al. (2006) reported that the digestive activity of sheep was enhanced when rice straw was replaced with wormwood (*Artemisia* species) in its diet. Iqbal et al. (2004) reported that *A. brevifolia*, locally named as ‘Afsanteen’ is broadly used in ethnoveterinary medicine of Pakistan as an anthelmintic. Wright (2002) mentioned the conventional use of *Artemisia annua* L. for fever and malaria in China. In Thailand, *Artemisia indica* Willd. stem extract is used for malaria (Farnsworth and Bunyapraphatsara 1992). The conventional Chinese medicine ‘*Herba Artemisiae Scopariae*’ is the dried sprout of *Artemisia scoparia* Waldst. et Kit which can clear away heat, promote diuresis, normalize the function of the gall bladder, and cure jaundice (Committee of National Pharmacopoeia 2005). In addition to having a cholagogic effect, it also has other pharmacological actions, such as protecting liver, lowering the blood pressure, eliminating fever, sedation, anti-inflammation, antibacterial, anti-pathogenic microbes, and antitumor action (Ramezani et al. 2004). Cha et al. (2005) reported that *A. scoparia* has extensive clinical applications in the treatment of acute icteric infectious hepatitis, hyperlipemia and oral ulcer. *Artemisia aucheri* is a native plant very common in north of Iran, which is used to treat leishmaniasis in folk medicine of Iran (Azadbakht et al. 2003; Furtado, Cisalpino, and Santos 1960). The whole plant of *A. dubia* is used as a purgative. It is used in the treatment of hysteria, asthma, skin diseases like scabies and ulcers in Magar of Bukini, Baglung and Western Nepal (Sapkota 2008).

This plant is used in traditional medicine for the treatment of various diseases such as poor appetite, indigestion, constipation, travel sickness, parasitic infection, irregular menstruation, menstrual pain, cramp, cold, epilepsy, typhoid, tuberculosis,

urinary calculi, colic fever, asthma, bronchitis, sciatica, flatulence, anaemia, insomnia, gout, depression, nervousness, hysteria, measles, bruise, chilblain, leprosy, pruritus, malaria, fungal infection, leishmaniasis and cancer. This herb is also used as antiseptic, antioxidant, anthelmintic, expectorant, diuretic, diaphoretic, cholagogue and insect repellent. These medicinal properties of *Artemisia nilagirica* may be due to the secondary metabolites such as flavonoids, terpenoids, saponins, polysaccharides and essential oil constituents (Ahameethunisa and Hopper 2010; Ashok and Upadhyaya 2010; Avula et al. 2009; Bhatt and Baek, 2006; Devmurari and Jivani 2010; Devmurari et al. 2010; Ganesan and Paulsamy 2011; Judžentienė and Buzelytė 2006; Perumal et al. 2010; Pradeep et al. 2010; Satani and Mishra 2012; Sati et al. 2013; Shafi et al. 2004; Suseela, Gopalakrishnan and Varghese 2010; Tajadod et al. 2012; Vijayalakshmi et al. 2011; Xie et al. 2008). Rani et al. (2012) reported the pharmacognostic and phytochemical screening of *Artemisia nilagirica* leaves in Nilgiris district of Tamil Nadu.

1.10.2.2. Insecticidal Properties

Several *Artemisia* species have insecticidal, insect repellent and insect antifeedent properties (Grainge and Ahmed 1988; Jacobson 1989; Shakarami, Kamali, and Moharramipour 2004). Negahban and Moharramipour (2005) reported that *Artemisia scoparia* Waldst and Kit have fumigant activity against several stored-product pests. Extracts of *A. absinthium* L. have insecticidal action against the storage pest *Sitophilus granarius* L. (Ignatowicz and Wesolowska 1994) and nematocidal action against *Meloidogyne incognata* Kofoid and White (Walker 1995), whereas, Negahban, Moharramipour, and Sefidkoun (2007) reported the fumigant toxicity of essential oil from *Artemisia sieberi* Besser against three insects, *Callosobruchus maculatus*, *Sitophilus oryzae*, and *Tribolium castaneum*.

1.10.2.3. Other uses

The oil of *Artemisia herba-alba* acts as a good inhibitor for the corrosion of steel in phosphoric acid medium (Benabdellah et al. 2006). Wright (2002) mentioned the high value essential oil of *Artemisia pallens* Bess., which is used in perfumery as ‘davana oil’ in India. *Artemisia pallens* is also used in cosmetics and flavoring industries (Rekha and Langer 2007). The seeds of *Artemisia sphaerocephala* Krasch contains a layer of gum which is polysaccharide in nature and can be used as thickener, stabilizer, water retention

agent, filmogen (Bai, Yong, and Yun 2000). The leaf juice of *A. dubia* is used for the treatment of leprosy and in preparation of fermenting medium for their traditional liquor in Madhupur, Tangail, Bangladesh (Anisuzzaman et al. 2007). *Artemisia absinthium* is cultivated for the mass of ferny, aromatic silvery grey foliage and *Artemisia ludoviciana* is used as an ornamental plant for its silvery white leaves (American Horticulture Society 2000).

1.11. Origin of the research problem

The genus *Artemisia* of family Asteraceae (Compositae) is one of the largest and most complicated genus of the family. There are about 500 species of *Artemisia* reported in the world and out of which about 45 species are found in India (Shah 2014). They consists of herbs and shrubs with high medicinal values. Most of them are aromatic plants with rich source of essential oils. *Artemisia* species are mainly used in traditional system of medicine, Unani, Ayurveda and ethobotanically used as an incense due to their sweet aromatic odour or as an offering to local deities (Shah 2014). The famous and most effective antimalarial drug artemisinin is extracted from *Artemisia annua*, a Chinese medicinal plant. Artemisinin is discovered by You-You Tu, a Chinese phytochemist and her team of phytochemical experts from the medicinal plant *Artemisia annua*, which is mentioned in Chinese medicinal books. About 45 species of *Artemisia* are reported from India, of which two are from Kerala. From the extensive literature survey conducted, it is known that the works on *Artemisia* spp. in Kerala is not sufficient. During the collection of *Artemisia* spp. which are reported in Kerala, *Artemisia nilagirica* (C.B. Clarke) Pampan. and *Artemisia japonica* Thunb., and a plant which is similar in morphology to *Artemisia nilagirica*, but of short stature was collected from Idukki district of Kerala. The plant did not flower during the study period. So there is a question of proper identity of this plant. Based on the overall appearance and aroma, this plant was also chosen for the present study. There is a need to study the phytochemical aspects of *Artemisia* spp. because they are a rich source of essential oils. DNA barcoding is a modern method of identification of species, and an aid to conventional taxonomic method to identify a species and to understand the range of variability. So the present study envisages to analyse the variability of essential oils, to estimate the content of artemisinin, to find out a proper DNA barcode for *Artemisia* spp. and to study the morpho-anatomical characters which may eventually solve the identity of *Artemisia* sp. with short stature.

1.12. Relevance of the present work

This work focusses on the phytochemical and molecular aspects of *Artemisia* spp. reported in Kerala. During the collection of the plants, a plant which is morphologically similar to *Artemisia* spp. was seen. Identity of this plant was not known, because it did not flower during the tenure of the study. So the significance of the study lies in this aspect. The work focusses on studying the phytochemical and molecular aspects, which aids to the conventional taxonomic method for the proper identification of the species, to find the variability in the phytochemical constituents of the species, and also to conduct DNA barcoding of *Artemisia* spp. under study.

1.13. Objectives

- To analyse the essential oil constituents in selected *Artemisia* spp. by Gas Chromatography-Mass Spectroscopy (GC-MS).
- To study the variation in the essential oil constituents in different seasons and locations.
- To estimate the antimalarial drug artemisinin in using High Performance Liquid Chromatography (HPLC).
- To conduct molecular studies using DNA barcoding method.
- To conduct phylogenetic analysis and to infer the relationships with other species deposited in the GenBank.
- To compare the morpho- anatomical features.