DISCUSSION

Documentation of traditional knowledge

Living close to the nature, tribal communities have acquired immense information about the use of wild flora and fauna which is not known to the outer world. This rich knowledge, if subjected to scientific scrutiny could benefit the mankind in many ways (Jain and Tiwari, 2012). Consumption of Wild Leafy Vegetables (WLVs) is the dietary culture of ethnic people of Sikkim where livestock and WLV play important role in the socio-economic life of hill people. While, few of the plants consumed for their leaves may be high in their fat content, others are rich in proteins; most of them are good sources of multi vitamins and minerals (Sundriyal, 2003). *Urtica dioica, Nasturtium officinale* and *Diplazium esculentum* are commonly consumed by majority of people from all age groups while *Amaranthus viridis* and *Chenopodium album* are mostly preferred by elder generation. Wild vegetables are generally held in low esteem by younger (and supposedly more modernized) members of the community (Modi *et al.*, 2006). All the five selected species are used for enthnomedical (EM) values. Among different plant parts, generally higher nutrient concentration is recorded in leaves (Sundriyal and Sundriyal, 2001). Wild food plants (WFPs) contribute to the nutrition, economy and even cultural identity of people in many parts of the world (Ghorbani *et al.*, 2012). Different factors determine the preference and use of WEPs such as abundance, availability, cultural preference, economic conditions, shortage periods or unsecured food production systems. Understanding and knowing the patterns of selection, use, cultural significance and value of wild food plants for local communities is helpful in setting priorities for conservation and/or domestication of these plants (Ghorbani *et al.*, 2012). The plants in natural habitat are less familiar to the present day younger generation, unless, they are involved into its commercial transaction. Transmission of traditional knowledge from the elder generation to the younger generation is quite low. Many indigenous communities abandon or change their traditional customs and thereby lose their plant knowledge over time (Benz *et al.*, 2000; Byg and Balslev, 2001; Ladio and Lozada, 2003). The systematic documentation of indigenous knowledge regarding the identity and use of wild foods by rural communities is now an urgent need (Manandhar, 2002) because both indigenous knowledge and the biological resources are diminishing with habitat destruction and a disinterest among the younger generation (Acharya and Acharya, 2009).

Documentation of common and less familiar WLVs consumed by different ethnic people of Sikkim.

A total of 26 wild leafy vegetable species are observed to be cooked and consumed in different forms by the ethnic people of Sikkim. Out of 26 species, 16 herbs, 4 trees, 1 shrub, 1 under shrub, 2 climbing, shrubs 1 grass and 1 fern have been documented through primary and secondary data sources. Tribals mostly eat vegetables of leafy varieties, which grow as wild weeds (Nutrition news, 1996). Out of 26 species, 5 species viz: *Amaranthus viridis* Linn. (*lattey sag*) (Amarantheceae), *Chenopodium album* Linn. *(bethu sag)* (Chenopodiaceae), *Diplazium esculentum* Retz.) Sw. (*ningro*) (Athyraceae), *Nasturtium officinale* Brown. (*simrayo*) (Brassicaceae) and *Urtica dioica* Linn. (*sisnoo*) (Urticaceae), has been prioritized and documented for detail assessment. Such foods of Sikkim if studied properly, mainly on anti-oxidant properties and other bio-active compounds, may find place in the global markets (Rai *et al.*, 2005)

Availability season

The WLVs prioritized for detail assessment are available at different availability intensity in the urban and rural markets during the months of March-August every year. The poor people in remote villages consume several other WLVs at the time of food and vegetable scarcity.

During food scarcity period, people from urban and rural communities heavily depend on gathering these vegetables from their natural habitats (Manandhar, 1982). Consumption of WLVs could be by choice, chance, tradition, taste, necessity, knowledge or any other ethnical values known to the natives of the Himalayas. A large share of rural population is meeting their nutritional requirement through nonconventional means, by consuming various wild plants and animal resources (Singh and Arora, 1978).

It is during the crucial hours of food and vegetable scarcity in the Himalaya, due to the torrential monsoon rain, landslides and other natural calamities the less familiar and common wild, non-conventional leafy vegetable, such as *Amaranthus viridis* Linn. locally known as *Lattey sag or lunde sag, Diplazium esculentum* (Retz.) Sw. locally called as *Ningro, Nasturtium officinale* Brown. locally known as *simrayo, Chenopodium album* Linn. locally called as *Betu sag* and *Urtica dioica* Linn. locally known as *sisnoo,* also enter into the food basket of the Sikkimese ethnic groups. In times of scarcity or when the staple food is in short supply, people are mostly dependent upon various species of wild plants (Sinha and Lakra, 2005). In Sikkim Himalaya the natives consume nearly 190 such wild edible species (Sundriyal, 1999).

Ethnic importance:

Though clinical study of wild edible plants has not been carried out, people strongly believe, they have certain therapeutic values (Rai *et al.*, 2005). *Lattey sag* is used as WLVs, fodder for livestock and as ethno-medicines in TSM. The Nepalese in traditional system use *Amaranthus viridis* to reduce labour pain and act as antipyretic (Kirtikar and Basu, 1987). Various parts of the nettle plant can be used as food, medicines, fibers, cosmetics and in industry and biodynamic agriculture and is also very important plant for wildlife (Sheikh and Sumaira 2007).

In ayurveda *Chenopodium album* is reported to be useful in curing anorexia, cough, dysentery, diarrhea, oedema, piles and kills small worms (Bakshi *et al.*, 1999). The entire plant is commonly used for food and medicinal values and it grows in waste places and as weed in wheat or other crops fields, in almost all parts and is used as *sag*, in *bathua roti* and *bathua paratha* (Bakshi *et al.*, 1999). The plant extract of *Chenopodium album* has also been identified to contain free radical scavenging activity and might have some use in cancer treatment (Kumar and Kumar, 2009). Dried fronds of *Diplazium esculentum* are reported to be preferred animal bedding material during winter season. Several of these species have market value, but only *Diplazium esculentum* and *Megacarpaea polyandra* are actually sold or purchased as fresh vegetables in the study villages.

(Maikhuri, 2008). Some wild edible plants are used on a daily basis in one region or by a community, while being considered as weed in other areas or by other communities (Ghorbani, *et al.*, 2012). Stinging nettles can be planted alongside of gardens to help control pests such as *Chamaepsila rosae* (carrot fly), aphids and black flies. These insects often prefer eating *Urtica dioica* instead of carrots and other garden produce allowing the produce to thrive. Thus, planting nettles can allow for alternative, organic gardening methods that eliminate the need to use pesticides (anonymous). *Urtica dioica* stems are very fibrous and have been used by humans for hundreds of years to make rope and cloth. This practice of weaving nettles into fabric was even displayed in *Hans Christian Andersen's* fairytale *The Princess and the Swan,* where the princess used nettles to weave several coats by midnight.

Ecological distribution

Out of 26 wild leafy vegetables documented, 16 are herbs, 2 climbing shrubs,1 shrub, 1 under shrub, 4 trees, 1 grass and 1 fern. *Urtica hyperborean* Jacq. (Urticaceae) is available in an altitudinal range as high as 13000-16700 ft. Majority of these WLV species are available in the mid hills and mid upper hills, 2900-6500 ft and 4900-8200 ft, respectively.

Similarly, the selected five, common and less familiar wild leafy vegetables are distributed up to an altitudinal range of 6000 ft. (*Amaranthus viridis*), 12000 ft. (*Chenopodium album*), 8000 ft. (*Diplazium esculentum*), 12000ft. (*Nasturtium officinale*) and 7000 ft (*Urtica dioica*). *Chenopodium album* Linn. is found in areas around Mumbai, Kashmir, Sikkim and throughout Pakistan (Baquer *et al.*, 1989). *Urtica dioica* Linn is found up to 9000 ft (Rai *et al.*, 2005). *Diplazium esculentum* (Retz.) Sw. (fern), commonly known as *ningro* is found up to 8000 ft during March to December (Tamang, 2005). *Amaranthus viridis* is found at 4200 ft. (Joshi *et al.*, 2007). *Nasturtium officinale* Brown. and *Chenopodium album* Linn. are found up to 12000 ft. (Rai, et al., 2005). The five selected WLV species therefore showed a wide range of ecological distribution. The Sikkim Himalaya forms a part of the Eastern Himalaya and covers an elevation range of 984-28139 ft. above sea level. The climate is humid with high rainfall and the area exhibits luxuriant vegetation (Sundriyal and Sundriyal, 2000).

Foraging

Except *sisnoo* all others are collected by plucking with hand or by uprooting the young plant. All the selected wild leafy vegetables are collected and gathered from their natural habitats. Foraging of *sisnoo* and *ningro* is comparatively technical and harder. Local people do not put any value to their own labour. And therefore even the low income in the form of hard cash, is considered as good profit because often the collectors are directly involved in selling of the produce (Sundriyal and Sundriyal, 2000).

Socio-economy

Out of 26 WLVs documented nearly 8 reach the commercial market out of which the selected 5 species are preferred and consumed widely by the ethnic people of Sikkim. All the five WLVs have their specific importance in EM and TSM. All the five WLVs are used in moderate or large quantity for consumption by the ethnic communities of Sikkim. It is interesting to note that collection of WLV is generally done by the female folk of the villages. Women were found to play a major role in the collection and preparation of wild leafy vegetables, whereas men and youth generally do not harvest or prepare wild vegetables (Modi *et al.,* 2006). It is equally interesting to note that in all the four districts the percentage of female vegetable vendors dealing with the marketing of wild leafy vegetables are higher than that of male. Historically, the collecting of leafy vegetables and the knowledge associated with this practice was a female domain among both the Khoisan (Fox and

Norwood, 1982; Parsons, 1993) and the Bantu-speaking tribes (Jansen *et al.*, 2004). In contemporary South Africa this practice continues to be associated with women. However, the available evidence indicates that once a particular plant species becomes domesticated and is grown as a crop, men readily become involved, especially when its production is commercialized (Van Averbeke and Juma, 2006 a). As such, the female vendors involved in the trade of WLVs in the Sikkim Himalaya are 76.25 % and male 23.75 %. This indicates a positive trend of traditional knowledge transmission, economic empowerment and participation in economic kinetics of rural lives in the hills. Leafy vegetables also tend to be regarded as a female food, but gender distinctions in terms of their consumption are much less universal than in terms of their collection (Whitbread, 1986; Hart and Vorster, 2006). The women and children collect plants while on their way to work in the fields and surrounding areas of their work place (Farooque, 2002). Also, interesting to note that there is no governmental control and intervention over the market price of WLVs commercialized in the Sikkim yet it is at a reasonable growth within the purchasing capacity of the people. Except *Amaranthus viridis* and *Chenopodium album* which are of moderate demand, *Diplazium esculentum, Nasturtium officinale* and *Urtica dioica* are of high demand in all the major, urban and rural markets of Sikkim. *Nasturtium officinale,* *Diplazium esculentum* and *Urtica dioica* are all of high demand and accordingly the supply of these species are at par.

Out of 43 wild edible species that are sold in the three markets, *S. axillaris* was sold in the highest quantity followed by *M. edulis, Diplazium esculentum, Urtica dioca, E. latifolia, Dendrocalamus hamiltonii, Agaricus* sp. and *B. sapida* (Sundriyal and Sundriyal 2003). *Amaranthus viridis* and *Chenopodium album* are found growing luxuriantly in crop fields as weeds yet some people have started its small scale cultivation as a semi - domesticated vegetable crop in home gardens and homesteads for meeting both commercial and domestic demand. As such the main supply source of *Chenopodium album* and *Amaranthus viridis* to meet the market and domestic demand is the crop fields and home gardens. It is found growing as weed in crop fields (Kumar *et al.*, 2007). In maize, major source of allelochemicals is root exudates and maize is allelopathic to *Chenopodium album, Amaranthus sp.* (Das, 2001). While the main source of supply of *Diplazium esculentum, Urtica dioica* is still the wild habitat. *Nasturtium officinale* is collected from both its natural and semi-domesticated habitat. Major supply of *Chenopodium album* and *Nasturtium officinale* to the urban markets is observed to be from the agriculturally in-habitat regions situated in the peri-urban areas. Due to high market demands, some farmers have started rearing a few species that are still found in wild habitats. Though in small numbers, these species are also in the semi-domesticated stage. A few farmers are willing to maintain wild edible plants in the private community forests (Sundriyal and Sundriyal, 2003). WLVs have a significant share of economic return in the socio-economy of Sikkimese ethnic people. There is a significant growth in the market price of these WLVs. In 2001, per *mutta* urban market price of all five WLVs was Rs 2. In 2011, the per *mutta* price has increased to Rs.15. Similarly in rural markets *lattey sag, bethu sag* and *simrayo* per mutta market price were Rs.1 and that of *sisnoo* and *ningro* were Rs.1.50 where as in 2011, the price increased to Rs.12 for *lattey sag* and Rs.15 for *bethu sag, sisnoo, ningro* and *simrayo*. This shows a very high rise in price of about 7.5-10 times, within a decade. Since 1981 to 1996-97, the prices of various wild edible species have gone up by 3 to 6 times, at Gangtok (Sundriyal and Sundriyal, 2000). This indicates growing popularity, acceptability, preference and larger consumption volume of these wild leafy vegetables by the ethnic people of Sikkim. Except for labour cost, time and space these WLVs are almost zero investment economic-gain to the rural ethnic people of the Sikkim Himalaya, as they are collected from their natural habitat. According to Rai *et al.* (2005) the ethnic people of Sikkim, usually collect the edible wild plants from their natural habitats and sell in the local markets. In most cases, 100 % profit is made out of selling these plants. The profit is used for livelihood.

The results of assessment on, ethnic community-wise edibility acceptance percentage amongst the younger generation of 20-24 years age group has shown that, *ningro* and *sisnoo* are consumed by almost all the younger generation belonging to the three ethnic communities of Sikkim and the percentage range has been estimated within 82.2-90 %. The edibility acceptance percentage of *Simrayo* was also found to be almost equal for all the three ethnic communities which was within the range of 85.5-87.7 %. Use of wild edibles as a supplement in the delicious indigenous cuisine of ethnic Bhotiya tribes is promising (Maikhuri *et al.*, 2001). Consumption of *bethu* is higher amongst Nepali younger generation with 55.5 % while 35.5% and 27.7 % of Lepcha and Bhutia younger generation respectively. It is quite interesting to note that 42.2 % of younger generation belonging to Nepali community accepts the edibility of *lattey sag* and only 28.8 % and 20 % values estimated for Lepcha and Bhutia communities respectively. The state of Sikkim is rich in cultural and biological diversity and the ethnic groups differ from each other in their food habits, dresses and living styles (Sundriyal and Sundriyal, 2000).

Mode of consumption

The major diet of Sikkimese ethnic people are rice, *dal*, one or two varieties of vegetable preparations, meat/egg, pickle, milk and milk products. The percentage of non- vegetarian is higher than vegetarian people. Tamang (2007) has recorded that 11.7 % of people in Sikkim are vegetarian and 88.3 % are non-vegetarians.

Typically, the ethnic people in rural villages traditionally consume two heavy diets, morning lunch locally called *behan ko bhat* and evening dinner locally called *belka ko bhat* with a day time snacks locally called *khaza* (boiled tubers, beaten rice, *roti* etc.) and tea, in the late afternoon. Regular intake of fruits in rural villages is not much practiced. Therefore, the required vitamins, minerals and fibers are traditionally supplemented through the intake of leafy vegetables.

The WLVs are consumed as potherbs, side dish, and relish with every other food items prepared for consumption. *Bethu sag* and *Lattey sag* are generally prepared with potatoes or meat. *Sisnoo* is prepared as potherb and soup. Bhutia community generally prefers to consume *sisnoo* with meat. *Simrayo* is prepared as a side dish, curry or soup. It is also prepared with potato and meat. *Ningro* is consumed as a side dish, curry and *achaar*. *Ningro* curry is mostly preferred with *churpi* (a fermented milk product) or potato. Young fronds of *Diplazium esculentum* are eaten as vegetables, sometimes with chhurpi, a traditional cheese-like product (Tamang, 2005).

Nutritional composition

Traditionally wild edible species have been meeting the protein, carbohydrate, fat, vitamin, and mineral requirement of the local residents to a greater extent (Sundriyal, 1999). All the five selected species come to the market and are sold, therefore information on the chemical constituents of these food plants adds to the existing knowledge about the nutritional values of wild leafy vegetables in the Himalaya. Wild edible plants are also good source of vitamin-C (Sundriyal *et al.*, 2001)

The moisture content was high (> 90 % wet weight) in the leaves of *Diplazium esculentum* and *Nasturtium officinale* and 86.7 %, 84.8 % and 84.5 % in *Amaranthus viridis, Chenopodium album* and *Urtica dioica* respectively. These values were within the range estimated for some wild edible plants reported by Vishwakarma and Dubey, (2011) and Rai *et. al.*, (2005). Among all vegetables, the lowest value for moisture content was observed in white goosefoot (*Chenopodium album*) 71.3 % (Khanzadi, 2011). Ejoh *et al.* (2007)

reported that non conventional leafy vegetables contain as high as 89.01 % water. High moisture content provides for greater activity of water soluble enzymes and co-enzymes needed for metabolic activities of leafy vegetables (Iheanacho and Udenbuani, 2009). The high moisture content of vegetables makes them to aid the digestion of food. Their shelf life is very short because the high moisture facilitates bacterial action resulting into spoilage (Olaiya and Adebisi, 2010). It may be due to the high moisture content, as such *Diplazium esculentum* and *Nasturtium officinale* are the most perishable amongst the five selected WLVs. Ash content which is an index of mineral contents in biota (Adepado, 2011) varied from 12.2-24.9 % DM. Except in *Amaranthus viridis,* the values were higher than the values reported for other edible leaves such as *Veronia colorate* (15.86 % DM) and *Moringa oliefera* (15.09 % DM) as reported by Lockett *et al.* (2000). These results were in agreement with the results of Ajayi *et al.* (2006) who reported an ash content of some leafy vegetables that ranged from 0.6-34 %. Crude fiber was estimated highest in the leaves of *Urtica dioica* (13.2 %) fallowed by *Chenopodium album* with 12.9 %. Lowest crude fiber was estimated in *Diplazium esculentum* with 4.6 %. These values were within the range, 8.50-20.90 % reported for some Nigerian vegetables by Isong and Idiong, (1997). Dietary fiber helps to prevent constipation, bowel problems and piles (Asaolu *et al.,* (2012). Fat content was determined quite low in all the five selected species. The highest fat content was recorded in *Nasturtium officinale* (9.6 %) fallowed by 8.3 and 5.2 % in *Diplazium esculentum* and *Urtica dioica* respectively.

Diplazium esculentum is rather a good source of protein (Irawan, *et al.*, 2006). According to Handique, (1993), young leaves of *Diplazium esculentum* contain low fat and a moderate amount of fiber. Much low fat content was estimated in *Chenopodium album* and *Amaranthus viridis,* less than 5 %. Crude fat content of *Amaranthus viridis* (0.47 %) were lower when compared to that of the Moringa leaf (2.63 %) (Sharma *et al.*, 2012). Except *Nasturtium officinale* and *Diplazium esculentum,* the fat content of other three WLVs were found to be less than the range 8.3-27.0 % DM reported by Isong and Idiong, (1997) for some vegetables consumed in the Republic of Nigeria. A diet providing 1-2 % of its caloric energy as fat is said to be sufficient to human beings, as excess fat consumption yields to certain cardiovascular disorders such as atherosclerosis, cancer and aging (Davidson *et al.*, 1975). All the five selected species showed quite remarkable percentage of protein. It was determined highest in the leaves of *Nasturtium officnale* with 33.8 % fallowed by *Diplazium esculentum* with 31.2 % and *Urtica dioica* with 28.5 %. The leaves and twigs of sisnoo have high content of protein (Rai *et al.*, 2005). Protein content in *Chenopodium album* and *Amaranthus viridis* were estimated as 23% and 19.8 % respectively. Gopalan *et al.* (1971), has also reported 7% to 32 % protein in common leafy vegetables in India. Plant food that provides more than 12% of its calorific value from protein is considered as a good source of protein (Pearson, 1976). In that context, all the five WLVs contain more than 12 % protein hence can be considered as good sources for protein for human diet. The protein content percentage range of top 20 leafy vegetables (wet matter basis) by protein is 3.75 % in *Lepidium sativum* to 7.6 % in *Sauropus androgynus* (Chapman and Hall, 1997). *Urtica dioica, Chenopodium album* and *Nasturtium officinale* thus compete with these exotic leafy vegetables of the world. Carbohydrate content varied from 31.7-64.6 %.Highest carbohydrate content was determined in *Amaranthus viridis.* Gopalan *et al.* (1996) reported 20.0-66.8 % carbohydrate in some conventional Indian leafy vegetables. The energy expressed in terms of calorific value (food value) varied from 343.0-376.7 kcal/100 g DM. *Diplazium esculentum* was determined to have the highest calorific value of 376.7 kcal/100 g amongst the five selected species, followed by *Amaranthus viridis* having 368.2 kcal/100 g. Lowest calorific value was estimated in *Chenopodium album* with 343.0 kcal/100 g. These values support the previously reported findings of Vishwakarma and Dubey, (2011) within the range of 134.6-431.6 kcal/100 g.

Minerals

Consumption of wild leafy vegetables as a source of micronutrients in many tropical areas is significant in small children's diet to ensure normal growth and intellectual development (FAO, 2010). Sodium and potassium are important intracellular and extracellular cations respectively. Sodium is involved in the regulation of plasma volume, acid-base balance, nerve and muscle contraction (Akpanyung, 2005).

Potassium was the most abundant element estimated within the range of 917.2-382 mg/100g in the samples investigated. Sodium content was recorded within the range of 7.4-68.8mg/100g which suggested the possibility of incorporating the selected WLVs into the diets of obese patient. These values are in agreement with the results reported for edible wild plants of Sikkim by Rai *et.al.* (2005). Sodium concentrations in the samples were low in comparison to the concentration of potassium. This result agreed with the results reported for leafy vegetables (Hassan and Umar, 2006; 2008). Calcium content values were estimated within the range of 24.7-192.7 mg/100g. These values are similar to those reported in common green leafy vegetables of Peshawar District of Pakistan by Nasiruddin *et al.* (2012).

Iron content of selected WLVs was estimated within the range of 5.4-11.2 mg/100 g. These values were found to be within the range estimated by Pankaj and Dibakar (2013) for some wild green leafy vegetables of North-East India. The consequences of iron deficiency include reduced work capacity, impairments in behavior and intellectual performance and decrease resistance to infection (Dioxin and Harris, 2004). Sufficient amount of elemental Copper were present in the samples tested. The copper content was within the range of 0.32-1.22 mg/100 g.

Copper content values estimated for *Diplazium esculentum, Nasturtium officnale* and *Urtica dioica* were similar to those estimated for some leafy vegetables consumed in Kano, Nigeria by Mohammed *et al.* (2011), while *Amaranthus viridis* and *Chenopodium album* had slightly higher values of Cu content. Zinc was present within the range of 2.04-9.73 mg/100 g. Our results for Copper and Zinc were in close agreement to Singh *et al.* (2001) who reported 0.8-1.9 copper and 1.8-10.2 mg 100^{-1} g Zinc in different leafy vegetables. The difference in copper level could be due to the fact that many soils are geographically deficient in certain minerals and therefore foods plants grown in them lack those nutrients (Mohammed and Sharif, 2011). A similar problem can be caused by over farming or poor soil management (Nielson, 1996). Magnesium content was determined within the range of 0.22-0.48 %. The differences in the mineral content of the vegetable plant might be due to soil compositions and the rate of uptake of minerals by individual plant (Anjorin *et al.,* 2010; Asaolu and Asaolu, 2010).

Vitamin-C

The vitamin-C content in the selected common and less familiar leafy vegetables were recorded within the range of 3-44 mg/100 g. Similar observations have been recorded by Gupta *et al.* (2005) who reported 3-295 mg 100^{-1} g in thirteen locally available vegetables.

Antioxidant capacity

Free radicals are involved in many disorders like neurodegenerative diseases, cancer and AIDS. Antioxidants through their scavenging power are useful for the management of those diseases. 1,1-diphenyl-2-picrylhydrazyl (DPPH) stable free radical method is an easy, rapid and sensitive way to survey the antioxidant activity of a specific compound or plant extracts (Koleva *et al.*, 2002). The model of scavenging the stable DPPH is a widely used method to evaluate antioxidant activities compared to other methods (Potterat, 1997). DPPH stable free radical method is an easy, rapid and sensitive way to survey the antioxidant activity of a specific compound or plant extracts (Koleva *et al.*, 2002).

At 10 µg/ml of methanolic extracts of plant samples the highest inhibition percentage was determined in *Amaranthus viridis* (38.39 %) and lowest was recorded in *Urtica dioica* (27.24 %). Similarly at 100 µg/ml the inhibition percentage value of *Amaranthus viridis* was estimated as 61.87 % and that of *Urtica dioica* was 53.19 %. The DPPH free radical scavenging activities (inhibition percentage) of 100 µg/ml methanolic extract the selected common and less familiar WLVs decreased in the following order : *Amaranthus viridis* > *Chenopodium album* > *Diplazium esculentum* > *Nasturtium officinale* > *Urtica dioica*. The highest antioxidant activity was therefore shown by *Amaranthus viridis* (IC_{50} 38 µg/ml) and lowest was shown by *Urtica dioica* (IC_{50} 87μg/ml). The methanolic extracts of selected five WLVs exhibited IC_{50} values below 100 μg/ml, indicating to have very good potential as free radical scavengers. Similar result has been reported in some uncommon vegetables of Pakistan by Khanzadi, (2011). The methanolic extract of all the plants under investigation exhibited different extent of antioxidant activity and thus provide a valuable source of nutraceutical supplements.

Total Phenolic Content

Phenolic compounds are generated by plants in response to environmental stress. It has been reported that light stimulates the synthesis of flavonoids, especially anthocyanins and flavones via phenylalanine ammonia lyase (PAL) (Dixon and Paiva, 1995) and phenolics are thought to provide a means of protection against UV-B damage and subsequent cell death by protecting DNA from dimerization and breakage (Strack, 1997). Therefore plants in high-mountain areas which are exposed to a number of stress factors such as low air temperature, decreased partial pressure, increased UV radiation and unfavorable water regime have generally increased accumulation of antioxidants such as flavonoids (Chanishvili *et al.*, 2007).

A wide variation in the amount of total phenolic content ranging from 18-176 mg/g in GAE, was observed in the samples investigated. The total phenolic content of methanolic extract of selected five WLVs decreased in the following order: *Urtica dioica* > *Chenopodium album* > *Amaranthus viridis* > *Nasturtium officinale* > *Diplazium esculentum*. The TPC of *Urtica dioica* was recorded about 9.7 times higher than that of *Diplazium esculentum*. Several factors such as environmental, climatic, or geographic factors as well as extraction techniques may significantly influence the quality and the quantity of phenolic components present in nettle (Zoran *et al.*, 2012., Ozkan *et al.*,2011; Pourmorad *et al.*, 2006).

Although some studies have demonstrated a correlation between phenolic content and antioxidant capacity (Yang *et al.*, 2002), in general our results show no correlation between total phenolic content and antioxidant activity. As such it is in agreement with several the other findings. Bajpai *et al.* (2005); Modarresi *et al.* (2009). reported no correlation between total phenolic content and antioxidant capacities of a number of medicinal plant extracts. Some plants showed high phenol contents but comparatively low DPPH activity (Khanzadi, 2011). No correlation between total phenolic content and antioxidant capacity in our plant samples is possible owing to the presence of the following factors: the antioxidant capacity observed was not solely from the phenolic contents, but could possibly be due to the presence of some other photochemical such as ascorbic acid, tocopherol and pigments as well as the synergistic effects among them, which also contribute to the total antioxidant capacity. According to Winston, (1999), the leafy part of the vegetables contain the active component which consist of the flavonoid, terpenoid, lignan, sulphide, polyphenol, carotenoid, caumarin, saponin, curcumin and sterol.

Pathogenic bacteria

The count of enterobacteriaceae and *Staphylococcus aureus* in *Amaranthu virdis* and *Chenopodium album* was recorded at the level of 10^1 cfu/g. The detection level of *Bacillus cereus* was less than 10 cfu/g in few samples. These pathogens might have introduced during handling. Otherwise, no other pathogenic bacteria such as *Listeria* sp., *Salmonella* sp., and *Shigella* sp., were detected in the samples analyzed. Small number of *Bacillus cereus* in foods is not considered significant (Roberts *et al.*, 1996).

Domestication model

Today, we rely on a narrow range of foods which additionally was selected for a narrower and lower spectrum of phytochemicals. Useful biochemical and minerals may fall short in our westemized urban culinary scheme. Wild natural habitat is the major source of foraging of WLVs in the sub-himalayan region. Local inhabitants incur both socio-economic return and environmental return from this source. However, over exploitation of these sources lead to several adverse effects which has subsequently led to the irreparable loss of biodiversity and marginalization of wild bio resources and environment. There are large numbers of wild plants that are being exploited at maximum level. It is very difficult to answer how could the harvest levels be reduced, income of local residents is increased and conservation is ensured for wild edible plants (Shanker *et al.*, 1998).

Under this situation, these wild leafy vegetables are to be minutely focused for intensive research and wide literature corpus, field works, aspects on people-plant interaction, and socio-political negotiations. Results of these parameters should firmly justify the selection of plant species based on positive traits desired for domestication. This shall be followed by pre-domestication cultivation which is subjected to intensive research on population biology, habitat dynamics, microhabitat requirements and propagation and cultivation prospects. Once all these are ascertained, the plant is decided for domestication. Successful domestication leads to local and socio-political acceptance which in turn receives governmental concern and eventually gets included in the governmental programmes and policies. Use of wild edible plants as a supplementary food resource holds promise. This aspect needs thorough investigation, so that economically important species are promoted for domestication. (Sundriyal and Sundriyal, 2003). Some progressive farmers have started rearing a few selected species in the private or community forests if planting materials are made available to them. Such attitudes of the farmers need to be harvested for adoption of these species in traditional agro forestry systems and subsequently in enterprise development (Sundriyal and Sundriyal, 2000). Modi *et al.* (2006) stated that cultivated lands are more suitable for the growth and development of wild leafy vegetables, and the availability of wild leafy vegetables could therefore be enhanced by cultural practices associated with crop management. Liphadzi and Kirkham, (2006) argued that production of wild leafy vegetables in home gardens or availability thereof in local markets would be advantageous as these vegetables are relatively drought tolerant and grow on soils of limited fertility (Shiundu, 2002). Crop production systems should aim to increase the use of under-exploited natural resources such as traditional food crops (FAO, 1997).

Conclusion

Traditional knowledge, knowledge on ethnic values, data on ecological distribution, socio economy and documentation of wild leafy vegetables of the Sikkim Himalayas is sparse outside this region. Foraging from wild is an age old tradition of the ethnic communities of this Sub-Himalayan region however; it has several adverse effects as identified during the study.

The present study has shown that the wild leafy vegetables examined are nutritionally rich in terms of calorific value, fiber content, protein content, mineral content, vitamin-C content, low fat content which altogether indicate the potentiality of these WLVs as good source of non-conventional vegetables. Due to their demonstrated nutritional qualities they can help to overcome nutritional deficiency. The results on antioxidant activities and total phenolic content reasonably support their ethnomedicinal values and that they can be consumed for normal growth and adequate protection against several diseases. The study on marketing and socioeconomic profile has surfaced out the commercial viability of all the wild leafy vegetables examined. Moreover, the study on gender percentage has shown a clear avenue of womens' economic empowerment. Based on the synergetic inference of all these results we believe to draw that these selected common and less familiar wild leafy vegetables can be introduced for further intensive research including the antinutritional or toxicological factors and biological evaluation of the nutrient contents and subsequently in the line of pre-domestication and domestication strategy as proposed in the Ethnic Food, Health and Evironment (EFHE) model of WLV species, domestication.