Chapter-1

Introduction

The Himalayan region is rich in biodiversity owing to varied climatic, geographical, topographical, physiological and ecological situations (Khoshoo, 1991). The north-eastern Himalayan region exhibits a high degree of plant diversity than any other region in the Indian sub-continent, and it is considered as the primary centre of origin for many plants (Vavilov, 1950). The area is one of the thirty four global biodiversity hotspots of the world (Myers et al., 2000; Mittermeier et al., 2004). The northeastern Himalayan region exhibits high plant diversity than any other region in the Indian sub-continent, and it is considered as the origin of a large number of plants (Vavilov, 1950). Sikkim, a North Eastern Himalayan state of India coordinates at 27° 04’ 46” to 28° 07’ 48” N latitudes and 88° 00’ 58” and 88° 55’ 25” E longitudes, it covers an area of just 7,096 square km with an elevation range of 300 to 8,586 m. from mean sea level (MSL). The state is inhabited by diverse ethnic communities, major being Bhutia, Lepcha and Nepali constituting more than ten hilly tribes. More than 64 percent of the population in the state depends on agriculture for their livelihood. The entire state is now organically certified land. Agricultural land in Sikkim is estimated to be around 1,09,000 hectares, i.e. 15.36 percent of the total geographical area. Sikkim has a net cultivable area of about 79,000 hectares (11.13%); with an irrigated area of 15 percent of the total operational holdings of 110000 hectares.

The food bowl of different ethnic communities of Sikkim Himalayas usually comprises of wild edible plants and local germplasm or local uses. The term wild food is used to describe all those plant resources usually found growing outside the
agricultural areas and harvested or collected for the purpose of human consumption. In the Sikkim Himalaya, several varieties of locally available vegetables (wild or cultivated) are commonly consumed and are considered as an integral part of ethnoculture. The ethnic people of Sikkim consume inflorescences, roots, tubers rhizome, leaves and fruits of wild plants (Rai et al., 2005, Sundriyal et al., 2004) and usually smelly plants are being attracted by them. The edible wild or local germplasms are not only consumed but also used for the therapeutic purpose as a source of nutrients. The different tribes have rich knowledge on the use of indigenous vegetables as medicine, such plant consumed as vegetables play a significant role in sustaining the livelihood of people and providing the nutrient security. Local people are often seen selling wild edibles or cultivated underutilized vegetables in the local market. The consumption pattern of these vegetables depends upon the community and locality. The vegetables known or consumed by one community are not consumed by the other. The trial and error on edibility and taste over the generation have helped in using them as vegetables. On the other hand overpopulation, increasing deforestation and overexploitation have created the danger of extinction of some of the valuable species of wild edible vegetables (Maden and Dakhal, 1998). “Food is the medicine and medicine is the food” said by Hippocrates nearly 2500 years ago (Proper diet is the medicine and there is no medicine like proper diet). Even good medicines will not cure a patient without an appropriate accompanying diet. In fact, Ayurveda says that a well-modulated or regulated diet is the best medicine. Important guidelines regarding dietetics are given in a very elaborate manner that is to be thoroughly understood and carefully practised along with the modern nutraceuticals (Gupta et al., 2007, Goyal, 2007).
The increased knowledge of the relationship between nutrients and health has resulted in several new products categories, such as Nutraceuticals. The word nutraceutical is a portmanteau of the words nutrient and pharmaceutical coined by Dr DeFelice in 1989 and the product category represents a unique interaction between the pharmaceutical and food industries (Brower, 1998). Nutraceuticals are diet supplements that deliver a concentrated form of a bioactive component from a food and used for the purpose of enhancing health in dosages that sometimes exceeds the normal foods (Zeisel, 1999). The nutraceuticals can either be taken as dietary supplements or as functional foods. The dietary supplements can be in the form of liquid concentrates or capsules whereas functional foods are enriched foods which are very close to the original natural food.

The major source of biologically active substances, such as vitamins and secondary metabolites (polyphenols, carotenoids, sterols, glucosinolates, and saponins) are present in most of the vegetables (Alothman et al., 2009). A number of studies revealed that individuals who eat five servings daily or more of fruits and vegetables have approximately half the risk of developing a wide variety of cancer types, particularly those of the gastrointestinal tract, suggesting that consuming phenolic-rich fruits and vegetables increases the antioxidant capacity of the blood (Gescher et al., 1998). Vegetables are important sources of minerals, fibre and vitamins, which provide essential nutrients for human health. Increased consumption of vegetable significantly reduces the incidence of chronic diseases, such as cancer, cardiovascular diseases and other age-related disorders. Various compounds such as polyphenols, carotenoids (pro-vitamin A), vitamins C and E (tocopherol) present in vegetables have antioxidant and free radical scavenging activities and play a significant role in the prevention of many diseases (Spiller, 2001; Prakash, et al.,
Polyphenols express biological activities, such as antifungal, antibacterial, antiviral, anti-inflammatory, anticancerous and antioxidative (Harborne and Williams, 2000; Soobrattee et al., 2005) and therefore continue identification of vegetables with high polyphenol content is of paramount importance to the scientific community due to the potential health benefits of these compounds (Vinson et al., 2001).

The phenolic compounds constitute a large group of secondary metabolites derived from phenylalanine pathway and are widely distributed throughout the plant kingdom (Mann, 1987; Harborne, 2001). Although they typically comprise less than 2% of the fresh weight basis of the plant, phenolic compounds serve the diverse functions like imparting colour to leaves and fruits, attracting or repelling insects, antimicrobial action, antiviral activity, protection from harmful ultraviolet radiation and protection from herbivores (Harborne, 1967; Macheix et al., 1990; Harborne and Williams, 2000). Chemically, phenolics or polyphenols are aromatic rings bearing compounds with one or more hydroxyl groups including functional derivatives (ester/methyl esters, glycosides etc.) (Harborne, 1967; Macheix et al., 1990; Shahidi and Naczk, 1995). More than 8,000 phenolic compounds have been identified in plants (Wrolstad, 2005) and the major are the phenolic acids and flavonoids (Macheix et al., 1990; Robbins, 2003). Phenolic acids in plants are predominantly substituted derivatives of hydroxybenzoic and hydroxycinnamic acids. These derivatives differ in patterns of hydroxylation and methoxylation of their aromatic rings (Harborne, 1994). The flavonoids share a common base structure consisting of two phenolic rings connected via an oxygenated heterocyclic pyran ring (Harborne, 1967). They are divided into several groups differing in the oxidation state of the pyran ring and include five major classes: anthocyanins, flavanols, flavanones, flavones and flavonols.
Vegetables are one of the major dietary sources of various antioxidant phytocompounds for humans. Our daily diet plays a key role in healthy ageing and prevents chronic diseases including obesity, diabetes, cardiovascular ailments, cancer, and osteoporosis. Only a small percentage of the population consume the recommended intake of fruits and vegetables, to meet the requirements of vitamins, minerals, antioxidants, enzymes and nutrients. In humans, they have a beneficial effect because of the positive biological responses they elicit, often reducing the risk of chronic disease. Foods with high phytonutrient content are sometimes called “super foods” since they are known to have health benefits beyond those of most foods (Heber, 2009). A significant number of phytochemicals have been reported in fruits, vegetables and other plant foodstuffs, which is linked to the reduction of risk of disease. The anti-cancer properties of fruits and vegetables have been highly recognised recently and are also reported to fruits and vegetables not only help decrease chances of developing cancer. They also decrease the risk of developing coronary heart disease and strokes.

Increasing epidemiological data suggest that a high intake of fruits and vegetables offers a number of health benefits against degenerative diseases (Rissanen et al., 2003). Numerous studies have suggested that the antioxidant activity, due to the phenolic composition of a food or natural health product, contributes to their protective effects against chronic and degenerative diseases (Heinonen et al., 1998; Record et al., 2001). Several specific plant phenolic compounds have been reported to exhibit anti-inflammatory, anti-carcinogenic, vasodilatory and antimicrobial activities (Rice-Evans et al., 1996; Robards and Antolovich, 1997; Harborne and Williams, 2000; Wollgast and Anklam, 2000). Therefore, in assessing the potential value of a vegetable for human consumption it is pertinent to determine the phenolic
composition and potent antioxidant activity of such compounds. The phenolic composition is generally unique to the plant species and can vary with its growth and climate where they are growing (Manach et al., 2004). The antioxidant activities of fruits vary with the type of phenolics compounds (Rice-Evans et al., 1995). It has also been found that some phenolic compounds act synergistically to increase overall antioxidant activity.

Traditional vegetables are very nutritious if they are consumed fresh or cooked at a medium temperature owing to their high content such as vitamins fibres and minerals. Nutritional elements besides nutrition also play a role in contributing to human health owing to different biological properties which have been linked to disease prevention (Hollman et al., 1996). For instance, fruit and vegetables are documented to be high in antioxidants, which delay the oxidation of other molecules by inhibiting the initiation or propagation of oxidising chain reactions by free radical and therefore may reduce oxidative damage to the human body (Hollman and Arts 2000, Ismail et al., 2004). The occurrence of such oxidative damage is believed to be a significant causative factor in the development of chronic diseases such as cancer and cardiovascular disease (CVD) (Proteggente et al., 2002, Arts and Hollman 2005). The risk of these diseases could be reduced by increasing daily intake of fruits and vegetables such as broccoli, spinach, shallots, potato and carrots which are rich sources of antioxidants (Hertog et al., 1992, Cao et al., 1996, Heim et al., 2002). Apart from having high antioxidant activities and vitamins; fruit and vegetables are the source of carotenoids, polyphenols and non-antioxidant vitamins that are responsible for protection against cancer and CVD (Heim et al., 2002, Tucker 2003, Rao and Rao 2007).
In recent decades, a resurgence of interest has focused on wild plant species for their possible nutritional and medicinal values to broaden the diversity of human diet (Flyman and Afolayan, 2007; Afolayan and Jimoh, 2009). This is because people today are more concerned about the effects of modern agricultural technology and marketing, which only cultivate plant types that have high productivity and consequently caused massive loss of biodiversity. On the other hand, increasing research on underutilized vegetables in different regions showed that most of these wild greens have great nutritional values and antioxidant properties, which are comparable to those commercially cultivated vegetables (Afolayan and Jimoh, 2009) and there has been no document on nutraceutical potential of indigenous vegetables of Sikkim.

So, this work is envisaged for exploring these vegetables as potential nutraceuticals with the following objectives:

1. To survey the knowledge of ethnic community of Sikkim about the medicinal properties of vegetables.
2. To characterize and quantify constituent phenolics of selected vegetables.
3. To elucidate nutritional and ionic profiling of selected vegetables.
4. To study the antioxidant activity of selected vegetables.

During the present study following five vegetables were considered to meet the above mentioned objective:

1. *Solanum aethiopicum* L.
2. *Solanum macrocarpon* L.
3. *Capsicum annuum* var. *cerasiformae* L.
5. *Nasturtium officinale* W.T.Aiton

*Solanum aethiopicum*, one of the leading vegetables in tropical Africa was reported to have been domesticated from the wild *Solanum anguivi* Lam., via the semi-domesticated *Solanum distichum* Schumach. & Thonn. (Lim, 2013). *S. aethiopicum* L. is commonly known as the African eggplant or Ethiopian eggplant characterized by round shape of fruit with green strips. Its leaves are eaten as a leafy vegetable and fruits are eaten either raw or cooked, whereas berries are used as an ornament in Asia. This is perennial or annual deciduous shrub which grows up to 2 m, often heavily branched, root system extending both vertically and laterally; branches and leaves with or without prickles and stellate hairs.

*Solanum macrocarpon* is a small tropical perennial plant that originated from Africa, it is widely distributed in West Africa, from Sierra Leone to Nigeria, from Cameroon eastward to Ethiopia and Southern Zimbabwe, it is also found in some parts of Southeast Asia, Brazil and Southern Europe (Rubatzky and Yamaguchi, 1997). It is cultivated either for fruits, which are 3-10 cm in diameter, flat in shape, non-ribbed, with a smooth surface and white or green coloured at the commercially mature stage, or for its leaves, which are used in the same way as spinach (Nyadanu and Lowor, 2015).

*Capsicum annuum* var. *cerasiformae* is also one of the hottest found species in these regions are the members of *C. annuum* complex with a Scoville rating of 100,000 to 350,000 SHU (Bhutia et al., 2016). It is mostly grown in Sikkim and its surrounding regions like Darjeeling for its pungent fruits. *C. annuum* var. *cerasiformae* is well known for its special type of pungency. *C. annuum* var. *cerasiformae* is almost round cherry size and bright red when fully ripen. It is used to make fresh or fermented pickle and spice up curry, daal or soup. It is popular during
cold winter months as its heat keeps the body warm. It is either simply pickled in saline vinegar or with spices and jarred for several months, and consumed alongside with traditional meal by the local people.

*Tupistra aurantiaca* Wall commonly known as Nakima in the local language of Sikkim belongs to family Liliaceae found in Sikkim Himalaya upto 7000 ft. Its inflorescence becomes available in the market from August to October which is eaten as vegetable and pickle. It is one of the costliest wild vegetable in Sikkim and very much popular in Bhutia and Lepcha communities of Sikkim.

*Nasturtium officinale* W.T. Aiton (Water Cress) commonly known as Simrayo in the local language of Sikkim belongs to the family of Brassicaceae. It is found in Sikkim Himalayan area even upto an altitude of 12,000 ft. Its young twigs are used to eat as vegetable or in soup. Peoples have believed that it reduces blood pressure.