INTRODUCTION

Nature has served as a rich repository of medicinal plants for thousands of years and an impressive number of modern drugs have been isolated from natural sources, notably of plant origin (Cowan, 1999; De Carvalho and Ferreira, 2001; Kayser and Kiderlen, 2001). Herbal medicines, based on their traditional uses in the form of powders, liquids or mixtures, have been the basis of treatment for various ailments in India since ancient times. The beneficial health effects of many plants, used for centuries as seasoning agents in food and beverages, have been claimed for preventing food deterioration and as antimicrobials against pathogenic microorganisms (Ahmad et al., 1998; Arora and Kaur, 1999; Rojas et al., 2006; Arora et al., 2009).

India possesses rich floristic wealth and diversified genetic resources of medicinal plants (Arora et al., 2003). These are widely used in the traditional systems of medicine and are referred in the folklore. Herbal medicines have been the basis of treatment and cure for various diseases and physiological condition in traditional methods practiced such as Ayurveda, Unani and Siddha. Several plant species are used by many ethnic groups for the treatment of various ailments ranging from minor infections to dysentery, skin diseases, asthma, malaria and a horde of other indications (Perumalsamy and Ignacimuthu, 1998, 2000; Dahanukar et al., 2000). The past three decades have seen a dramatic increase in microbial resistance to antimicrobial agents (Chopra et al., 1996) that leads to repeated use of antibiotics and insufficient control of the disease (NCID, 2002).

Infectious diseases are the world’s leading cause for premature deaths, killing almost 50,000 people every day. In recent years, drug resistance to human pathogenic
bacteria has been commonly reported from all over the world (Robin et al., 1998). However, the situation is alarming in developing as well as developed countries due to the indiscriminate use of antibiotics. The drug-resistant bacteria and fungal pathogens have further complicated the treatment of infectious diseases in immune compromised, AIDS and cancer patients (Diamond, 1993). In the present scenario of emergence of multiple drug resistance to human pathogenic organisms, this has necessitated a search for new antimicrobial substances from other sources including plants. Traditionally used medicinal plants produce a variety of compounds of known therapeutic properties (Iyengar, 1985; Chopra et al., 1992; Harborne and Baxter, 1995). The substances that can either inhibit the growth of pathogens or kill them and have no or least toxicity to host cells are considered candidates for developing new antimicrobial drugs. In recent years, antimicrobial properties of medicinal plants are being increasingly reported from different parts of the world (Grosvenor, et al., 1995; Ratnakar and Murthy, 1995; Silva et al., 1996; Saxena, 1997; David, 1997; Nimri et al., 1999; Saxena and Sharma, 1999) and there has been a growing interest in alternative therapies and the therapeutic use of natural products, especially those derived from plants (Goldfrank et al., 1982). This interest in drugs of plant origin may be due to several reasons like, inefficiency of conventional medicines and abusive and/or incorrect use of synthetic drugs resulting in side effects and other problems.

Natural products produced by plants, microorganisms, insects and animals have been isolated as biologically active pharmacophores (Gordon and David, 2005; Wang et al., 2006; Cragg and Newman, 2007). Approximately one-third of the top-selling drugs in the world are natural products or their derivatives often with ethno pharmacological background (Kingston, 2009). The advantage of natural
products for random screening is the structural diversity provided by natural products, which is greater than that provided by the most available combinatorial approaches based on heterocyclic compounds (Harvey, 1999). Cox (1994) suggested that the ethno-directed sampling is most likely to succeed in identifying drugs used in the treatment of cancer, inflammatory and dermatological complaints. According to Chatterjee et al. (2006), tribal healers in most of the countries administered the ethnomedicine to treat cut wounds, skin infection, swelling, aging, mental illness, cancer, asthma, diabetes, jaundice, scabies, eczema, venereal diseases, snakebite and gastric ulcer, and they provide instructions to local people about the preparation of medicine from herbs. The use of plant extracts and pure compounds isolated from natural sources provided the important source to modern pharmaceutical compounds (Alluri et al., 2006). Currently, plants are important sources for the discovery of novel pharmacologically active compounds with many blockbuster drugs being derived directly or indirectly from plants. Natural products are widely viewed as templates for structure optimization programs designed to make perfect new drugs, referred to by industry as “New Chemical Entities” (NCEs) (Raskin et al., 2002). The WHO considers phytotherapy in its health programs and suggested basic procedure for the validation of drugs from plant origin in developing countries.

Traditional knowledge of medicinal plants has always guided the search for new cures. In spite of the advent of modern high throughput drug discovery and screening techniques, traditional knowledge systems have given clues to the discovery of valuable drugs (Buenz et al., 2004). Nowadays, traditional medicinal practices form an integral part of complementary or alternative medicine. Although their efficacy and mechanism of action have not been tested scientifically in most cases,
these simple medicinal preparations often mediate beneficial responses due to their active chemical constituents (Park and Pezzutto, 2002).

Phytochemistry is fundamentally devoted to the study of secondary metabolism, which reflects the diversity of biochemistry. Tens to thousands of complex molecules were invented from plants during their development to serve the purpose of resistance against plant pathogens and predators. It is these compounds which have fascinated natural product chemists, biochemists, pharmacognosists and phytopathologists in the past decades by their structure, mechanism of synthesis, underlying chemical reactions, function and commercial applications (Spenser, 1968).

Primary metabolic routes produce primary metabolites, which are present almost universally in nature and are necessary for all life forms. These compounds include common carbohydrates, fats, proteins and nucleic acids that are needed to create and maintain life. Apart from fats, these compounds are polymeric and usually chemically large molecules. Typically, they are involved in the energy regulation of organisms and with growth and development of tissues; in short, they are the building blocks of organisms. The secondary metabolites are of more limited occurrence. While some do not have a proven function in the organism, others apparently play a vital role. Some secondary metabolites of plants are found only in certain species of families, showing the individuality of species (Samuelsson, 1992).

Most studies on such medicinal plants pertain to their organic contents, viz. essential oils, glycosides, vitamins, alkaloids and other active components and their pharmacological/therapeutic effects. Besides several organic compounds, it is now well established that many trace elements play a vital role in general well-being as well as in the cure of diseases. Several studies have reported elemental contents in
plant extracts, which are consumed by us either as an herbal drink or medicine (Powel et al., 1998; Abou Arab and Donia, 2000; Kumar et al., 2005). These elements are present at varying concentrations in different parts of the plants, especially in roots, seeds and leaves which are used as a dietary item as well as an ingredient in the ayurvedic medicinal preparation.

Medicinal plants are still a major part of the traditional medical system in developing countries. Several herbal remedies are now being intensively used in therapy. The use of medicinal plants as antiinflammatory and antiarthritic drugs is a practice common in India, although in most cases the active principles of the plants are unknown. However, scientific evaluation of the pharmacological effects, viz; anticancer, antidiabetic, hepatoprotective, antifertility, antihyperlipidaemic, antiinflammatory and immunomodulatory activities of the herbal crude extracts can still be used as a logical research strategy in the search for new drugs.

**Anticancer**

According to the World Health Organization (WHO) based on the morbidity, mortality, economic burden and emotional hardship, cancer may be considered the most onerous health problem affecting people worldwide. Currently, over 22.4 million people in the world are suffering from cancer. Approximately 10.1 million new cases are diagnosed with cancer annually and more than 6.2 million die of the disease in the year 2000. This represents an increase of around 19% in incidence and 18% in mortality since 1990.

Cancer is one of the leading causes of morbidity and mortality worldwide, despite enormous efforts of science researchers from various disciplines aimed at ameliorating the dismal outcome of cancer mortality. The rate of death due to cancer
has not declined significantly even with advances in surgery, radiotherapy and chemotherapy. Prevention of cancer remains evidently an essential part of the contest against cancer in the world (Zhao et al., 2010; Jermal et al., 2009).

Cancer cells occur as a result of unique multiple genetic disorders that may arise from exposure to environmental and occupational carcinogenic agents or dietary habits and infectious agents (Sugimura, 1992). The increased incidence of cancer in the world today justifies the application of phytochemical chemoprevention. This is the use of common natural dietary compounds from plants to inhibit, block or reverse tumour multiplication at various stages such as initiation, promotion or progression of carcinogenesis. These phytochemicals lower the risk of cancer development in humans via for example, radical scavenging, antioxidation mechanisms, antiinflammatory and antiproliferative mechanisms (Kwak and Kensler, 2010; Parys et al., 2010; Surh, 2003). An important aim of cancer research is to find therapeutic compounds having high specificity for cancerous cells/tumor and fewer side effects than the presently used cytostatic/cytotoxic agents.

**Antidiabetic**

Diabetes mellitus is the most common endocrine disorder. More than 150 million people are suffering from it worldwide (Tripathi, 2003) and it is likely to increase to 300 million by the year 2025. More than one-fifth of them are Indians and the International Diabetes Federation, declared India “Diabetic Capital of the World”. Synthetic antidiabetic agents can produce serious side effects and they are not suitable for use during pregnancy. In view of the adverse effects associated with the synthetic drugs and considering natural medicine to be safer, cheaper and effective, traditional antidiabetic plants can be explored (Kamboj, 2000). Many plants have been used for
the treatment of diabetes mellitus in Indian system of medicine and in other ancient systems of the world. Out of these, only a few have been evaluated as per modern system of medicine. Furthermore, after the recommendation made by WHO on diabetes mellitus, investigations on hypoglycemic agents from medicinal plants have become more important (WHO, 1980). Since the plant products have less side effects, they have the potential as good hypoglycemic drugs. They may also provide clues for the development of new and better oral drugs for diabetes.

**Hepatoprotective**

Liver disease is still a worldwide health problem. Unfortunately, conventional or synthetic drugs used in the treatment of liver diseases are inadequate and sometimes can have serious side effects (Guntupalli *et al.*, 2006). In the absence of a reliable liver protective drug in modern medicine there are a number of medicinal preparations in Ayurveda recommended for the treatment of liver disorders (Chatterjee, 2000). In view of severe undesirable side effects of synthetic agents, there is a growing focus on the systematic research methodology and scientific evaluation of the traditional herbal medicines that are claimed to possess hepatoprotective activity.

**Antifertility**

India within a few years of time span will be the leading country as far as the population growth is concerned. Since the population is rising tremendously, this may affect drastically the economic growth of India. Family planning has been promoted through several methods of contraception, but due to the side effects produced by the use steroidal contraceptive (Bingel and Benoit, 1973) and use of abortifaciant drugs, there is a need for the drug which is effective with lesser side effects.
Antiinflammatory

Antiinflammatory refers to the property of a substance or treatment that reduces inflammation. Inflammatory diseases including different types of rheumatic diseases are very common throughout the world. Although rheumatism is one of the oldest known diseases of mankind and affects a large population of the world, no substantial progress has been made in achieving a permanent cure. The search involving screening and development of drugs for antiinflammatory activity is an unending problem. There is much hope for finding active antirheumatic compounds from indigenous plants, as these are still used in therapeutics despite the progress made in conventional chemistry and pharmacology for producing effective drugs (Handa et al., 1992).

With this backdrop, the present study was carried out to investigate the phytochemical profile and pharmacological activities viz; antioxidant, anticancer, antidiabetic, hepatoprotective, antifertility, and antiinflammatory activities of the whole plant ethanol extract of *Cynoglossum zeylanicum* (Vahl ex Hornem.) Thunb. ex Lehm. (Boraginaceae), through animal model.

The current investigations were carried out to:

1. Study the following pharmacochemical characterization and qualitative photochemical analysis of whole plant of *Cynoglossum zeylanicum*.
   - Ash and extractive values
   - Fluorescence analysis
   - Preliminary phytochemical screening

2. Examine the HPTLC profile of whole plant of *C. zeylanicum* to confirm the presence of alkaloids, coumarins, glycosides, steroids and phenols.
3. GC-MS analysis of whole plant ethanol extract of *C. zeylanicum* to identify the phytocompounds.

4. LC-MS analysis of whole plant of *C. zeylanicum* to identify the compounds.

5. Isolate and characterize the phytocompounds using spectral studies.

6. Assess *in vitro* antioxidant activity of different solvent extracts of whole plant of *C. zeylanicum*.

7. Evaluate the anticancer activity of the whole plant ethanol extract of *C. zeylanicum*.

8. Determine the antidiabetic activity of ethanol extract of whole plant of *C. zeylanicum*.

9. Assess the hepatoprotective activity of the whole plant ethanol extract of selected plant.

10. Examine the antifertility activity of the whole plant ethanol extract of *C. zeylanicum*.

11. Evaluate the antiinflammatory activity of ethanol extract of whole plant of *C. zeylanicum* on carrageenan induced edema in rats.