INTRODUCTION

1.1. CURRENT STATUS OF MEDICINAL PLANTS

Throughout the ages, humans have relied on the nature for their basic needs for the production of food stuffs, shelter, clothing, means of transport, fertilizers, flavors, fragrances and not the least medicine. Plants have formed the basis of traditional systems of medicine that have been in existence for thousands of years and continue to provide mankind with new remedies (Gurib Fakim 2006).

Research on medicinal plants had continued to be an area of major interest and properties for pharmacologists, microbiologists and drugs developing in India and abroad for the last several decades. Plant products as part of food or botanical potions and power have been used with varying success to cure and prevent diseases throughout history (Raskin et al. 2002). The medicinal plants have been found as a source of diverse bioactive and therapeutic compounds. In recent years there has been rowing interest in alternative therapies and the therapeutic use of natural products especially those derived form plants (Gold frank et al., 1982; Cowan 1999).

This interest in drugs of plant origin is due to several reasons namely conventional medicine can be inefficient (e.g. side effects and ineffective therapies), abusive and/or incorrect use of synthetic results in side effects and other problems and a large percentage of the worlds population does not have access to conventional pharmacological treatments. (Rates, 2001) Plants have interdependent biochemical pathways that lead to the syntheses of numerous metabolites. Most of these metabolites are physiologically active and are being exploited for human and animals as they are being screened for various therapeutic properties as a source of new drugs. Recent findings shown their useful properties like anticancer (Konishi et al., 1998; Konoshima, 2002), antiviral (Hudson, 1990; Cowan, 1999) antidysenteric (Chopra, et al. 1958; De-Souza, 1991), antiseptic and antihepatotoxic (Evan,2001), antistress (Mplantinos, 1998), immunotherapeutic (Lednicer and Snader, 1991), anti-
inflammatory (Chopra et al. 1956, Lee 1998, 2009) and antipyretic (Chattopadhyay et al. 2005) effects of medicinal plants. With the realization that plants are a repository of thousands of potential medicines, concentrated efforts from India and around the world have made to screen the traditional medicinal plants for various uses.

As per World Bank reports trade in medicinal plants, botanical drug products and raw material is growing at an annual growth rate between 5 to 15%. The Global pharmaceutical market has risen from US $550 billion in 2004 worth to a close to US$900 billion in the year 2008. The herbal industry shares about US$62 billion with good growth potential. In India the value of botanicals related trade is about US$10 billion per annum with annual export of US$1.1 billion. Presently the United States is the largest market for Indian botanical products accounting for about 50% of the total exports. Within the European community botanical medicine represents an important share of the pharmaceutical market. The dietary supplement, self medication and functional good segments is driven by consumer and health concerns. Broadly speaking, these trends include antiaging, weight control, joint and bone health digestion / immunity cardiovascular health / diabetes, cognition / memory, female / male and the growing wellness and beauty trends. Another trend benefiting the herbs and botanical market is the natural and the exotic ingredients trend, which is taking off in functional food, as well as medicinal products (Sangita et al., 2011).

India also has a very long, safe and continuous usage of many herbal drugs in the officially recognized alternative systems of health viz. Ayurveda, Yoga, Unani, Siddha, Homeopathy and Naturopathy. These systems have rightfully existed side by side with Allopathy and are not in ‘the domain of obscurity’, as stated by (Venkat Subramanian, 2003). Millions of Indians use herbal drugs regularly, as spices, home-remedies, health foods as well as over-the-counter (OTC) as self-medication or also as drugs prescribed in the non-allopathic systems (Gautam et.al. 2003). The developer of potent natural product penicillin, Nobel-laureate Ernst Boris Chain wrote an inspiring article entitled “The quest for new biodynamic substances”. In 1967, he wrote, “In Indian continent there has been an extensive drive aimed at the systemic study
of medicinal plants traditionally used in these countries in folklore medicine; this has failed, so far, to bring to light new classes of compounds with interesting pharmacologic activities. As far as drug research is concerned, therefore, we cannot expect many major surprises to come from the study of plant constituents” (Chain, 1967).

1.2. **NIGELLA SATIVA, A MEDICINALLY IMPORTANT PLANT**

1.2.1. Classification

| Kingdom: | Plantae          |
| Division: | Magnoliophyta    |
| Class:    | Magnoliopsida    |
| Order:    | Ranunculales     |
| Family:   | Ranunculaceae    |
| Genus:    | Nigella          |
| Species:  | *N. sativa*      |

1.2.2. Description

*Nigella sativa*, commonly known as kalonji, Black cumin, fennel flower, blackseed, or black onion seed, is an annual flowering plant, belonging to Ranunculaceae family, native to southwest Asia. The plant is indigenous to the Mediterranean region but now found widely in India (Jammu, Kashmir, Himachal Pradesh, Bihar, Assam and Punjab).

It grows to 20–30 cm tall, with finely divided, linear (but not thread-like) leaves. The flowers are delicate, and usually colored pale blue and white, with 5–10 petals. The fruit is a large and inflated capsule composed of 3–7 united follicles, each containing numerous seeds. The seeds are usually three-cornered, with two sides flat and one convex, black or brown externally white and oleaginous, strong agreeable aromatic odour, like that of nutmegs, and a spicy, pungent taste. The seed is used as a spice (Varghese, 1996; Dwivedi, 2003).
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Plate 1.1: Plants of *N. sativa.*

Plate 1.2: Flower of *N. sativa.*

Plate 1.3: A capsule (fruit) of *N. sativa.*

Plate 1.4: Seeds of *N. sativa.*

1.2.3. History of Cultivation

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According to Zohary and Hopf (2000), archeological evidence about the earliest cultivation of *N. sativa* "is still scanty", but they report that *N. sativa* seeds have been found in several sites from ancient Egypt, including Tutankhamun's tomb. Although its exact role in Egyptian culture is unknown, it is known that items entombed with a pharaoh were carefully selected to assist him in the after life.

The earliest written reference to *N. sativa* is thought to be in the book of Isaiah in the Old Testament where the reaping of *Nigella* and wheat is contrasted (Isaiah 28: 25, 27). Easton's Bible dictionary states that the Hebrew word *ketsah* refers to without doubt to *N. sativa* (although not all translations are in agreement). According to Zohary and Hopf, *N. sativa* "was another traditional condiment of the Old World during classical times; and its black seeds were extensively used to flavor food." (Zohary and Hopf, 2000).

### 1.2.4. Nutritional value

Black seed is rich in nutritional values. (Sharma *et al.*, 2009).

- The black seed contains Monosaccharides (glucose, rhamnose, xylose, and arabinose) and non-starch polysaccharide component which is a useful source of dietary components.
- It is rich in fatty acids, particularly the unsaturated and essential fatty acids (Linoleic and Linoleic acid).
- Fifteen amino acids make up the protein content of the black seed, including eight of the nine essential amino acids.
- Black seed contains Arginine which is essential for infant growth.
- Chemical analysis has further revealed that the black seed contains carotene, which is converted by the liver into vitamin A, the vitamin known for its anti-cancer activity.
- The black seed is also a source of calcium, iron, sodium, and potassium.

### 1.2.5. History of Medicinal Uses
N. sativa has been used for medicinal purposes for centuries, both as a herb and pressed into oil, in Asia, Middle East, and Africa. It has been traditionally used for a variety of conditions and treatments related to respiratory health, stomach and intestinal health, kidney and liver function, circulatory and immune system support, as analgesic, antiinflammatory, antiallergic, antioxidants, anticancer, antiviral and for general well-being. Its many uses have earned Nigella the Arabic approbation 'Habbatul barakah', meaning the seed of blessing.

In Islam, it is regarded as one of the greatest forms of healing medicine available. It is included in the list of natural drugs of 'Tibb-e-Nabavi' as Prophet Muhammad (Peace be upon him) once stated that the “black seed can heal every disease-except death-as recounted in the following hadith:” (Sahih Muslim : Book 26 Kitab As-Salam, Number 5489)

Narrated Khalid bin Sa'd (May Allah be pleased with him): We went out and Ghalib bin Abjar (May Allah be pleased with him) was accompanying us. He fell ill on the way and when we arrived at Medina he was still sick. Ibn Abi 'Atiq came to visit him and said to us, "Treat him with black cumin. Take five or seven seeds and crush them (mix the powder with oil) and drop the resulting mixture into both nostrils, for 'Aisha (May Allah be pleased with her) has narrated to me that she heard the Prophet (Peace be upon him) saying, 'This black cumin is healing for all diseases except As-Sam.' 'Aisha said, 'What is As-Sam?' He said, 'Death.' "(Sahih Bukhari)

Avicenna, most famous for his volumes called The Canon of Medicine, refers to Nigella as the seed that stimulates the body's energy and helps recovery from fatigue and dispiritedness.

Seeds of this plant have also been extensively used in the Unani system of medicine ranging from external application to ingestion for diseases such as diabetes, kidney failure (Bhatti & Rehman, 2009).

In folk medicine, it has been traditionally used for variety of applications including treatments related to respiratory health, stomach and intestinal health, kidney and liver function, circulatory and immune system support, and for general overall wellbeing (Anwar, 2005). Recent Integral University, Lucknow.
pharmacological investigations have proved the potential therapeutic effects of 
NS seed as well as its oil through various studies (Tariq, 2008).

1.2.6. Clinical Activities of *N. sativa*

1.2.6.1 Antimicrobial and antidermatophyte activity

The ethanolic extract of *N. sativa* was shown to have outstanding *in vitro* antibacterial activity against both methicillin resistant and sensitive strains of *Staphylococcus aureus* (Hanafy and Hatem, 1991). Microgram concentrations of the diethyl ether extract of *N. sativa* (25-400 μg extract/disc) inhibited growth of Gram-positive bacteria (*Staphylococcus aureus*), Gram-negative bacteria (*Escheria coli* and *Pseudomonas aeruginosa*) and a pathogenic yeast (*Candida albicans*) (Nair et al. 2005). *In vivo* studies showed that the diethyl ether extract successfully eradicated localized infections of *Staphylococcus aureus* in mice (Nair et al. 2005). *N. sativa* oil may potentially be useful for inhibition of *Listeria monocytogenes* in food as it showed strong antibacterial activity against 20 strains of the bacteria with the oil producing inhibition zones that were significantly larger than that of Gentamicin (Salem and Hossain, 2000).

*N. sativa* elicited antiviral effect against *Murine cytomegalovirus* (MCMV) (Aljabre et.al 2005). It is also a source of antidermatophyte drugs. (Aboul-Ela, 2002).

1.2.6.2. Anticestodal activities

The essential oil of the Black Seed has been reported to exhibit fairly good antiparasitic (anthelminintic) activity against earthworms (*Pheritima posthuma*), tapeworms (*Taenia solium*), hookworms (*Bunostomum trigonocephalum*) and nodular worms (*Oesophagostomum colombionum*). The anthelminintic activity against earthworms and tapeworms was found to be
comparable with that of the chemical agent piperizine phosphate. (Agarwal et al. 1979; Akhtar, 1991, 1997.)

1.2.6.2. Antioxidant activity

The antioxidant activity of *N. sativa* oil was dependent on thymoquinone and carvacrol (Thippeswamy & Naidu, 2005). The antioxidant potency of a methanolic extract of *N. sativa* was found to be higher than the aqueous extract in soybean lipoxygenase and rat liver microsomal lipid peroxidation assays, and also in the DPPH assay (Al-Saleh et al. 2006). Antioxidants present in *N. sativa* seeds include selenium, DL-α- and DL-γ-tocopherol, all-trans retinol, thymoquinone and thymol (Kanter et al. 2006). *N. sativa* and thymoquinone partly protected rat gastric mucosa from acute ethanol-induced gastric mucosal damage, with the gastroprotection mediated by their antiperoxidative, antioxidant and antihistaminic effects (Al-Othman et al. 2006). Supplementation of the diet of rats fed oxidised corn oil with *N. sativa* led to an improvement in the overall antioxidant capacity as evidenced by a marked reduction in red blood cell hemolysis and plasma alanine transaminase (ALT), aspartic transaminase (AST) activities and a reduction in the formation of thiobarbituric acid reactive substances, indices of peroxidative damage (Badary et al. 2003). The antioxidant effects are attributed to thymoquinone, a main constituent of the volatile oil of *N. sativa*. Thymoquinone inhibited iron-dependent microsomal lipid peroxidation (El-Saleh et al. 2004). Rats pretreated with thymoquinone (100 mg/kg orally) or commercial black seed oil (100 µL/kg orally) for 30 min and for 1 week were protected against methionine induced-hyperhomocysteinemia and its associated state of oxidative (Al-Ghamdi, 2001).

1.2.6.4. Hepatoprotective activity
Thymoquinone, one of the active constituents of *N. sativa*, is reported to have hepatoprotective activity." An in-vitro study showed the protective effect against tert-butyl hydroperoxide (TBHP)-induced oxidative damage to hepatocytes. The activity was demonstrated by a decreased leakage of alanine transaminase (ALT), aspartic transaminase (AST) and decreased trypan blue uptake (El Gazzar *et al.* 2006).

1.2.6.5. Antidiabetic activity

Significant hypoglycaemic activity has been reported and is thought to be due to the essential oil present. Clinical studies have confirmed these results and suggest that the antidiabetic action of the plant extract (El-Dakhakhny *et al.* 2002).

1.2.6.6. Analgesic and anti-inflammatory activity

The aqueous and methanolic extracts of *N. sativa* (dose equivalent to 1.25 g dried plant/kg weight) showed analgesic effect in mice as it produced significant increases in reaction times in the hot plate and pressure tests. Both extracts elicited depressant activity on exploratory conduct and reduced spontaneous motility in mice without causing failure of motor coordination. Both extracts also reduced the normal body temperature (Al-Naggar *et al.* 2003).

The aqueous extract also has an anti-inflammatory effect as demonstrated by its inhibitory effects on carrageenan-induced paw edema in mice (Al-Naggar *et al.* 2003). In rat models of acute lung injury or acute respiratory distress syndrome, thymoquinone (6 mg/kg, administered intraperitoneally) was able to improve lung oxygenation (El Mezayen *et al.* 2006). The anti-inflammatory effect of thymoquinone was supported by its ability to attenuate allergic airway inflammation by inhibiting Th2 cytokines and eosinophil infiltration into the airways and goblet cell hyperplasia (D’antuono *et al.* 2002; Boskabady *et al.* 2004).
Aqueous and macerated extracts of *N. sativa* produced relaxant, anticholinergic (functional antagonism) and antihistaminic effects on guinea pig tracheal chains (Gilani *et al.* 2004).

1.2.6.7. Antitumor activity

Besides the activities mentioned above, the oil and seed constituents of *N. sativa* showed anti-tumor effects in *vitro* and in *vivo* (Salem, 2005, Suryavanshi *et al.* 2007). *N. sativa* (50 and 100 mg/kg body weight, orally) given prophylactically to potassium bromate-treated rats elicited potent chemopreventive effects as evidenced by the suppression of hyperproliferative response, reanl oxidative stress and toxicity (Khan & Sultana, 2005). *N. sativa* also protected against ferric nitrilotriacetate (Fe-NTA)-induced oxidative stress, hyperproliferative response and renal carcinogenesis in rats (Salomi *et al.* 1992). The active principle of *N. sativa* seeds exhibited 50% cytotoxicity to Ehrlich ascites carcinoma, Dalton’s lymphoma ascites and Sarcoma-180 cells with little activity against lymphocytes (Swamy & Tan, 2000). The anti-tumor effects of *N. sativa* oil was attributed to the volatile oil obtained from the seed, the major active components of which were thymoquinone and dithymoquinone (Shoieb *et al.* 2003). Thymoquinone killed cancer cells by a process that involved apoptosis and cell cycle arrest with little effect in non-cancerous cells (Iddamaldeniya *et al.* 2003).

*N. sativa* decreased the frequency of mammary carcinoma in rats (Ilhan *et al.* 2005) and azoxymethane-induced genotoxic effects and colon cancer in rats (Al-Johar *et al.* 2008).

1.2.6.8. Anti-histamine activity

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Histamine is a substance released by bodily tissues, sometimes creating allergic reactions and is associated with conditions such as bronchial asthma. It was reported that the use of Nigellone, a compound isolated from *N. sativa* oil suppressed the symptoms of the condition in the majority of patients. Following the results of this early study, crystalline nigellone was administered to children and adults in the treatment of bronchial asthma with effective results and no sign of toxicity. This delay could be attributed to the possibility of crystalline nigellone being an inhibitory agent on histamine (Chakravarty, 1993).

**1.2.6.9. Anticonvulsant effects**

Thymoquinone may have anticonvulsant activity in petit-mal epilepsy probably through an opioid receptor-mediated increase in GABAergic tone (Ilhan *et al.* 2005). The use of *N. sativa* oil could be a potential approach for arresting or inhibiting seizure genesis caused by excitotoxic agents (Büyüköztürk *et al.* 2005).

**1.2.6.10. Immunomodulatory effect**

Studies begun just over a decade ago suggest that if used on an ongoing basis, black seed can play an important role to enhance human immunity, particularly in immunocompromise patients.

A study was conducted with human volunteers to test the efficiency of black seed as a natural immune enhancer revealed that the majority of subjects who took black seed displayed a 72% increase in helper to suppressor T-cells ratio, as well as an increase in natural killer cell functional activity. They reported, "These findings may be of great practical significance since a natural immune enhancer like the black seed could play an important role in the treatment of cancer, AIDS, and other disease conditions associated with immune deficiency states." (El-Kadi and Kandil, 1986)

*N. sativa* does not seem to have immunomodulatory effect on T-helper 1 and T-helper 2 cells in response to allergen stimulation (Kacem and Meraibi, *Integral University, Lucknow*).
2006). However, the extract inhibited human neutrophil elastase activity which was mainly attributed to carvacrol. (Enomoto et al. 2001)

1.2.6.11. Hematological effects

A methanolic extract of *N. sativa* showed inhibitory effects on arachidonic acid-induced platelet aggregation and on blood coagulation (Al-Jishi & Hozaifa, 2003). The extracts appear to induce transient changes in the coagulation activity of rats (Mansi, 2005). *N. sativa* may have a beneficial role as a hypoglycaemic agent with protective effects against pancreatic β-cell damage from alloxan-induced diabetes in rats by virtue of its ability to decrease oxidative stress and to preserve pancreatic β-cell integrity (Meral et al. 2003). Treatment of alloxan-induced diabetic rabbits with *N. sativa* resulted in lowering of elevated glucose concentrations, and an increase in the lowered serum triiodothyronine concentration (Meral et al. 2004). *N. sativa* also increased the depressed red and white blood cells count, the packed cell volume and neutrophil percentage but decreased the elevated heart rate in the alloxan-induced diabetic rabbits (Awad, 2003).

*N. sativa* oil may also play a role in modulating the balance of fibrinolysis/thrombus formation by modulating the fibrinolytic potential of endothelial cells (El-Dakhakhny et al. 2000; Awad and Binder, 2005).

1.2.6.12. Effect on gastric secretion

*N. sativa* extract was proven to have a protective action against ethanol-induced ulcer in rats (Zaoui et al. 2002).

1.2.6.13. Antifertility activity

The antifertility activity of *N. sativa* in male rats has been established, shown by an inhibition of spermatogenesis and a significant reduction in sialic
acid content of the testis, epididymis, seminal vesicles and prostate (Vohora et al.1973)

1.2.6.14. Abortifacient activity

Hot water extract of N. sativa in large oral doses reported to cause abortion. Abortion also results when whole seeds are swallowed in large doses. (Chopra et al.1949; Nayar 1954; Saha et al. 1961; Burkill, 1966; Lemordant, 1971; Malhi &Trivedi, 1972; Vohora et al. 1973; Oomachan & Khan, 1981; Bellakhdar et al. 1991).

1.2.6.15. Promotes lactation

A study showed that black seed's oil increase the milk flow of nursing mothers could be attributed to a combination of lipid portion and hormonal structures found in the black seed.

Research shows that Black Seed Oil contains more than 100 components, some of which are still unidentified, that work together synergistically. It is a rich source of polyunsaturated fatty acids (also known as "essential fatty acids") which are the building blocks of cells and help the body produce Prostaglandine (Jain & Tarefdar, 1970; Zagari, 1993).

1.2.6.16. Anthelmintic activity

Hot water extract or seeds of N. sativa were used as oral anthelmintic in human adults (Al-Yahya, 1986; Zagari, 1993). Larvicidal activity has been reported against Culex pipiens (Gayar & Shazli, 1968). It is found to be highly effective against Entamoeba histolytica (Dhar et al., 1968). Extract of its dried seeds in ethyle alcohol have been used as anticestodal agents (Akhtar & Riffat, 1991).

1.2.6.17. Other activities
Other reports include hypocholesterolaemic (Al-Awadi & Gumma, 1987; Eskandar et al., 1995) antihypertensive (Zawahry, 1964), antihypotensive (Zawahry, 1964; Dhar et al., 1968), and galactagogue (Zawahry, 1964; Burkill, 1966; Agrawala, 1968; Suwal, 1970) effects of *N. sativa* seeds extract and oil.

### 1.3 SEED GERMINATION

Germination is in effect re-animation of the quiescent but viable embryo seed during the physiological and biochemical changes. Germination is a technologic application widely used for its ability to decrease levels of antinutritional factors present in legume seeds and improve the concentration and availability of their nutrients (Alonso et al., 1998; Vidal-Valverde et al., 2002). However, germination is also a very active and complex metabolic process that may alter the chemical, structural, and organoleptic properties of the seed meal, thus decreasing its nutritive value (Nnanna et al., 1990; Rozan et al., 2000).

Reserve mobilization and metabolic changes associated with seed germination have been the objectives of several studies and this subject has been revived by many (Khan, 1978; Bewley and Black, 1983, 1985, 1994; Mayer and Poljakoff-Mayber, 1989). Germination is characterized by the hydrolysis of reserves, including lipids, proteins and carbohydrates of the storage tissues. The products such as sugars and amino acids are subsequently translocated in the embryonic axis for synthesizing cellular constituents required for growth and differentiation. Studies on reserve mobilization (Mayer and Poljakoff—Mayber, 1989) have shown that various substances such as soluble sugars, insoluble polysaccharides, soluble protein and nitrogen as well as nucleic acid, phosphorus move out of the cotyledon and are transferred to other part of the growing embryo.

The changes in storage materials during germination are the result of the activity of many hydrolytic enzymes. Either these enzymes are present in the dry seed or they very rapidly become active as the seed imbibes water and many are synthesized de novo (Mayer and Poljakoff—Mayber, 1989).
Generally enzymes breaking down starch, proteins, hemicellulose, polyphosphates, lipids and other storage materials become rapidly active as germination proceeds. Such enzymes are not necessarily produced in the same cells in which the storage materials are located. Moreover there exists a signalling system which regulates the production of enzymes and the interaction between different parts of the seed such as embryonic axis and cotyledons, endosperm, embryo and aleurone layer depending on the seed. (Mayer and Poljakoff-Mayber, 1989). They further suggest that when the seeds become hydrated, very marked changes are observed in their chemical composition. There are three main types of such chemical changes generally observed in various parts of the seed namely:

1) The breaking down of certain reserve materials in the seed;
2) The transmission of broken—down products from one part of the seed to another (especially from endosperm to embryo or from cotyledons to the growing parts) and
3) The synthesis of new materials from the broken-down products: and the initiation of protein synthesis.

In the recent decades more and more attention is paid to the healthy nutrition, to its role in health maintaining and in the prevention of certain diseases. Changes in the nutritional habits, in foods consumed and in the food preparation methods have contributed to the decrease of the nutritional value. Germination is a natural biological process that every higher plants exhibit, during which the polysaccharides degrade into oligo- and monosaccharides, the fats into free fatty acids, whereas the proteins into oligopeptides and free amino acids, which processes support the biochemical mechanisms in our organism. They improve the efficiency of both the protein-decomposing and the carbohydrate- and fatty acid-decomposing enzymes therefore germination can be considered as one kind of predigestion that helps in breaking down the high-molecular complex materials into their building blocks. After the germination also compounds with health-maintaining effects and phytochemical properties (glucosinolates, natural antioxidants) could be detected that can have a considerable role among others also in the prevention of cancer. (Sangronis and Machado, 2007). Thus, germination can lead to the
development of such functional foods that have a positive effect on the human organism and that help in maintaining the health (Sangronis and Machado, 2007). Compared to seeds, the sprouts have a higher nutritional value: higher quality of protein, more favourable amino acid composition, higher polyunsaturated fatty acid content, better bioavailability of trace elements and essential minerals and higher vitamin content. During sprouting the amount of such antinutritive materials as haemagglutinins, trypsin inhibitor activity, tannins, pentosans, phytic acid, decreases. Researches found that the sprouts are a good source of ascorbic acid, riboflavin, choline, thiamin, tocopherol and pantothenic acid (Lintschinger et al., 1997).

1.4 HYPOTHESIS

In dormant seeds, the activity of various metabolites is suppressed and primary and secondary metabolites are not produced in optimum concentrations. In numerous studies, germinating seeds especially sprouts are known to contain high concentrations of various compound/metabolites of nutritional and medicinal value and several biochemical constituents & enzymes. It is also known that several bioactive compounds could be highly expressed under certain stress conditions and some of these compounds have shown promising biological potential. In general, the expression of bioactive compounds could be relatively high in the germinated seeds compared to the non-germinated. In this regard the present study was carried out.

1.5 AIMS AND OBJECTIVES

Keeping the foregoing account in view, the present investigation has been planned on the following aspects:

1. Standardization of seed germination in N. sativa and morphological studies in different phases of germination.
2. Estimation of biomolecules, (as reported in N. sativa seed) during different phases.
3. Assay of enzymes and antioxidant enzymes in different phases of germination.
4. Evaluation of antimicrobial potential of *N. sativa* in different stages of germination.
5. Study of bioactive compounds in different phases of germination.

The data and the observations are reported in the subsequent chapters, supported by relevant literature on the subject and other possible interpretations.

1.6 SIGNIFICANCE OF THE PROPOSED STUDY

The present study was undertaken to explore the germination biochemistry of *N. sativa* seed. The work will help in a better understanding of the biochemical changes taking place in *N. sativa* seeds during different phases of germination. It will also give an insight into the nutritional and medicinal profile of this seed at various germination stages. The study will also reveal those germination stages in which the seed contain optimum levels of bioactive compounds and therefore its biological activity.

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