Studies on Some Wild Leafy Vegetables of Sikkim with Reference to Ecological Distribution and Nutritional Composition

Thesis Submitted for the Degree of Doctor of Philosophy in Science (Botany)

of the

UNIVERSITY OF NORTH BENGAL

2013

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ACKNOWLEDGEMENT

First, I thank god for everything.

As such, many people have extended their invaluable help and support to accomplish this research work. With immense pleasure I take this opportunity to sincerely thank all of them.

First of all I would like to express my earnest thanks to Professor Jyoti Prakash Tamang, my teacher, my mentor and my research supervisor who encouraged and inspired me into this field. His excellent guidance and great ideas has immensely enriched this work. Besides, he constantly motivated me throughout my research period without which I would not have been able to complete this manuscript by this time. His firm gesticulation of affirmation strongly inculcated in me the confidence and determination. Words will never be sufficient to express my respect and gratitude to him. In fact, I am indebted towards him.

I am very much thankful to Dr. M. P Kharel, Principal Sikkim Government College, Tadong for his unconditional support and very convincing encouragements.

I express my gratitude to Prof. Prabir Kumar Sarkar, Prof. Abhaya Prasad Das, Prof. Bishwanath Chakraborty, Prof. (Mrs.) Usha Chakraborty, all my well-regarded teachers, of the Department of Botany, University of North Bengal for all their help, support, inspiration and blessings. I thank all of them for giving me invaluable education during my post graduation. I am very much thankful to Associate Prof. Subash Chandra Roy for his unconditional support and

concern. I thank Associate Prof. Anirudha Shah, Associate Prof. Arnab Sen and Associate Prof. Polash Mondal of the Department of Botany, NBU, for their kind support and encouragements.

I sincerely thank the Head of the Department of Botany, University of North Bengal for extending me all the necessary fascilities, support and guidance as and when required. I also express my sincere thanks to all the non teaching staffs and Research Scholars of the Department of Botany, NBU, for their kind support and encouragement. My special thanks to Mr. Kiran Sunar, Senior Research Fellow, Immuno-Pathology Laboratory, NBU and Mr. Saurav Moktan, Senior Research Fellow, Taxonomy and Environmental Biology Laboratory, NBU, for their kind help and encouragement.

I am very much thankful to the Registrar and the staff of the Registrar's office, University of North Bengal, for extending me their kind support and instantaneous help.

I have my most special thanks to Dr. Arun Kumar Rai, Asst. Professor, Department of Botany, Sikkim Government College, Tadong, for being with me all through the hard, yet, interesting times of my research work and helping me across the day and night in working out my experiments. I have my sincere thanks towards Dr. Buddhiman Tamang, Asst. Professor, Department of Microbiology, Sikkim University, for his kind support and help in working out the experiments on estimation of antioxidant and minerals. I am thankful to Dr. S. Manivannan, Associate Professor and Head of the Department, Department of Floriculture and Horticulture, Sikkim University, for his unconditional and invaluable help in working out

experiments on vitamins and minerals. I thank all the laboratory staffs, Department of Horticulture, Sikkim University for their kind help and support. I express my special thanks to Mrs. Pramila Sharma, Department of Microbiology, Sikkim University for her all time support and help in working out experiments on antioxidant and phenolic content. I extend my sincere thanks to Dr. Arun Chettri, Assistant Professor, Department of Plantation and Mangement, Sikkim University for his kind help and support. I would like to express my sincere gratitude to Dr. Mrs. Namrata Thapa, Associate Professor, Sikkim Government College, Tadong, for her constant help and encouragement.

I express my gratitude to Head of the Department of Botany and all my colleagues for their encouragement and support in my research work. I am thankful to Ms. Nikki Kharel, Asst. Professor, Department of Botany, for her kind help and support. I am very much thankful to Mr. Santosh Subba, Laboratory Instructor, Department of Botany Sikkim Government College, Tadong for his constant help and concern. I have my very special thanks to Mr. Arjun Sharma and Mrs. Kaushila Gurung of Sikkim Government College, Tadong for bearing with me and managing the office, during the course of my research work. I thank Dr. Bhasker Chakraborty, Associate Professor, Department of Chemistry, Sikkim Government College, Tadong and Mr. Govind Luitel, Research Scholar, Research Lab, Chemistry Department, Sikkim Government College, Tadong for their help and support. I am very much thankful to Dr. Kanad Das, Scientist "C", Botanical Survey of India, Sikkim Himalayan Circle, Mr.

Sundar Rai and Mr Subash Pradhan, Botanical Survey of India, Sikkim Himalayan Circle, for their kind help and support. I thank all the vegetable vendors whom I have encountered with, for, bearing with me during the course of my survey, working out on the questionnaire and collection of data. I thank all the village elders, foragers and informants who have lent their patient hearing to my queries and helped me work out on my area of research.

I sincerely thank Shri. Dinesh Sharma, Under Secretary cum D.D.O Sikkim Government College, Tadong. I express my earnest thanks to Mr. Chanchal Das, for his help and encouragement. I extend my sincere gratitude to Mr. Tamding, O.S, HRDD, Government of Sikkim, I show my sincere thanks to all the Teaching , Non- teaching staffs , Student representative council and the informant students of Sikkim Government College, Tadong, who have directly and indirectly supported me during my research work.

I express my genuine gratitude towards my parents Late. Shri. Nanda Prasad Pradhan and Late Smt. Budhha Laximi Pradhan for their blessings and everything that made a dignified life and living, possible for me. I express my sincere thanks to all my family members at Pakyong and Chandmari, Gangtok for their valuable advice, encouragement and support. I extend my special thanks to my brother Mr. Badri Kr. Pradhan for his kind help and support.

Finally, I express my deep sense of gratitude to my wife Mrs. Bindhya Pradhan who was beside me at all time for making things go right even when it was not going right. I thank her for bearing with me during the course of my research work. Her constant support and

encouragement inculcated a sense of self confidence in me, this thesis is in fact the embodiment of it. I thank my two little children Ms. Vedshara Pradhan and Master Hrig Vedant Pradhan for bearing with me during the hard times and critical hours of my research work. I thank them for their constant help, support and tolerance.

Date: [illegible] Ju[illegible] 2013

Sudhan Pradhan

CONTENTS

INTRODUCTION

The human life and culture has directly or indirectly been influenced by their surrounding environment. The primitive people were well acquainted with the properties and uses of plants of their surroundings (Jadhav, 2006). They have inherited rich traditional knowledge of surrounding plants used as food, fodder, fibers, woods, fuel, medicine, beverage, tannin, dye, gum, resin, cosmetics, crafts and religious ceremonies (Jadhav, 2006). The listings of plants and animals of ethno biological value are important for knowing and evaluating human-plant relationship to their environment (Alcorn, 1981a, 1984b; Bye, 1979).

Human consumption of wild plants has been documented from antiquity into the common Era. Dietary use of wild fruits, nuts, seeds, and leaves appear in numerous records from ancient Egypt (Darby, 1977), Greece (Athenaeus, 1927-1942), Rome (Apicius, 1958), India (Charaka, 1981), China (Simoons, 1991) and the Medieval era (Arano, 1976). Today, most human plant food is based on rather limited number of crops, but it is clear that in many parts of the world the use of wild plants is not negligible (Prescott and Prescott, 1990; Scherrer *et al.*, 2005; Bussmann *et al.* 2006; Bussman and Sharon, 2006; Kunwar *et al.*, 2006; Cavender, 2006; Pieroni *et al.* 2007). Many publications have emphasized on the diversity and value of wild edible plants (Maikhuri *et al.*, 2000; Kala, 2007; Dhyani *et al.*, 2007). The nutritional value of traditional wild plants is higher than several known common vegetables and fruits (Nordeide *et al.*, 1996;

Sundriyal and Sundriyal, 2001; Orech *et al.*, 2007). The improved and better varieties of fruits, vegetables, cereals and most of other plant products of today are the works of modern scientists by making use of technologies based on the ancient village folk information, on the wild plants (Malla *et.al.*, 1982). Therefore, our ancestors and of course the villagers, are the prime contributors to the development of modern science and technology which has been taking an innovative role in the path of progress and welfare of the society (Malla *et.al.*, 1982).

However, the diversity of uncultivated plant species, their occurrence and relationship with cultivated species and their use by humans has rarely been studied systematically (Grivetti and Ogle, 2000). Changing social values, depopulation of rural areas has led to erosion of traditional knowledge (Maikhuri *et al.*, 2004). Decades of official food security policies worldwide have completely overlooked the importance of most food represented by wild species and harvested from impoverished and agriculturally unproductive lands, herein referred to as marginal lands (Prescott-Allen and Prescott-Allen, 1990). The indigenous people of a particular place generally depend on nearby forest areas to supply their needs. The biological resources are used in many ways, such as timber, fuel-wood, food, wild vegetables, spices, wild fruits, and often important medicines. Among them, WEPs play a major role in supplying food for poor communities in many rural parts of the world (Sundriyal *et*

al., 2003). Wild plants, aside from being used by poor communities, are commonly used today as a supplement for healthy diets in even the most developed regions of the world (Redzic, 2006).

Approximately 75,000 species of plants world-wide are believed to be edible (Walters and Hamilton, 1993). Over the centuries, people have been dependent on this resource for their subsistence as they are efficient and cheap sources of several important micronutrients (Ali and Tsou, 1997). It has even been suggested that wild food plants are nutritionally superior to some of the cultivated ones (Burlingame, 2000). However, these plant resources and their indigenous use are in danger of being lost in areas where environmental and cultural transformations have led to changes in feeding practices. 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). Changes in land-use due to urbanization and habitat destruction, as well as the slash and burn system of traditional farming with its associated shifting cultivation, have been causing forest destruction and degradation.

In developing nations, numerous types of edible wild plants are exploited as sources of food hence provide an adequate level of nutrition to the inhabitants (Aberoumand *et al.*, 2009).Today, most human plant food is based on rather limited number of crops (12 crops contribute more

than 85–90% of worlds caloric intake) (Bussman and Sharon,2006; Kunwar *et al.*, 2006; Cavender, 2006; Pieroni *et al.*, 2007). Wild food plants play a very important role in the livelihoods of rural communities as an integral part of the subsistence strategy of people in many developing countries (Johns and Kokwaro, 1991; Leakey and Newton, 1994). Uncultivated food is an important component of the local society and culture, and loss of those means a loss of important components of culture and religion (Akhtar, 2001).

Besides growing a few crops, people frequently collect wild edible plants for food and other plants from natural habitats to meet their subsistence needs. 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 *et al.*, 2003). In addition to providing food directly, uncultivated plants provide an opportunity for cash generation (Harris and Mohammed, 2003). Many uncultivated plant resources have significant economic value derived from their collection and sale (Melnyk, 1994). In particular, the hill people depend on a combination of forest products, livestock and agricultural products, and their livelihoods would not be sustainable without these resources (Manandhar, 1995, 2002). The value and potential of uncultivated foods in the food security and nutrition of rural people is also neglected in agricultural and

environmental programs (Gari, 2002; Ogle, 2001; Ogle *et al.* 2003). Also, detailed studies about their availability, status, and contribution in the livelihood support are few (Regmi *et al.*, 2006; Shrestha *et al.*, 2001; Shrestha and Dhillion, 2006).

Vegetables are the edible parts of plant that are consumed wholly or in parts, raw or cooked as part of main dish or salad. A vegetable includes leaves, stems, roots, flowers, seed, fruits, bulbs, tubers and fungi (Uzo, 1989; Uwaegbute, 1989). Vegetables are good sources of oil, carbohydrates, minerals and vitamins depending on the vegetable consumed (Ihekoronye and Ngoddy, 1985). Ononugbu, 2002, reported that vegetable fats and oil lower blood lipids thereby reducing the occurrence of disease associated with damage of coronary artery. Apart from the variety which they add to the menu (Mepha & Eboh, 2007; Subukola *et al.*, 2007), they are valuable sources of nutrients especially in rural areas where they contribute substantially to protein, minerals, vitamins, fibers and other nutrients which are usually in short supply in daily diets (Mohammed and Sharif, 2011). Minerals cannot be synthesized by animals and must be provided from plants or mineral-rich water (Anjorin *et al.*, 2010).

Vegetables are important sources of protective foods, which are highly beneficial for the maintenance of good health and prevention of diseases (Sheela *et al.*, 2004; Nnamani *et al.*, 2007). Indigenous leafy

vegetables are vegetables of a locality which originated from an area and may or may not be confined to that particular region (Guarino, 1997). They account for about 10% of the world higher plants often regarded as weeds. Some indigenous leafy vegetables grow in the wild and are readily available in the field as they do not require any formal cultivation. Many of them are resilient, adaptive, and tolerate adverse climatic conditions more than the exotic species (Raghuvanshi *et al.,* 2001).

Although they can be raised comparatively at lower management cost and on poor marginal soil, they have remained underutilized, due to lack of awareness of their nutritional values in favour of the exotic ones (Chweya and Eyzaguirre, 1999; Odhav *et al.,*2007). Leafy vegetables are rich sources of carotene, ascorbic acid, riboflavin, folic acid and minerals like calcium, iron and phosphorous (Nnamani *et al.,* 2007). George (2003) stated that even though the bulk of their weight is water, leafy vegetables represent a veritable natural pharmacy of minerals, vitamins and phytochemicals. The fiber content of vegetables contribute to the feeling of satisfaction and prevents constipation (Noonan *et al.,* 1999), while the proteins in vegetables are superior to those found in fruits, although inferior to those found in grains and legumes (George, 2003). It is often difficult to determine the nutritional contribution of wild plant foods to total dietary intake because of the lack of compositional data (Faber *et. al.,* 2007). Carbohydrates, fats and proteins are sometime referred to as the

proximate principles and form the major portion of the diet while minerals play an important role in the regulation of metabolic activity in the body (Gopalan *et.,al* 2004).

The importance of antioxidant constituents of plant material has also been established in the maintenance of health by acting against stress related diseases such as, diabetes, cancer and coronary heart diseases (Idowu *et al.,* 2006). Several epidemiological studies suggest that a high intake of foods rich in natural anti-oxidants increases the anti-oxidant capacity of plasma and reduces the risk of some cancers, heart diseases and strokes(Justesen and Knuthsen, 2001). These properties are attributed to a variety of constituents, including vitamins and numerous phyto-chemicals, mainly phenolic compounds such as flavanoids (Justesen and Knuthsen, 2001. Traditional rural diet used to include interesting amount of leafy vegetables (Heinrich *et al.,* 2005). Several greens are claimed to have health- promoting or disease preventing property beyond the basic function of supplying nutrients (Pardo *et al.,* 2005). Vegetables are known as excellent sources of natural antioxidants, and consumption of fresh plants in the diet may therefore contribute to daily antioxidant intake (Chu *et al.,* 2002).

Populations living in Mediterranean countries benefit from a longer life expectancy and a lower incidence rate of chronic diseases than Northern Europeans or North Americans (Simopoulos, 2001; Schröder,

2007). Migrant studies say the Mediterranean diet and lifestyle are behind these societal differences, rather than any genetic or racial factors (James *et al.*, 1989; Darmon and Khlat, 2001; Trichopoulou, 2004). As a matter of fact, traditional Mediterranean diets are unquestionably healthier than North European and American diets: they include a significantly large amount and variety of plant foods (such as fruits, vegetables, wild leafy greens, breads, seeds, nuts and olive oil) and thus guarantee an adequate intake of carotenoids, vitamin C, tocopherols, α-linolenic acid, various important minerals, and several possibly beneficial non-nutrient substances such as polyphenols and anthocyanines (Visioli and Galli, 2001).

As a matter of fact, dietary diversity is a crucial element of a high quality diet (Johns, 2003). Not only does it guarantee an adequate intake of nutrients but also it increases their bioavailability (Kennedy *et al.*, 2003). Recently, a 10-country study conducted by Hoddinott and Yohannes, (2002) using data from Ghana, Malawi, Mali, Kenya, India, the Philippines, Mozambique, Mexico, Bangladesh and Egypt, suggested that dietary diversity could also be a useful indicator of food security (defined as energy availability). Indeed, the results indicated that in each of these ten countries, there was a positive, significant association between household diet diversity and household calorie availability per capita.

However, the dietary intake pattern of people worldwide is changing from a traditional diet (i.e. one containing plant and animal foods harvested from the local environment) to one containing many manufactured, processed, and otherwise non-traditional foods (Kuhnlein and Receveur, 1996). The rapid urbanization might suggest a decrease in the consumption of wild edible plants and a break in the transmission of indigenous knowledge. The risks of the transition from a primarily traditional diet to one containing more market (i.e. store-bought) foods include an increase in the prevalence of chronic diseases and a decrease in the dietary intakes of some key micronutrients that are present (often in abundance) in wild edible plants (Whiting and MacKenzie, 1998).

The people who eat wild edible plants do not usually mention them in nutritional surveys (Kabuye and Ngugi, 2001) but the use of these foods, which has evolved over the decades, has served to provide food and maintain general health among populations. In fact many of the food plants are used for nutrition and medicine (Kabuye and Ngugi, 2001). In Jordan, Tukan *et al.*, (1998) showed different uses of common edible wild plants such as sumac (*Rhus coriara*), chicory (*Cichorium pumilum* Jacq.) and Spanish thistle (*Centaurea iberica* Trev. Ex. Sprengel.), wild lettuce (*Lactuca tuberosa* Jacq.), viper's grass (*Scorzonera papposa* DC.), goat's beard (*Tragopogon coelesyriaca* Boiss.) and gundelia (*Gundelia tournefortii* L.). Interestingly, over half of these plants were consumed raw without any

preliminary preparation other than cleaning and trimming. Many were also consumed as snacks thus providing important sources of nutrients as compared to some modem empty-calorie foods. Tukan *et al.*, (1998) also highlighted the numerous ways of consuming such plants as part of salads, stews, spices or seasoning or even as hot drinks. The actual value of these wild edible plants in the diet of an individual is dependent on a variety of factors, for example frequency of consumption, method of preparation or cooking, freshness and amounts eaten (Shackleton, 2003). When drying leaves, they must not be exposed to the sun since some active compounds or nutrients may evaporate and this then means that they must be green in colour when dry (Bhat and Rubuluza, 2001). Many of the local vegetable materials are under-exploited because of inadequate scientific knowledge of their nutritional potentials (Florence *et al.*, 2011)..

Marketing plays an important role in the socio-economic development of any area as it helps serve the people and the region (Berry, 1967; Sundriyal and Sundriyal, 2004 b). Local economic surveys of the biological resources cannot be completed without studying the plant and animal products sold in the local markets (Bennett, 1992; Wells and Brandon, 1992). A large variety of wild edibles, medicinal and ornamental plants, and various ethno biological utility items are often sold at a much smaller level, probably at the local level only, and very few items flow out of the region in most of the areas (Jana, 1997). Access to market places and

value of their goods, determined by availability, supply and demand (Martin, 1995).

Promoting dark-green leafy vegetables may be difficult, as traditional food crops (e.g. green leafy vegetables) are often seen as the 'poor person's food' (FAO, 1997). Many people are not aware of the nutritional value of such plants and many regard them as inferior (Steyn *et al.,* 2001b). Lack of popularity and unavailability were given as possible reasons for the low consumption of indigenous vegetables (pumpkin leaves 3%; dried green cowpea leaves 3%) observed among college students in Limpopo Province (Mbhenyane *et al.,* 2005). Campaigns promoting these vegetables should focus on the younger generation, as they have less knowledge regarding wild green leafy vegetables Modi *et al.,* 2006). Diet surveys tend to ignore wild plants in comparison to cultivated ones (Etkin *et al.,* 1994), and this is a methodological deficiency (Bonet and Valles, 2002).

Genetic resources of many traditional vegetables are threatened by genetic erosion. This is mainly due to the (i) expansion of mechanized, intensive agriculture (ii) introduction of exotic vegetable species and improved varieties; (iii) loss and degradation of agricultural and forest land (e.g., caused by infrastructure development, soil erosion, and logging of forests to fulfill the demands of the growing population); (iv) over-exploiting of wild plants (e.g., for food, fuel, or fodder); and (v) poor

marketing opportunities for traditional vegetables (Manandhar, 1989). The value and potential of uncultivated foods in the food security and nutrition of rural people is also neglected in agricultural and environmental programs (Gari *et al.*, 2002; Ogle 2001; Ogle *et al.*, 2003). As such, the intake of traditionally consumed wild edible species is nowadays receiving renewed attention, due to the recognition of their potential benefit for human health. (Sa´nchez-Mata *et al.*, 2012). 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 *et al.* (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). As such, the cultivated plants with high chemical inputs such as chemical fertilizers, plant growth regulators, herbicides etc has lost their natural taste, appearance and nutritive values (Sekeroglu *et al.*, 2006). Consumption of cooked and pureed green leafy vegetables was shown to have a beneficial effect on improving vitamin-A status (Takyi, 1999; Haskell *et al.*, 2005). A South African study showed that home-gardens

that focused on dark-green leafy vegetables and yellow/orange fleshed vegetables improved children's vitamin A status (Faber *et al.,* 2002 b). Cooking oil was added during preparation of both *imifino* and spinach for all the children who consumed dark green leafy vegetables during the 5 days recall period. This will have a beneficial effect on improving vitamin A status because fat enhances carotenoid absorption (Jayarajan *et al.,* 1980).

Himalayan regions are particularly rich in biodiversity due to varied geographical, physiographical, topographical, climatic and ecological zones within the region (Khoshoo, 1992). Higher Himalayas are going through the phase of transition due to increasing population pressure, tourism related activities while its rich herbal wealth is in huge market demand (Maikhuri *et al.,* 1998). Besides, harvesting crops after tough hustle in their small and terraced fields and still being paid with low productivity local inhabitants are frequent enough to collect these wild edibles for food and other plants from their natural habitats to meet their subsistence requirements. Use of wild edibles as a supplement in the delicious indigenous hill cuisine is therefore promising (Maikhuri *et al.,* 2001).

In Sikkim Himalaya the natives consume nearly 190 such wild edible species (Sundriyal, 1999). Selection of a particular species for inclusion in the diet is location specific and influenced by the availability

of plant material. Nearly 47 species (fruits and vegetables) come to the market. (Sundriyal and Sundriyal, 2004 b). Among different plant parts, generally higher nutrient concentration was recorded for leaves, followed by new shoots and fruits. (Sundriyal and Sundriyal, 2004 a).

During recent years there has been 'a growing interest to evaluate various wild edible plants for their nutritional value (Arora and Pandey 1996; Bokhary *et al.*, 1987; Bokhary and Parvez, 1993; Dhyani and Khali, 1993; Ifon and Bassir, 1980; Maikhuri, 1991; Maikhuri *et al.*, 1994; Sadhu, 1990; Wesche-Ebeling *et al.*, 1995). Nevertheless, a careful examination of the literature reveals that there are still a large number of wild edible species which are inexpensive and commonly used by locals and whose nutritional potential have not yet been adequately studied (Sundriyal and Sundriyal, 2001). It is suggested that a few wild edible species need to be grown for commercial cultivation and adopted in the traditional agro forestry systems, which will lead to reduced pressure on them in natural forest stands as well as producing economic benefits for poor farmers (Sundriyal *et al.*, 2004). Most of the traditional leafy vegetables have a potential for income generation but fail to compete with exotic vegetables at present due to lack of awareness (Maikhuri, 2000; Jansen *et al.*, 2004). These species are commonly called neglected or underutilized species. Numerous terms have been employed to characterize these less well-known species including minor crops, underutilized species, neglected

species or orphan crops, underexploited, underdeveloped species, abandoned, new, lost, underused, local, traditional, forgotten, alternative, niche and promising species (Padulosi *et al.*, 2003).

Sikkim (Fig. A) is the Himalayan state of India with an area of 7096 sq. km and the altitude ranges from 300 m to 8500 m. The state comprises of four districts: North, East, South and West. In regards to Sikkim the total population is 6, 07,688 lakhs out of which 4, 55, 962 is rural population and 1, 51, 726 population is urban respectively (Census of India, 2011). It is populated by three major ethnic groups of people, the Nepali, the Bhutia and the Lepcha. The food survey shows that 11.7 % of people in Sikkim are vegetarian and 88.3% are non-vegetarians (Tamang, 2007).

The ethnic people of Sikkim consume roots, tubers, rhizomes, leaves and fruits of wild plants. (Rai et al., 2005; Sundriyal and Sundriyal, 2004a). Some of them sell the edible wild fruits, vegetables in nearby markets, which are in high demand among the local consumers.

Taxonomical description, distribution and ethnical importance of wild edible plants have been well documented (Harra, 1966; Bennet, 1987; Sundriyal and Rai, 1996; Rai *et al.*, 1998; Gurung, 2002; Sundriyal and Sundriyal 2004b). Traditional foods have important bearing in the dietary habits of the people of Sikkim (Tamang, 2005). However, information on the nutritional value, socio-economy and anti-oxidant property of the

wild leafy vegetables of Sikkim is meager, except the study conducted by Sundriyal and Sundriyal (2004 a,b), and Rai *et al.*, (2005). The present thesis deals with the studies on some wild leafy vegetables of Sikkim with reference to ecological distribution and nutritional composition.

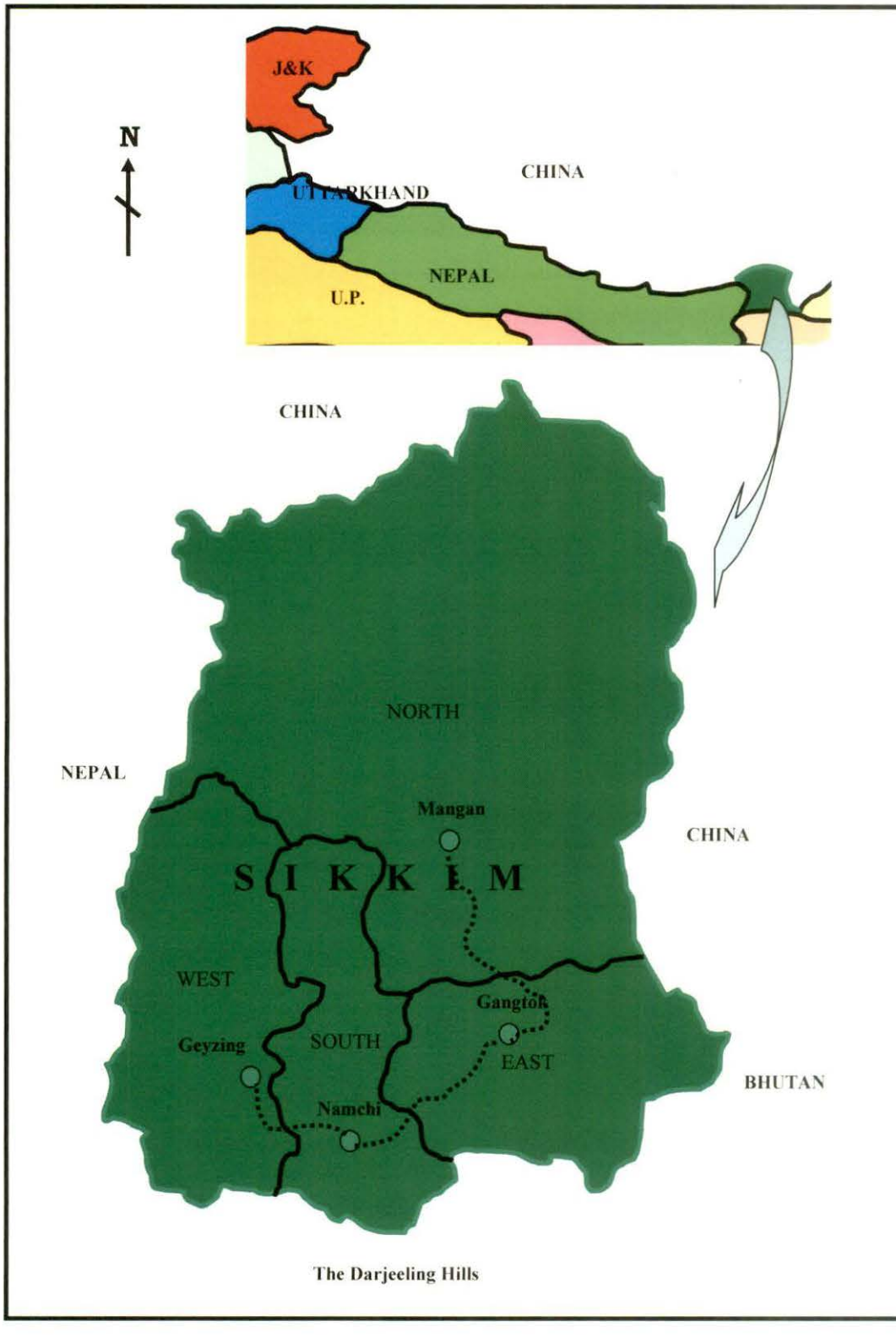

Fig A. Map showing the Sikkim Himalaya

Objectives of the thesis were to:

- To document common and less-familiar wild leafy vegetables consumed by different ethnic people of Sikkim.
- To study ecological distribution and socio-economy of common wild leafy vegetables.
- To determine nutritional composition such as moisture content, ash, protein, fat, carbohydrate, crude fiber, caloric content, vitamin c, beta - carotene, anti-oxidants and minerals.
- To examine microbiological safety of raw wild leafy vegetables.
- To propose a model for domestication of wild leafy vegetables based on nutritive value.

REVIEW
OF
LITERATURE

Vegetables are important sources of protective foods, which are highly beneficial for the maintenance of good health and prevention of diseases (Sheele *et al.,* 2004; Nnamani *et al.,* 2007). They account for about 10% of the world higher plants often regarded as weeds (Raghuvanshi *et al.,* 2001). Although they can be raised comparatively at lower management cost and on poor marginal soil, they have remained underutilized, due to lack of awareness of their nutritional values in favour of the exotic ones (Chweya and Eyzaguirre, 1999; Odhav *et al.,*2007). Campaigns promoting these vegetables should focus on the younger generation, as they have less knowledge regarding wild green leafy vegetables (Modi *et al.,* 2006). Diet surveys tend to ignore wild plants in comparison to cultivated ones (Etkin and Rose, 1994), and this is a methodological deficiency (Bonet and Valles, 2002). There are still a large number of wild edible species which are inexpensive and commonly used by locals and whose nutritional potential have not yet been adequately studied (Sundriyal and Sundriyal, 2001).

An extensive and updated review on some common and less familiar wild leafy vegetables of the world was prepared in this chapter referring journals, reprints, books, monographs, reports, dissertation, etc. Table A, shows a compilation of some wild leafy vegetables of the world.

Table A: Wild leafy vegetables of the world

Plants	Family	Country	Recipe	Reference
Adansonia digi tata Linn.	Malvaceae	Sahalian Region of Africa	Cooked	Ezeagu *et al.* (2005).
Alternanthera sessilis (L.)R. Br	Amaranthaceae	South East Asia, India	Cooked	Anitha *et al.* (2012), Borah *et al.* (2011)
Amaranthus viridis Linn.	Amaranthaceae	Nigeria, India, South Africa	Cooked	Mnkeni *et al.* (2007), Olaiya *et al.* (2010)
Bidens pilosa Linn.	Asteraceae	South Africa, West Africa, India, North America	Cooked	Bala (2006), Ballard *et al.* (1986)
Bryonia dioica Jacq.	Cucurbitaceae	Spain, Portugal	Cooked / Raw	Tardío (2010).
Cleome gynandra Linn.	Capperaceae	East Africa, India	Cooked	Muchuweti *et al.* (2007), Narendhirakannan, *et al.* (2007)
Enhydra fluctuans Lour.	Asteraceae	India	Cooked	Sannigrahi, *et al.* (2011)
Houttuynia cordata Thunb.	Sauraceae	China, Japan, India	Cooked / Raw	Meng *et al.* (2005 a), Tapan (2011)
Leptadenia hastate (Pers.) Decne.	Asclepiadaceae	Ethiopia	Cooked	Thomas (2012)
Limnocharis flava(L). Buchenau.	Limnocharitace ae	South East Asia, Malaysia	Cooked	Saupi *et al.* (2009)
Moringa oleifera Lam.	Moringaceae	Nigeria, Ghana	Cooked	Ferreira *et al.* (2008), De Silva (2010)
Moringa stenopetala (Bak. F)	Moringaceae	Kenya, Ethiopia	Cooked	Demeulenaere (2001)
Paederia foetida Linn.	Rubiaceae	Indonesia, Malaysia	Cooked	Srianta *et al.* (2012), Khare *et al.* (2007)
Plantago major Linn.	Plantaginaceae	Europe	Cooked	Zubair *et al.* (2010)

Continued (Table A)

Portulaca oleracea Linn.	Portulacaceae	Egypt, Italy, India	Cooked	Simopoulos (2004), Sudhakar *el al.* (2010), Mohammed *e t al.* (2011)
Rumex vesicarius Linn.	Polygonaceae	Egypt, Turkey, Saudi Arabia, India	Cooked	Mohammed *et al.* (2006), Rao *et al.* (2011)
Silybum marianum (L.) Gaertn.)	Asteraceae	Europe, Egypt	Cooked	Murphy, *et al.* (2000), Gazak *et al.* (2004)
Solanum nigrum Linn.	Solanaceae	Nigeria, Kenya, India	Cooked	Fallah *et al.* (2005), Akubugwo *et al.* (2008), Jainu *et al.* (2006)
Sonchus asper (L.) Hill.	Asteraceae	Mediterranean, Europe	Cooked	Leonti *et al.* (2006), Guil-Guerrero *et al.* (1998)
Talinum triangulare (Jacq.) Willd.	Portulacaceae	Nigeria	Cooked	Akachuku *et al.* (1995), Nya *et al.* (2010)
Vernonia amygdalina Del.	Asteraceae	Sub Saharan, Region, Nigeria	Cooked	Owoeye *et al.* (2010), Yedjou *et al.* (2008), Ijeh *et al.* (1996)

***Adansonia digitata* L.**

Family: Malvaceae

Adansonia digitata L. called the baobab tree in both English and French is very characteristic of the Sahelian region and belongs to the Malvaceae family. *Adsonia digitata* is well adopted deciduous tree native to the arid parts of central Africa and widely spread in savannah regions in Nigeria (Wickens, 1980; FAO,1988). Its leaves, bark and fruits are used as food and for medicinal purposes in many parts of Africa (Ezeagu, 2005). In Sahel, the leaf is a staple, the Hausas used to make *miyan kuka,* a soup prepared by boiling the leaf in salt water and reported to be rich source of Vitamin-C. During acute seasonal food supply fluctuations or famine period, the leaves and fruits of *Adansonia digitata* are of particular importance as supplementary and emergency food (Humphrey *et al.,* 1993).

It has multi-purpose uses and every part of the plant is reported to be useful (Igboeli *et al.,* 1997; Gebauer *et al.,* 2002). The leaves, for instance, are used in the preparation of soup. Seeds are used as a thickening agent in soups, but they can be fermented and used as a flavouring agent, or roasted and eaten as snacks (Addy and Eteshola, 1984). The pulp is either sucked or made into a drink while the bark is used in making ropes (Igboeli *et al.,* 1997). The different parts of the plant provide food, shelter, clothing and medicine as well as material for

hunting and fishing (Venter and Venter, 1996; Sidibe and Williams, 2002). Baobab tree provides income and employment to rural and urban households (Coulibaly *et al.*, 1993).

Previously published biochemical analyses revealed that the leaves, the seeds and the pulp from baobab are rich in nutrients (Becker, 1983; Glew *et al.*, 1997; Diop *et al.*, 2005; Nkafamiya *et al.*, 2007; Chadare *et al.*, 2009). Literature reviews on baobab provided information on the species taxonomy, distribution, utilization, agronomy, agro-ecology, phytochemistry and pharmacology (Sidibe and Williams, 2002; Diop *et al.*, 2005; De Caluwe *et al.*, 2010). Gebauer *et al.* (2002) brought out information on baobab botany, ecology, origin, propagation, main uses, genetic improvement and especially its importance for nutrition and poverty alleviation (De Caluwe *et al.*, 2010). It tolerates a wide range of vegetation types including scrub, wooded savannah hot, dry areas, and semiarid to sub-humid tropics south of the Sahara. It prefers arid areas and well-drained sandy sites between 450 and 600 m above sea level, with a rainfall of 300 to 500 mm per year (Palmer and Pitman, 1972). In the rainy season, wild gathered foods were used as much as fresh cultivated foods (Nordeide *et al.*, 1996). The wild food resources were more frequently used in rural than in urban areas, with *A. digitata* as the dominating green leaves. Green leaves were rich in energy, protein and minerals (calcium, iron) (Nordeide *et al.*, 1996).

Alternanthera sessilis (L.) R. Br

Family: Amarantheceae

Alternanthera sessilis is an aquatic plant known by several common names, including *sessile joy weed* and *dwarf copperleaf.* It is an annual or perennial prostrate herb with several spreading branches, bearing short petioled simple leaves and small white flowers found throughout the hotter part of India ascending to an altitude of 1200 m (Wealth of India, Raw materials, 1985). Young shoots and leaves are eaten as a vegetable in Southeast Asia. Occasionally it is cultivated for food or for use in herbal medicines (Arollado and Osi, 2010). This species is classified as a weed in parts of the southern States of the USA. It is usually (but not always especially in areas of high humidity where it can even be a garden weed) found in wet or damp spots. Although it is a weed and pest, in Srilanka, this is eaten as vegetable to increase the flow of milk (Arollado and Osi, 2010). In India, *Alternanthera sessilis* is commonly known as *Gudari saag,* Matsyaakshi, and is distributed in warmer parts of India. It is used as lactogogue, galactogogue, abortifacient and febrifuge. (Kritikar and Basu, 2001). In Senegal and India, the leafy twigs are ground to a powder and applied on snakebites. The people of Nepal use its roots for the treatment of stomachache (Sreedevi and Chaturvedi, 1993). The plant consists of alpha and beta spinasterol (Rastogi, 1993), Lupeal, isolated from the roots (Gupta *et al.,* 2004). The plant also contains Beta-sitosterol, stigmasterol

etc. (Sinha *et al.,* 1984). In the indigenous system of medicine the herb has been reported to be used as galactogogue, cholagogue, and febrifuge and in indigestion problem (Anandkumar and Sachidanand, 2001). The leaves are used in eye diseases, cuts, wounds and antidote to snake bite; skin diseases (Gupta *et al.,* 2004). Petroleum ether extract of plant was reported to yield nonacosane, 16-hentriacontane, ß-sitosterol, stigmasterol and handianol (Reviews on Indian Medicinal Plants, 2004). β-sitosterol and its glycoside in *Alternanthera sessilis* possess potent anti-inflammatoray and antipyretic activity (Nayak *et al.,* 2010). Also *A. sessilis* is a potential source of natural antioxidant (Borah *et al.,* 2011). *Alternanthera sessilis* possess potent anti-inflammatory and antipyretic activity (Nayak *et al.,* 2010). Also *A. sessilis* is a potential source of natural antioxidant. Antioxidant carotene is found in large amounts in *Alternanthera sessilis,* useful in night blindness (Borah *et al.,* 2011). Antioxidant carotene is found in large amounts in *Alternanthera sessilis,* useful in night blindness. The antidiabetic activity of *A. sessilis* can be attributed to the presence triterpenoids, phytosterols and glycosides. (Rao *et al.,* 2011). Ethanolic extract of *Alternanthera sessilis* produces significant memory enhancing activity when evaluated by elevated plus maze model. (Shreya *et al.,* 2011). Both aqueous and ethanolic extracts of aerial parts of *Alternanthera sessilis* Linn. possess significant nootropic potential in the view of its facilitatory effect on the retention of acquired learning and retention

(Surendra *et al.,* 2011). The phytochemical studies on aqueous extracts of leaf showed positive result for phenols, flavonoids, tannins and saponins (Anitha and Kanimozhi , 2012). The petroleum benzene and ether extracts inhibit the growth of some human and plant pathogenic bacteria (Ragasa *et al.,* 2002). Previous studies on this plant showed that it has hepatoprotective activity (Song-Chow *et al.,* 2006). *A. sessilis* is also known to alleviate dementia (Bala and Manyam *et al.,* 1999). The ethanol extract of *A. sessilis* showed 70% free radical scavenging activity (Acharya and Pokhrel, 2006). *A. sessilis* contains β-carotene (Chandrika, *et al.,* 2006), α-spirasterol, uronic acid and β-sitosterol (Acharya and Pokhrel, 2006).

***Amaranthus virids* Linn.**

Family: Amarantheceae

Amaranthus virids commonly called *Choulai* in Hindi, has been used in Indian and Nepalese traditional system to reduce labor pain and act an antipyretic (Kirtikar and Basu, 1987). *A. viridis* considered as one of the fast growing annuals of weed is widespread throughout different habitat types in Egypt (Kosinova, 1975). It grows mainly on waste lands, along water coarses and as a weed in cultivated crops. It is known to flower all through the year and produce enormous amounts of pollen in the airspora. *A. viridis* as one of the major components of outdoor airspora (Syed *et al.,* 2007). The plant possesses antiproliferative and antifungal

properties as well as ribosome inactivating protein, β-carotene (Kaur *et al.*, 2006). The sheets and the young plant of *Amarantus viridis* are also used as fodder for cattle and like green manure (Ouedraogo *et al.*, 2011). Other traditional uses range from an anti-inflammatory agent of the urinary tract, in venereal diseases, vermifuge, diuretic, antirheumatic, antidiabetic, antiulcer, analgesic, antiemetic, treatment of respiratory and eye problems and treatment of asthma (Agra *et al.*, 2007, The Wealth of India, 1988) *A. viridis* is a common plant in certain parts of Asia especially Pakistan, where it is consumed as a leafy vegetable (Khan *et al.*, 2011). A decoction of the entire plant is used to stop dysentery and inflammation (Duke and Ayensu, 1985). The plant is antidiabetic, antihyperlipidemic and antioxidant (Ashok *et al.*, 2010). The plant is emollient and vermifuge (Chopra *et al.*, 1986). The root juice is used to treat inflammation during urination and constipation (Manandhar, 2002). The Negritos of the Philippines apply the bruised leaves directly to eczema, psoriasis and rashes et. cetera (Quisumbing,1951). *Amaranthus viridis* has inhibitory or allelopathy activities. The phenomenon of allelopathy in *Amaranthus viridis* is reflected more in dry extracts compared to fresh plant extracts (Sultana *et al.*, 2012).

***Bidens pilosa* Linn.**

Family: Asteraceae

Bidens pilosa Linn. var. radiate Family, Asteraceae, known from java before 1835 but apparently not present in Kalimantan (Soerjani *et al.*, 1987). It is considered as a weed in some tropical habitats. However, in some parts of the world it is a source of food (Grubben and Denton, 2004) . The plant is an annual erect, branching herb, growing up to 1.5 m tall with quadrangular, minutely hairy stem. The leaves are opposite, toothed; simple and ovate or compound with three to five or even seven lanceolate leaflets (Morton, 1962). It is widely distributed in the sub tropical and tropical regions of the world (Deba *et al.*, 2008). As a leafy vegetable the species is an excellent source of fiber and certain mineral elements (Odhav *et al.*, 2007). The whole plant or its aerial parts is used in various folk medicines and as a popular ingredient in herbal tea for its anti-inflammatory, antiseptic, liver-protective, blood-pressure lowering, and hypoglycemic effects (Chih *et al.*, 1996; Dimo *et al.*, 2002; Ubillas *et al.*,2000; Suzigan *et al.*, 2009). Although diverse bioactivities have been identified in *B. pilosa*, its antiviral activity has not attracted attention so far. *B. pilosa* has anti-HSV activity and is thus a potentially useful medical plant for treatment of HSV infection (Nakama *et al.*, 2012). Phytochemically, the plant is rich in flavonoids, terpenes, phenylpropanoids, lipids, and benzenoids (Gupta, 1996; Abajo *et al.*, 2004;

Sundararajan *et al.*, 2006). The leaves of *B. pilosa* have been reported to contain appreciable amount of proteins, fat, fiber, carbohydrate and calorific value, mineral elements, polyphenols, and generally low level of toxicants (Odhav *et al.*, 2007). Their antioxidant and antibacterial activities further lend credence to the biological value of this plant. Thus, it can be concluded that *B. pilosa* leaves can contribute significantly to the nutrient requirements of man and should be used as a source of nutrients to supplement other major sources. (Adedapo *et al.*, 2011).

Extensive research in the last few decades have shown that B. pilosa possessed anti-hyperglycemic (Ubillas *et al.*, 2000; Hsu *et al.*, 2009; anti-ulcerogenic (Tan *et al.*, 2000), anti-inflammatory (Geissberger and Sequin 1991; Jager *et al.*, 1996), Vaso-dilative, hypertensive (Dimo *et al.*, 1998, 2001), anti-malarial (Andrade-Neto *et al.*,2004), anti-pyretic (Sunderarajan *et al.*,2006), anti-cancer and anti-tumour (Steenkamp and Gouws, 2006; Kviencinski *et al.*, 2008), anti-oxidant (Abajo *et al.*, 2004; Chiang *et al.*, 2004; Yang *et al.*, 2006) and anti-bacterial activities (Khan *et al.*, 2001; Rojas *et al.*, 2006)

***Bryonia dioica* Jacq.**

Family: Cucurbitaceae

Bryonia dioica Jacq. belongs to the family Cucurbitaceae. Young shoots of *Bryonia dioica* are richer sources of carotenoids than many of the

commercially available leafy vegetables (Garcia-Herrera et al., 2012). As in other parts of the world, wild vegetables have played an important nutritional role in the Iberian Peninsula (Tardio *et al.*, 2005). The consumption of vegetables often include various wild greens traditionally collected throughout the countries (Spain and Portugal) and consumed in different ways as a part of the Mediterranean gastronomy (Tardio *et al.*, 2005). Young shoots *Bryonia dioica* have been known to have diuretic properties since ancient times, having been reported by Dioscorides in the first century (Font Quer, 1990).

Medicinal uses of *Bryonia* have been recorded for over two millennia. Probably the earliest references are in texts attributed to Hippocrates, who lived around 460–380 BC. Other early mentions of *Bryonie* are in Dioscorides's *De Materia Medica*, written in about 65 BC, and Pliny's *Historia Naturalis*, complete in 77 BC (Beck, 2005). The reason *Bryonia* is mentioned in these and other Egyptian, Greek, Roman, Medieval, and Renaissance sources is that bryony extracts contain numerous cucurbitacins that are biologically active (Krauze-Baranowska and Ciskowski, 1995; Isaev, 2000; Sturm and Stuppner, 2000; Chen *et al.*, 2005). Young shoots, however, are eaten as an asparagus substitute (Pieroni, 2000). Today, there is a considerable market for *Bryonia* preparations, mostly for homeopathic medicine, although effectiveness remains contested (Paris *et al.*, 2008).

Cleome gynandra **Linn.**

Family: Capperaceae

Cleome gynandra L. belongs to the family Capperaceae. It is an erect annual herb. Depending on the environment conditions it can grow up 1.5 m tall. The edible leaves are gathered for use and some ethnic groups in Africa do cultivate the crop as vegetable in home gardens, or near homesteads. (Chewya and Mnzava, 1997). The species is thought to have originated in Tropical Africa and Southeast Asia, and to have spread to other tropical and sub-tropical countries in the Northern and Southern hemispheres (Kokwaro *et al.*, 1976). It is found in Asia, Africa and America where it is regarded as weed (Iltis *et al.*, 1960, 1967; Kuhn *et al.*, 1988). The plant's nutritional value may vary with soil fertility, environment, plant type, plant age and the production techniques used (Chweya, 1995). Investigations on the nutritional composition of Cleome *gynandra* L have been conducted by (Gomez, 1981; Chweya, 1985; Mwajumwa *et al.*, 1991; Mnzava, 1990; Opole *et al.*, 1995). Increased soil fertility has been reported to increase protein but decreases Beta-carotene, ascorbic acid and iron of the leaves. Increased soil fertility has no effect on the phenolic compounds, or on the calcium and sodium content of the leaves (Chweya, 1995).

Throughout Africa, the tender leaves and young shoots are and often the flowers as well, are eaten boiled as a pot herb, tasty relish,

stew or side dish. The leaves and shoots are gathered from wild or are cultivated (Chewya and Mnzava, 1997). In East Africa, fresh leaves are used as ingredients in other food mashed foods, and the dried leaves are ground and incorporated in weaning foods (Mathenge, 1995). The leaves are rather bitter, and for this reason are cooked with other leafy vegetables such as *Vigna, Amaranthus, Solanum nigrum* etc. The vegetables are rich sources of nutrients, especially vitamins A and C and minerals such as calcium and iron (Arnold *et al.,* 1985). Boiling of leaves may reduce up to 81% of vitamin C content while drying reduces the vitamin content by 95 % (Sreeramula *et al.,* 1983; Mathooko and Imungi, 1994). In India it is eaten as potherb and flavouring in sauces and in Thailand it is consumed fermented in a product called *Pak-sian-dong* (FAO 1990). The vegetable is important as leafy vegetable in several countries of Africa. The indigenous knowledge possessed by rural women in Kenya indicates that it has several nutritional uses (Opole *et al.,* 1995). The use of leaves in several indigenous medicine system in many countries have been reported by (Purseglove *et al.,* 1943; Kokwaro *et al.,* 1976; Baruah and Sharma 1984; Opole *et al.,* 1995). The plant has been observed to have insecticidal, antifeedant, and repellent characteristics (Singh, 1983a; Malonza *et al.,* 1992; Pipithsangchan, 1993). The presence of biologically active ingredients and vital trace elements in the leaves readily account for free radical scavenging property of *C. gynandra* (Narendhirakannan *et*

al., 2005). Leaf of *Cleome gynandra* consumed as leafy vegetable has anti-inflammatory and lysosomal stability actions (Narendhirakannan *et al.,* 2007), potent dose-dependent anticancer activity comparable to that of 5-fluorouracil (Bala *et al.,* 2010) and free radical scavenging activity (Muchuweti *et al.,* 2007). It is also believed to improve eyesight and provide energy (van den Heever and Venter, 2007).

***Enhydra fluctuans* Lour.**

Family: Compositae

Enhydra fluctuans family, Composite is an edible semi aquatic herbaceous vegetable plant with serrate leaves grows all over India and is widely used in traditional system of Indian medicine (Sannigrahi, *et al.,* 2011). Dewanji *et al.,* (1993) reported that the plants had high crude protein content throughout all harvesting seasons. *Enhydra fluctuans* had low ash content and was a good source of beta-carotene (Dewanji *et al.,* 1993). The leaves, which are slightly bitter, are used to treat inflammation, skin diseases, and small pox. The leaves are also antibilious and are used in nervous diseases (Rahman *et al.,* 2002), and in torpidity of liver (Chopra *et al.,* 2000). The plant possesses nutritional value and its methanol extract has been reported to have antidiarrheal activity (Uddin *et al.,* 2005).

Recently the free radical scavenging potential of crude extract and different fractions have been reported (Sannigrahi, *et al.,* 2010a). Ethyl

acetate fraction of the plant exhibits anticancer activity against EAC cell in mice (Sannigrahi, *et al.,* 2010b). The leaves of *E. fluctuans* have been reported to have hypotensive activity (Joshi and Kamat, 1972; Dewanji *et al.,* 1993). Sesquiterpene lactones (Ali *et al.,* 1972), gibberellins (Ganguly, *et al.,* 1972) and cholesterol derivatives, (Krishnaswamy and Prasanna, 1975) have been reported to be present in this plant. The aerial parts of the plant has been reported to possess significant anthelmintic activity and antimicrobial activity (Ghosh *et al.,* 2007) Chemical constituents like - carotene (Krishnaswamy *et al.,* 1968), sesquiterpene lactones (Ali *et al.,* 1972), terpenes (Krishnaswamy *et al.,* 1995) have been reported from this plant. Recently, the free radical scavenging potential of crude extract and different fractions have been reported (Sannigrahi *et al.,* 2010a). Ethyl acetate fraction of the plant exhibits anticancer activity against EAC cell in mice (Sannigrahi *et al.,* 2010b). *Enhydra fluctuans* aerial parts possess central nervous system depressant activity (Roy *et al.,* 2011).

***Houttuynia cordata* Thunb.**

Family: Sauraceae

Houttuynia cordata Thunb. belongs to the family. The leaves and rhizome of this plant is used as vegetable, condiments and spices either cooked or raw (Singh, 2011). The leaves of *Houttuynia cordata* have been traditionally used as medicinal foods in East Asia (Shizuo, 2005). Similar

reports have been made from regions of the Eastern-Asia viz. Chinese, Japan and Himalaya and Vietnam of using the tender young shoots and leaves of *H. cordata,* either raw or cooked, as vegetable and leaves for flavouring salads or as a salad crop (Haywood, *Flowering Plants of the World*). Although there are reports of selling *H. cordata* in the market of some Asian countries they are sold as a creeping ornamental plant (Phillips and Rix, 1991). Plants from Japan were reported to have an orange scent, whilst those from China have a smell resembling coriander leaves (Bown, 1995). *Houttuynia cordata is* known as a medicinal plant in Japan and China (Meng *et al.,* 2005a; 2005b). Its medicinal effects are antibacterial, (Jong and Jean, 1993), anti cancer (Kim *et al.,* 2001), anti-leukemic (Chang *et al.,* 2001), and antioxidant (Chen *et al.,* 2003). The leaves of *H. cordata* have antioxidative effects on biological damage such as protein fragmentation (Shizuo, 2005). *H. cordata* known as *Jamyr-doh* in Khasi. The whole plant eaten raw. Leaf juice is taken for cholera, dysentery, curing of blood deficiency and purification of blood (Hynniewta and Kumar, 2008). Tender young shoots and leaves are eaten raw or cooked as a pot-herb (Chopra *et al.,* 1986). A decoction of this plant is used internally in the treatment of many ailments including cancer, coughs, dysentery, enteritis and fever (Chopra *et al.,* 1986). Externally, it is used in the treatment of snake bites and skin disorders. The leaves and

stems are harvested during the growing season and used fresh in decoctions. The leaf juice is antidote and astringent (Chopra *et al.*, 1986).

***Leptadenia hastata* (Pers.) Decne.**

Family: Asclepiadaceae

Leptadenia hastate (Pers.) Decne. belonging to the family Asclepiadaceae is widely used as vegetable in tropical Africa (Burkil, 1985). The majority of wild edible plants are gathered and consumed from *Duka* (March) to *Halet* (May) and from *Meko* (August) to *Tejo* (November). The vegetables are chopped and boiled to make *Belesha* (sauce) or as a relish to *Adano* (porridge) (Tilahun and Mirutse, 2010). Although, *Leptadenia hastate* were reported to be available in the rural market of Ethiopia (Balemie and Kibebew, 2006; Addis, 2009), research on market chain analysis and economic value of this plant has not yet been addressed (Ermais *et al.*, 2011). *L. hastate* is traditionally used in the management of diabetes mellitus and in the treatment of wounds and stomach ache (Bello *et al.*, 2011). The plant is medicinally important in the treatment of many ailments (Kerharo and Adams, 1974; Burkil, 1985; Oliver, 1986; Aliero *et al.*, 2001). The antibacterial and anti microbial effects of *Leptadenia hastata* have been reported by Aliero and Wara, (2009) and result of its toxicity studies showed that the plant is safe to use (Tambuoro *et al.*, 2005).

***Limnocharis flava* L. Buchenau**

Family: Limnocharitaceae

Limnocharis flava L. Buchenau. Family, Limnocharitaceae is considered as an aquatic weed in paddy fields and also blocking the water ways that fed waters for irrigation. Despite of being of undesirable value to the agriculture, the floral clusters and its young leaves are locally used as raw and cooked vegetables (Saupi *et al.*, 2009). About 100 species of the 225 vegetables in South East Asia are weeds or wild plants (Grubben *et al.*, 1994). People use available natural resources as sources of food to improve their socio economy (Tawan *et al.*, 2007). *Limnocharis flava* commonly known as yellow velvet leaf, is locally called *paku rawan* or *jinjir* in Malaysia (van den Bergh, 1994; Halimatul, 2003; Samy *et al.*, 2005; Muta *et al.*, 2005). It is an emergent plant in rice cultivated areas that may become noxious by overgrowing the areas (Mashoor, 1988; Karim *et al.*, 2004). In West Java and Thailand, it is cultivated in fertile soil and harvested after 2-3 months before being marketed (van den Bergh, 1994; Maisuthisakul *et al.*, 2008). Young shoot including leaves, petioles and flower clusters (un-opened inflorescence) are collected, consumed either raw or cooked (Edwards, 1980). The edible parts of *L. flava* provide good sources of minerals such as potassium, calcium, magnesium and copper (Saupi *et al.*, 2009).

Moringa oleifera Lam.

Family: Moringaceae

Moringa oleifera Lam. tree has probably been one of the most underutilized tropical crops. Leaves of *M. oleifera* could serve as a valuable source of nutrient for all age group (Oduro *et al.*, 2008). In Senegal and Haiti, health workers have been treating malnutrition in small children, pregnant and nursing women with *Moringa* leaf powder (Price, 1985). The leaves are known as great source of vitamins and minerals being served raw, cooked or dried (Oduro *et al.*, 2008). Fugile (2005), reported that 8 g serving of dried leaf powder will satisfy a child within age 1-3 with 14 % of protein, 40 % of calcium, 23 % of iron and nearly all the vitamin A that a child needs in a day. *Moringa* leaves have not received needed research-based attention in Ghana in the midst of its well known nutritional properties (Oduro *et al.*, 2008). A diet including *Moringa oleifera* should be more palatable than that with the sweet potato leaves because dietary fats function to increase food palatability by absorbing and retaining flavours (Lindsay, 1996). *Moringa oleifera* leaves are good source of protein when compared to other vegetables such as pumpkin leaves , okra leaves (FAO, 2006b). Crude fiber content of *Moringa oleifera* is quite high and this make it more favorable vegetable since high fiber content of foods help in digestion and prevention of colon cancer (Saldanha *et al.*,1995). *Moringa oleifera* has

exceptionally high nutritional value and this positions it high in the table of *Healthy Edible Plants and Vegetables*. The leaves nutritionally prevent malnourishment in children and have the capacity to boost the immune system (Oduro *et al.,* 2008). *Moringa oleifera* leaf powder prevents malnutrition in developing countries that usually appear in children during the weaning period, between 1 and 3 years old (Oduro *et al.,* 2008). Broin, (2006) reported that 30 g of leaf powder can cover one third of the daily allowance for proteins, 75% of the calcium needs and more than half of iron necessary for children under than three years in age. In addition, it provides the totality of the recommended dietary allowance for vitamin A and nearly one third of the needs in vitamin C. The leaf powder also is a fascinating dietary supplement for pregnant and lactating women to increase milk production and expel intestinal worms. Mosquin, (2008) reported that the leaves can be used to complement modern medicines in chronically ill people including those suffering from AIDS and HIV related illnesses. *Moringa oleifera* leaves treat different ailments such as anemia, abnormal blood pressure, blood impurities, headaches, hysteria, anxiety, cholera and diarrhea, eye and ear infections, fever, respiratory disorders and asthma, bronchitis, catarrh, chest congestion, cough, tuberculosis and inflammation of mucous membranes (Fahey, 2005). The leaves are also used to treat hepatitis, impotency, infertility and low sperm count, in addition to treating glandular

swelling, sprain, joints pain, pimples and psoriasis. The plant is rich in compounds containing the sugar, rhamnose, also rich in a unique group of compounds called glucosinolates and isothiocyanates (Fahey, 2005). In relation to antinutritional factors, the leaves have a small proportion of tannins (12 g/kg dry matter); saponin content (5.0% as diosgenin equivalent), phytate (21 g/kg) and lack of trypsin and amylase inhibitors, lectins, cyanogenic glucosides and glucosinolates (Makkar and Becker, 1997). *Moringa oleifera* leaves have nine essential amino acids that comprise the sulphur containing amino acids methionine and cystine (Makkar and Becker, 1997; Sena *et al.*, 1998) higher than levels recommended by the Food and Agriculture Organization (Ferreira *et al.*, 2008; WHO, 1985) with patterns similar to those of soybean seeds. Its beta-carotene content is 3 to 5 times more than in carrots. Beta carotene is extremely beneficial in healing and bone development, control of cholesterol and anti-cancer protection. The leaves are exceptionally reliable source of minerals. Its iron content is richer than lentils and beef meat. The iron is three times higher than the level found in spinach. The potassium content is also three times more than in bananas; also richer in calcium than milk. Lockett *et al.* (2000) reported that in North Eastern Nigeria *Moringa oleifera* serves as a good source of protein, fat and an excellent source of calcium and iron or copper and zinc. In addition, it has a high level of pro-vitamin A and C; at least as rich as carrots in vitamin

A. Vitamin A is the most prominent vitamin essential for immune protection against all infections. The vitamin C in the leaves is 6 to 7 times more than the amount of vitamin C in orange juice. The vitamin E is 10 times more than the daily recommendation of vitamin E. It also has high levels of vitamins B (Vitamin B1, B2 and B3) among many other medicinal benefits. The most notable feature is the sustainability of the vitamins with cooked leaves (Ferreira *et al.*, 2008; De Silva *et al.*, 2010).

***Moringa stenopetala* (Bak. f.)**

Family: Moringaceae

Moringa stenopetala belonging to the family Moraginaceae is endemic to East Africa, reported in Uganda and Sudan. The species is mainly present in North Kenya and leaves of *M. stenopetala* are an important ingredient in daily dish called *dama*. The leaves are called *mida* (Demeulenaere, 2001). *M. stenopetala* tree is recognized nutritious food source in East Africa (Yisehak *et al.*, 2010). Although the nutrient composition of *M. stenopetala* leaves in most cases is lower compared to *kale* and *swiss chard*, they can be a good source of nutrients in dry season potentially when other vegetables are scarce (Abuye *et al.*, 2003). However, the presence of small amount of cyanogenic glucosides in *M. stenopetala* leaves may have a health risk in areas of high incidence of endemic goiter as an exacerbating factor if consumed more for a long

period of time (Abuye *et al.*, 2003). *Moringa stenopetala* is commonly used in folk medicine as antimalarial, antihypertensive, against stomach pain, antidiabetic, antcholesterol, antispasmodic, and to expel retained placenta during birth (Mekonnen, et *al.*, 1999). The active constituent in *Moringa stenopetala* is glucosinolate, phenol carboxylic acids and fatty acids including oleic acid, palmitic acid, stearic acid eicosanic acid and lignoceric acid (Kalogo *et al.*, 2000).

***Paederia foetida* Linn.**

Family: Rubiaceae

Paederia foetida Linn. belongs to family, Rubiaceae. The plant is fast growing and shows a wide range of adaptability to different light, soil and salt conditions (Puff, 1991 a,b). It is able to establish and grow above the frost line, though some leaves may turn yellow-red or drop following a freeze. Occurs most commonly in West Central Florida (Wunderlin *et al.*, 1996), a principal and common weed in Hawaii, Brazil and a serious weed in New Guinea (Holm *et al.*, 1979). In India *P. foetida* is of medicinal value. It is usually found in the Himalayas. It is also reported to be used in gout, vesicle calculi, diarrhea, dysentery, pile, inflammation of liver and emetic (Blatter and Caius, 1981; Indian Meteria Medica, 2002). Leafy vegetable of wild (*Paederia foetida and Erechtitis hieracifolia)* are traditionally consumed in Indonesia as documented in PROSEA and

Thumbuhan Berguna, Indonesia (Heyne, 1987; Siemonsma and Piluek, 1994). It is also used as a remedial plant for diarrhea and dysentery in Bangladesh (Ghani, 1998) and to inhibit intestinal motility (Afroz *et al.*, 2006). Iridiod glycosides, paederolone, paederone, and paederenine are the phytochemicals identified in this plant (Ghani, 1998). Wong and Tan, (1994) reported number of steroids and terpenoids in the volatile oils of the leaves, stems and flower of *P. foetida. P. foetida* has been reported to be a potential dietary source of fiber, Sodium, Calcium, Potassium iron and vitamin-C. The leafy vegetable is a potential antioxidant source (Srianta *et al.*, 2012). The major classes of chemical constituent present in this plant are iridoid glycosides, sitosterol, stigmasterol, alkaloids, carbohydrates, protein, amino acids and volatile oil (Blatter and Caius, 1981; Khare, 2007).

***Plantago major* L.**

Family : Plantaginaceae

Plantago major L. belongs to family, Plantaginaceae. The name comes from Latin *planta*, meaning, *sole of the foot*, which refers to the broad leaves in the basal rossete, often touching the ground (Pilger, 1937). It is a temperate-zone plant with extreme ranges to the north and south, almost from pole to pole although very rare in lowland tropics. In its wild form it grows from sea level to 3500m altitude (Sagar and Harper, 1960). The

species grows best in moist areas such as river beds, seepage areas on hillsides, drains, places subjected to water runoff from buildings along roadsides and coastal areas (Webb *et al.*, 1988). *Plantago major* originated in Eurasia but is now naturalized almost throughout the world. Research on pollen has shown that this species was introduced to Nordic countries 4000 years ago (Jonsson, 1983). It is known to have been present in England in 1672 and is found in Canada since 1821. The Indians named it white *man's foot* (Samuelsen, 2000). There is an increasing interest in phytochemicals of *Plantago major* because of its potential use in functional food products and medicine. It has numerous phytochemicals in its leaves, shoots and roots, which apparently have medicinal properties and also can be used as taxonomic markers (Samuelsen, 2000). Flavones are the main flavonoids *in P. major* (Nishibe *et al.*, 1995). The concentration of verbascoside is higher in seeds and flowering stalks of *P. major*, whereas the concentration of plantamajoside is higher in leaves (Zubair *et al.*, 2008b). The antiviral activity of *Plantago major* is derived mainly from its phenolic compounds (Chiang *et al.*, 2002). Plantamajoside is the major known phenolic compound in *Plantago major*. Well documented biological effects of this compound include anti-inflammatory activity (Murai *et al.*, 1996); free radical scavenging and some anti-bacterial activity (Ravn and Brimer, 1988).

Plantago major has been used for different purposes in folk medicine all over the world. *Plantago major* has been reported to have anti-inflammatory, analgesic, antioxidant, immuno-modulating, anti-ulcerogenic, antihypertensive (Samuelsen, 2000; Nyunt *et al.*, 2007). It is also reported to be anti-leukemic, anti-carcinogenic, antiviral, (Chiang *et al.*, 2003), anticandidal (Holetz *et al.*, 2002), anti-nociceptive (Atta and El-Sooud, 2004) and reduction of immunodepressive effects of anticancer drugs (Shepeleva and Nezhenskaya, 2008). Tea made from green leaves of *Plantago major* has antioxidant properties but the antioxidant capacity is higher in fresh green leaves (Campos and Lissi, 1995).

***Portulaca oleracea* L.**

Family: Portulacaceae

Portulaca oleraceae L. commonly called *purslane,* belongs to the family portulacaceae. The name Portulaca is thought to be derived from the Latin *Porto* to carry and *Lac* meaning milk, since the plant contains a milky juice (Boulos and El-Hadidi, 1984). *Portulaca oleracea* is a nutritious vegetable for human consumption and it was mentioned in Egyptian texts from the time of Pharohs (Mohammed and Hussein, 1994). *Purslane* is eaten raw as salad and also is eaten cooked as a sauce in soups or as green. It has a slightly sour and salty taste and is eaten throughout much of Europe, the middle east, Asia, and Mexico (Byrne and Andrews, 1975).

Purslane is a common weed in turf grass areas as well as in field crops (Uddin *et al.*, 2009).

The use of this plant as a vegetable, spice and medicinal plant has been known since the times of the ancient Egyptians and was popular in England during the Middle Ages (Lanska, 1992), why it has fallen into obscurity is quite strange. *Purslane* in ancient times was looked upon as one of the anti-magic herbs, and strewn around a bed was said to afford protection against evil spirits (Grieve *et al.*, 1998). It was supposed to protect from evil spirits and if carried was supposed to attract love and luck. It was carried by soldiers to protect themselves in battle. If laid on the bed, it was believed to protect that person from having nightmares. (Lavender and Franklin, 1996). It is under the dominion of the moon (Leyel, 1987) and is supposed to work on the psychic senses and taken regularly helps develop clairvoyant faculties (Lavender and Franklin, 1996). *Purslane* is currently considered very interesting from a food point of view (van Wyk, 2005), so much that it is included in the list of *World Economic Plants* (Wiersema and Leon, 1999). The National Institute of Rural Sociology comprises *Portulaca oleracea* within the category of regional herbs of the Emilia Romagna Region (Picchi and Pieroni, 2005) . *Purslane* provides a rich plant source of nutritional benefits (Sudhakar *et al.*, 2010). It is one of the richest green plant sources of omega-3 fatty acids and a-linolenic acid (Simopoulos and Salem, 1986). In areas where

this weed is eaten, there is low incidence of cancer and heart disease, possibly due to purslane's naturally occurring omega-3 fatty acids (Simopoulos, 1991). It has been used as an antiseptic, anti-diurectic, vermifuge in oral ulcer and urinary disorders. Recent researches show that it exhibits a wide range of biological effects, including skeletal muscle relaxant effect (Parry *et al.*, 1993), analgesic and anti-inflammatory effects (Chan *et al.*, 2000), antifungal activity (Oh *et al.*, 2000) and anti-fertility effect (Verma *et* al., 1982). Also it has shown other beneficial effects such as anti-diabetic (Gong *et al.*, 2009) and wound healing properties (Rasheed *et al.*, 2003). In addition, *purslane* may have a protective effect against oxidative stress caused by vitamin A deficiency (Arruda *et al.*, 2004).

Purslane has potential as an animal feed, in aquaculture (Simopoulos *et al.*, 1995). It contains numerous common nutrients, including: vitamins (A, B_1, B_2, C, niacinamide, nicotinic acid, α-tocopherol, β-carotene, et. cetera); minerals (especially potassium); fatty acids, especially omega-3 acids whose concentration in *purslane* is the highest (Leung and Foster, 1996). Other constituents include mucilage composed of an acidic and a neutral fraction with structure determined, calcium oxalate, malic and citric acids, dopamine and dopa, coumarins, flavonoids, alkaloids, saponins, and urea among others used (Leung and Foster, 1996). It also contains vitamin A, C and E as well as dietary minerals such as calcium, potassium, magnesium and iron, pigments,

bitacyanins with potent anti-oxidants property (Ezekwe *et al.*, 1999). The plant has been examined for its anti-inflammatory, analgesic and antifungal activities both *in vitro and in vivo* studies (Rasheed and Dislam, 2010). The mixture of phytochemicals present in many of these plants contributes to their protective and health effects (Chu *et al.*, 2002). The water extracts of *P. oleracea* showed no cytotoxic or genotoxic effects, and has been certified safe for daily consumption as a vegetable (Yen *et al.*, 2001). Recent research has shown that *P. oleracea* is a rich source of omega-3 fatty acids, which is important in preventing heart attack and strengthening the immune system (Simopoulos, 2004).

***Rumex vesicarius* L.**

Family: Polygonaceae

Rumex vesicarius L. family Polygonaceae is a wild edible plant used as a sorrel, collected in spring time and eaten fresh, or cooked. *Rumex* the ancient Latin name for the *docks or sorrels, vesicarius,* vesica, a *bladder;* from the inflated pods following the flowers on these herbs (Rao, 2011). This leafy wild plant is common in different parts of the world (Tukan *et al.*, 1998). The fresh leaves may also be added to meat during cooking or as a soup ingredient (Tukan *et al.*, 1998). Green leafy vegetables are, in general, good sources of vitamins, minerals, and fibers (FAO, 1988). The chemical composition of the *Rumex vesicarius* leaves

indicate that they are good sources of minerals, a moderate source of protein and ascorbic acid, and that they are high in oxalic acid and low in tocopherol and lipids. There is a need to reduce the oxalic acid (Mohammed, 2006). The species has been reported to have many important medicinal uses such as treatment of tumors, hepatic diseases, bad digestion, constipation, calcules, heart troubles, pains, diseases of the spleen, hiccough, flatulence, asthma, bronchitis, dyspepsia, piles, scabies, leucoderma, toothache and nausea. The plant is also used as antioxidant, cooling, laxative, stomachic, tonic, analgesic, appetizer, diuretic, astringent, purgative, antispasmodic, aphrodisiac and antibacterial agents. The roasted seeds were eaten for the cure of dysentery. The plant can also be used to reduce biliary disorders and control cholesterol levels. The medicinal importance of this plant is a reflection to its chemical composition since this plant contains many bioactive substances such as flavonoids, anthraquinones particularly in roots quinones, carotenoids, vitamins (especially vitamin C), proteins, lipids, carbohydrates, reducing sugars, phenols, tannins, saponins, triterepenoids and organic acids. This plant is also a good source of minerals, such as; K, Na, Ca, Mg, Fe, Mn, Cu (Mostafa *et al.*, 2011; Prasad and Ramakrishnan, 2012 a,b,c). The bioactive phytochemicals found in *Rumex vesicarius* (such as polyphenols, flavonoids, carotenoids, tocopherols and ascorbic acid) have a role as antioxidant and detoxifying agents (Rao, 2003; Matkowski, 2008). Several

C-glycosides, Flavonoids and Anthraquinones are known to be constituents of this plant. The folklore claims that the plant is a potent diuretic, astringent, carminative, stomachic and tonic (Madhavashetty *et al.,* 2008; Nardkarnis et *al.,* 2002; Pullaiah, 1997). Anti-bacterial and Antioxidant activities of *Rumex vesicarius* was reported reported by Mostafa (2011).

Silybum marianum (L.) Gaertn.

Family: Asteraceae

Silybum marianum (L.) Gaertn. *Milk Thistle* has been used medicinally in Europe since the first century. It was also mentioned in the writings of Dioscorides, Jacobus Theodorus and Culpepper (Luper, 1998). *Silybum marianum* is a wild growing annually herb that is abundantly found in the Nile region (Delta) and Fayium region near water streams (Hassan *et al.,* 2003). Its leaves, flowers and roots have historically been considered a vegetable in European diets, and its fruits, which resemble seeds, have been roasted for use as a coffee substitute. The leaves of the plant are eaten in fresh salads and as a spinach substitute, the stalks eaten like asparagus (Murphy *et al.,* 2000). The dried seeds contain 1-4% silymarin flavonoids (Schulz *et al.,* 1997). Silymarin is a mixture of at least three flavonolignans, including silybin, silidianin, and silychristin. It is the primary active ingredient in milk thistle (Schulz *et al.,* 1997). Milk

thistle is used as an antidote for *Amanita* mushroom poisoning and to protect the liver and kidneys from toxic medications (Flora *et al.*, 1998). The German Commission recommends it for the treatment of dyspeptic complaints, toxin-induced liver damage, and hepatic cirrhosis and as a supportive therapy for chronic inflammatory liver conditions (Blumenthal M, 1998). In addition, milk thistle contains apigenin, silybonol, myristic, oleic, palmitic and stearic acids and betaine hydrochloride, which may have a hepatoprotective effect (Varma, 1980). The extracts of the flowers and leaves of *Silybum marianum* have been used for centuries to treat liver, spleen and gallbladder disorders (Rainone, 2005). The plant and its extracts are reported to possess hepatoprotective, antioxidant (Morazzoni and Bombardelli, 1995), anticancer (Zi X *et al.*, 1997) and antidiabetic (Maghrani *et al.*, 2004). It contains flavonolignan silymarin, which is an important bioactive principle having anticancer, anti-inflammatory, antioxidant, and immunomodulatory effects (Katiyar, 2005). Methanolic extract of leaf and leaf callus of *Silybum marianum* possesses a potent anti-inflammatory activity (Balian *et al.*, 2006). One of the important issues about plant *S. marianum* is that it may be accepted as a safe herbal product, since no health hazards or side effects are known in conjunction with the proper administration of designed therapeutic dosages (Med. Economic Company, 2000). Recently oxidized derivatives of silybin (the

major component forming 70–80% of silymarin) and their antiradical and antioxidant activity was studied by Gazak *et al.* (2004).

***Solanum nigrum* L.**

Family: Solanaceae

Solanum nigrum belonging to the family Solanaceae, commonly named *Black Morelle* is an annual herbaceous plant of 10 to 60 cm tall, with green, smooth and semi climbing stem. The leaves are eaten as vegetables in Congo (Dhellot *et al.*, 2006). It is a common species in arable lands, near rivers and old walls, grows everywhere in Africa and America (Edmonds and Chewya, 1997). *Solanum nigrum* is a popular leafy vegetable .in Kissi district of South west Kenya. This vegetable is nutritious and rich in beta-carotene, minerals such as iron and calcium and protein, especially methionine, an essential amino acid, (Onyango, 1993; Chweya, *et al.*, 1992). The vegetable is also high yielding compared to other indigenous vegetables (Onyango, *et al.*, 1993; Murage, *et al.*, 1990). The leaves and berries are used as vegetable in soup, Yam and coco yam porridges and as spinach in some parts of Nigeria particularly among the Igbo and Efik-Ibibio people of Southeastern Nigeria. Besides being used for human consumption, the leaves serves as fodder and browse for domestic herbivorous animals. In India *S. nigrum* mixed with other herbal medicines have hepato-protective effects in cirrhotic patients.

These protective effects can be attributed to the diuretic, anti-inflammatory, anti-oxidative and immuno-modulating properties of the component herbs (Fallah, *et al.,* 2005). It also protects against hepatitis - B virus infection (De silva, *et al.,* 2003; Galitskii, *et al.,* 1997; Kalab and Krecher, 1997). The extract of its fruits have anti- tumor and neuro-pharmacological properties and it can be used as an antioxidant and cancer chemo-preventive matter (Son, *et al.,* 2003; Perez, *et al.,* 1998). *S. nigrum* possess various compounds that are responsible for diverse activities. The major active components are glycoalkaloids, glycoproteins, and polysaccharides. It also contains polyphenolic compounds such as gallic acid, catechin, protocatechuic acid, caffeic acid, rutin and neringenin (Sikdar and Dutta, 2008).

***Sonchus asper* (L.) Hill**

Family: Asteraceae

Sonchus asper (L.) Hill commonly called spiny sow thistle belongs to the family Asteraceae. A native of Europe but is now a cosmopolitan weed is an annual plant with spiny leaves and yellow flowers resembling those of dandelion. The plant can reach a height up to 6ft. (Wagner *et al.,* 1999). The plant is a common weed in North American roadsides, landscapes and pastures. Its edible leaves make a palatable and nutritious leafy vegetable. It is believed that *Sonchus asper* could be used for

nutritional purposes, due to the high concentrations of nutrients that they contain. (Guil-Guerrero *et al.*, 1998). *Sonchus asper* is eaten cooked and raw in salads in Africa, Madagascar (Grubben and Denton, 2004) and in the Mediterranean (Leonti *et al.*, 2006). *S. asper* prefers well drained, slightly acid to alkaline soils, but are tolerant of saline soils (Lewin *et al.*, 1948; Hutchinson *et al.*, 1984). Their range in Canada suggests a broad tolerance to climatic variation (Hutchinson *et al.*, 1984). Occurs from 750-2550 m in altitude (Grubben and Denton, 2004). Its roots, stem, leaves, juice, latex or whole plant has also been used to treat a vast variety of conditions, ailments and diseases. These include treatment of wounds, boils, asthma, bronchitis, gastrointestinal infections, malaria, venereal disease and many more (Khan and Yadava, 2010). The latex has also been used to treat warts (Grubben and Denton, 2004). Chemical analysis of *S. asper* has confirmed that it contains large quantities of phenolic compounds, flavonoids, ascorbic acid, carotenoids and a variety of other antioxidants. *S. asper* extract protects rats from renal damage associated with CCl4 Khan and Yadava, 2010). The extract of *S. asper* is applied to wounds and boils. The leaves and roots of the plant are used in indigestion and as a febrifuge, while its roots act as a vermifuge. Its stems are given as a tonic and sedative (Ambasta, 1986). *Sonchus asper* is apparently restricted to coastal areas north of 64°N in Norway (Lid and Lid, 1998) and is only very rarely encountered in northern Scandinavia (Lewin *et al.*, 1948). *Sonchus asper* is a

colonizer of waste places, disturbed sites, roadsides, and cultivated areas (Hutchinson *et al.*, 1984; Di Tomaso and Healy 2007). In undisturbed areas, it will have no impact (Hutchinson *et al.*, 1984). *Sonchus asper* is a host for several nematode and aphid species and supports several major plant viruses (Hutchinson *et al.*, 1984). The plant is edible and may be grazed by herbivores (Lewin *et al.*, 1948). Because *Sonchus asper* is insect pollinated, its presence could alter plant-pollinator interactions. The leaves have prickly, spiny margins (DiTomaso and Healy 2007). *Sonchus asper* is able to compete with native species but only in disturbed areas (Hutchinson *et al.*, 1984). *Sonchus asper* does not form thickets, nor does it climb or smother surrounding vegetation (DiTomaso and Healy, 2007). *Sonchus asper* is a common annual weed in agricultural fields in Canada (Hutchinson *et al.*, 1984) and Europe (Lewin, 1948). Historically, it has been grown as a potherb in Europe and as a food source for edible snails (Lewin *et al.*, 1948).

Chemical studies of *Sunchus asper*, indicated a high content of vitamin-C (Afolayan and Jimoh, 2008) , carotenoids, and type ω-3 fatty acids (Guil-Guerrero *et al.*, 1998; El-Zalabani *et al.*, 1999). Phenolic compounds, which are secondary metabolites in plants, are one of the most widely occurring groups of phytochemicals that exhibit a wide range of physiological properties, such as antioxidant, anti-allergenic, anti-microbial, anti-artherogenic, anti-thrombotic, anti-inflammatory,

vasodilatory, and cardioprotective effects (Middleton *et al.,* 2000). Chemical characterization of *Sonchus asper* methanolic extract (SAME) has shown the presence of ionone derivatives of glycosides and sesquiterpene lactone glycosides (Helal *et al.,* 2000). These bioactive compounds have been shown to possess strong antioxidant and anti-inflammatory properties (Alpinar *et al.,* 2009). *Sonchus asper* methanolic extract has diuretic, refrigerant, sedative, and antiseptic properties that are used in the treatment of cough, bronchitis, and asthma (Koche *et al.,* 2008) as well as kidney inflammation (Zabihullah *et al.,* 2006), and its decoction is used in the treatment of impotence (Kareru *et al.,* 2007). *Sonchus asper* is used in various human disorder including wounds and burns (Rehman, *2006;* Qureshi *et al.,* 2009; Hussain *et al.,* 2008), cough, bronchitis and asthma (Ahmad *et al.,* 2006; Koche *et al.,* 2008), gastrointestinal infection, inflammation, diabetes and cardiac dysfunction (Sabeen and Ahmad, 2009), kidney and liver disorders (Zabihullah *et al.,* 2006; Rivera, and Oben, 1993), reproductive disorder like impotence (erectile dysfunction) in humans (Kareru *et al.,* 2007), jaundice (Jan *et al.,* 2009) and cancer (Sammon, 1997; Thomson and Shaw, 2002). *S. asper* contains flavonoids (Giner *et al.,* 1993; Manez *et al.,* 1994), glycosides (Shimizu *et al.,* 1989) ascorbic acid and carotenoids, possess antioxidant, anticancer; anti-inflammatory properties (Guil-Guerrero *et al.,* 1998).

Talinum triangulare (Jacq.) Willd.

Family: Portulacaceae

Talinum triangulare belongs to the family Portulacaceae. It is a herbaceous, perennial, caulescent and glabrous plant, widely grown in tropical regions as leaf vegetable (Ezekwe *et al.*, 2001). *Talinum triangular is* a non conventional vegetable crop which is originated from Tropical Africa and is widely grown in West Africa, America and Asia (Schippers *et al.*, 2000). It is consumed as a vegetable and a constituent of sauce or a softener of other vegetable species in vegetable soups (Aja, *et al.*, 2010). The leaves contain an appreciable amount of bioactive compounds such as flavonoids, alkaloids, saponins tannins. Medically the presence of these phytochemicals explains the use of this vegetable in ethno medicine for the management of various ailments (Aja *et al.*, 2010).

Nutritionally, *Talinum triagulare* leaf has been shown to posses the essential nutrients like Beta-carotene, minerals such as (calcium, potassium, and magnesium), pectin protein and vitamins (Ezekwa *et al.*, 2001). The plant has also been implicated medically in the management of cardiovascular diseases like stroke, obesity, etc. (Adewunmi and Sofowara, 1980). Water leaf as a vegetable has some inherent characteristics which makes it attractive to small holder farmers and consumers. Firstly, it is short duration crop, which is due for harvest between 35 to 45 days after planting (Rice *et al.*, 1986). Secondly it is used

as a softener when cooking fibrous vegetables such as *Gnetum africanum, Heinsia crinata* and *Telferia occidentalis*. It also has some medicinal use in humans and act as green forage for rabbit feed management (Ekpenyong, 1986). In addition, it also provides a complimentary source of income to small scale farming households (Udoh, 2005). Most research on water leaf production Ikwa Ibom state, Nigeria have focused on resource utilization (Udoh, 2005; Umoh, 2006; Udoh and Etim,2008). The anti-oxidant and hepato-protective activities of polysaccharides from *T. triangulare are* were reported by Liang *et al.,* 2011. The leaves of *T. triangulare* have hepatoprotective activity (Adefolaju, *et al.*, 2009).

***Vernonia amygdalina* Del.**

Family: Asteraceae

Vernonia amygdalina, Del. Belonging to family, Asteraceae has a rough bark with dense black straits, and elliptic leaves that are about 6 mm in length. The leaves are green and have a characteristic odour and bitter taste (Singha *et al.,* 1966). It is variously known as bitter leaf (English), oriwo (Edo), ewuro (Yoruba), shikawa (Hausa), and olubu (Igbo), is a tropical shrub, (Igile *et al,* 1995). The species is indigenous to tropical Africa and is found wild or cultivated all over sub- Saharan Africa (Bosch *et al,* 2005). The leaves are eaten, after crushing and washing thoroughly to remove the bitterness (Mayhew and Penny, 1998). *Vernonia*

amygdalina plant commonly found around homes in Southern Nigeria as a green vegetable or spice especially in the popular bitter-leaf soup (Igile *et al.*, 1995) also widely used for both therapeutic and nutritional purposes. *Vernonia amygdalina* grows under a range of ecological zones in Africa being drought tolerant and produces large fodder biomass for both human and animal nutrition (Bonsi *et al.*, 1995; Aregheore, 1998; Daodu and Babayemi, 2009).

Oboh and Enobhayisobo, (2009) reported that fresh green *Vernonia amygdalina* contain moisture, 83.0% (dry matter, 17.02%), protein, 1.30% and ash 0.50%. Mineral content has been reported to be, phosphorus, 61.55 µg g-1; selenium, 8.2x10-3µg g-1 ; iron, 4.71µg g-1 and zinc, 1.13µg g-1, based on fresh weight of leaves. Both the roots and leaves are used in phyto-medicine to treat fever, hiccups, kidney disease and stomach discomfort, among others (Gill, 1992; Hamowia and Saffaf, 1994). Anti-helmitic and anti-malarial properties (Abosi and Raserika, 2003) as well as anti-tumourigenic properties (Izevbigie *et al,* 2004), have also been reported for extracts from the plant. Other studies have demonstrated hypoglycemic and hypolipidaemic effects of the leaf extract in experimental animals (Akah and Okafor, 1992; Nwanjo, 2005). *V amygdalina* Del. has been shown to contains Significant quantities of lipids (Ejoh *et al.*, 2007; Eleyinmi *et al.*, 2008), proteins with high essential amino acid score (Igile et al., 1994; Udensi *et al.*, 2002; Ejoh *et al.*, 2007; Eleyinmi *et*

al., 2008) that compare favorably with values reported for *Telfairia occidentalis* and *Talinum triangulare* (Ijeh *et al.*, 1996), carbohydrates (Ejoh *et al.*, 2007) and fiber (Udensi *et al.*, 2002; Ejoh *et al.*, 2007). The plant has also been shown to contain appreciable quantities of ascorbic acid and caroteinoids (Udensi *et al.*, 2002; Ejoh *et al.*, 2007). Calcium, iron, potassium, phosphorous, manganese, copper and cobalt have also been found in significant quantities in *Vernonia amygdalina* (Bonsi *et al.*, 1995; Ejoh *et al.*, 2007; Eleyinmi *et al.*, 2008).

In many parts of West Africa, the plant has been domesticated (Igile *et al.*, 1994). It is known as *Grawa* in Amharic, *Ewuro* in Yoruba, *Etidot* in Ibibio, *Onugbu* in Igbo, *Ityuna* in Tiv, *Oriwo* in Edo and *Chusar-doki'*in Hausa (Egedigwe, 2010). *Vernonia amygdalina* is drought tolerant (though it grows better in a humid environment). It thrives on a range of ecological zones and is used as a hedge plant in some communities (Bonsi *et al.*, 1995). *Vernonia amygdalina* used as a fence post and pot-herb in the home and villages is one of the most widely consumed leafy vegetables in most countries in West and Central African being an excellent source of vitamin C and total carotenoid (Ejoh *et al.*, 2005). Ejoh *et al.* (2005) reported a vitamin C value and total carotenoid level of 197.5 and 30.0 mg 100^{-1} g, respectively for bitter leaf. Besides it is used as an indigenous vegetable in human nutrition, the plant has also acquired significant relevance in human medicine having been proven to possess potent

antimalarial and anti-helmintic properties as well as anti-tumorigenic properties (Izevbigie, 2003) laxative and fertility inducers in infertile women (Igile *et al.*, 1995). Its therapeutic constituent (quinine) cures malaria cleans the liver and lymphatic system and lungs for smokers. It could also be given to patients suffering from hyperglycemia (excessive sugar) as in diabetes mellitus and diabetes insipidus (Akah and Okafor, 1992). Furthermore, the leaves used as local medicine against leech that transmits bilharziose. The leaves used as vegetable stimulate the digestive system, as well as reduce fever. The tops of the shrub have some trado-medicinal value, also used instead of hops to make beer in Nigeria (Nwachukwu *et al.*, 2010). The broad macerated green leaves used as vegetables and condiments especially in cooking soup. Arhoghro *et al.* (2009) posit that the water extract serves as tonic for the prevention of certain illnesses. In addition, the aqueous leaf extract exhibited hepatoprotective activity due to its antioxidant property attributable to its flavonoid content, as a result of the sesquiterpene lactone present in the leaves (Arhoghro *et al.*, 2009). The broad greenish leaves contain natural quinine with a bitter taste due to anti-nutritional factors such as alkaloids, saponins, tannin and glycoside also sesquiterpene lactone and flavonoids (Akah and Okafor, 1992). Ohigashi *et al.* (1991) and Jisaka *et al.* (1992) reported the isolation of extremely bitter steroid glycoside and Vernonioside A from the leaves of *V. amygdalina*. Washing of the young

leaves often preferred for human consumption get rid of the bitter taste. Bitter leaf also contains saponins, sesquiterpene lactone, steroid glycosides, alkaloids, tannins and flavonoids (Akah and Okafor, 1992). Young leaves should be properly cooked in order to remove anti-nutrient effects before consumption. The local processing method of squeeze-washing raw or boiling helps to remove the bitter taste and foam. Washed bitter leaf can be preserved by freezing or drying, however, processing results in loss of some nutrients and anti nutritional factors (Ejoh *et al.*, 2003; Bender *et al.*, 1966).

MATERIALS AND METHODS

MATERIALS

(1). Chemicals and reagents for estimation of nutritional composition (AOAC 1990).

Sulphuric acid	1.25 %
Sodium hydroxide solution	1.25 %
Ethanol	25 ml
Potassium sulphate	0.1 g
Copper sulphate	0.9 g
Conc. sulphuric acid	25 ml
Aqueous Na2S	4%
Sodium hydroxide solution	40%
Sulphuric acid	0.1N
Methyl red indicator (I007, HiMedia).	About 5 drops
Sodium hydroxide solution	0.1N
Petroleum ether	1 ltr
Distilled water	10 ltr

(2). Chemicals and reagents for estimation of mineral using Flame Photometer (Rangana, 1986).

Potassium Chloride	1.908 g
Sodium Chloride	2.542 g

Calcium Carbonate	2.247 g
Distilled water	3 ltr
HCl (20 %)	5 ml
HCl (100 %)	10 ml
HCl (1%)	100 ml

Calcium standard solution:

2.247 g AR grade of $CaCO_3$ dissolved in distilled water. Approximately 10 ml of concentrated HCL added to effect complete solution of $CaCO_3$. Diluted to 1 litre with distilled water (1000 pp Ca). 10 ml of this solution diluted to 100 ml (100ppm Ca).

Potassium standard solution:

1.908 g of AR grade KCL dissolved in distilled water and diluted it up to 1 litre (1000 ppm K).

Sodium standard solution:

2.542 g NaCl Ar grade in 1 litre distilled water (1000 ppm Na).

(3). Chemicals and reagents for estimation of mineral following Tri-acid digestion method.

Nitric acid	9 ml

Perchloric acid	4 ml
Sulphuric acid	1 ml
Double distilled water	100 ml
Diethylene Triamine Penta Acetic Acid (0.005M)	1.967 g
Calcium chloride 0.01M	1.47 g
Tri ethanol amine (TEA) 0.1M	13.1 ml
Double distilled water	1000 ml
Zinc sulphate	0.439 g
Magnesium sulphate	10.141 g
Ammonium ferrous sulphate	0.702
Copper sulphate	0.392 g
Conc.H_2SO_4	5 ml
Neutral N NH4OAc solution	40 ppm

Extracting Solution:

For preparation of 1 litre of Diethylene Triamine Penta Acetic Acid (DTPA) extraction solution, 13.1ml reagent grade tri ethanol amine, 1.967 g DTPA (AR grade) and 1.47 g of $Cacl_2$ were dissolved in 100 ml of distilled water. The DTPA was allowed to dissolve for some time and diluted to approximately 900 ml. pH adjusted to 7.3 ± 0.5 with 1:1 HCl and diluted to 1 litre.

Zinc standard solution:

0.439 g AR grade of $ZnS0_4$. $7H_2O$ dissolved in 200 ml of distilled water in a beaker. It was then transferred to a litre volumetric flask and volume made up to the mark. 10 ml of this standard solution (100ppm Zn) was transferred to a Volumetric flask and diluted to the mark with DTPA extracting solution to have a stock solution of 10ppm Zn.

Iron standard solution:

0.702 g of AR grade ammonium ferrous sulphate dissolved in 300 ml distilled water in a beaker. 5 ml of concentrated H_2SO_4. It was then transferred to a litre measuring flask and volume made up to the mark (100ppm Fe).

Magnesium standard solution:

10.141 g $MgSO_4$. 7H2O dissolved in 200 ml distilled water and volume made to 1 litre (1000 ppm Mg). 10 ml of this solution diluted to 100 ml (100 ppm Mg).

Copper standard solution:

0.392g $CuSO_4.5H_2O$ AR grade dissolved in 400ml distilled water in a beaker. It was transferred to a litre volumetric flask and the volume made up to the mark with distilled water (100 ppm Cu).

(4). Chemicals and reagents for estimation of vitamin-C (Direct colorimetric method)

Metaphosphoric acid	2%
2, 6-dichlorophenol-indophenol	100 mg
Sodium bicarbonate	84 g
Ascorbic acid	100 mg
Distilled water	1000 ml

(5). Chemicals and reagents for antioxidant assay (Macwaan and Patel, 2010) and total phenol content estimation (Slinkard and Singleton, 1977).

(DPPH) 1, 1-diphenyl-2-picryl hydrazyl (Cat.: D9132, Sigma)

Vitamin C (Ascorbic acid) (61809405001730, Merck)

Folin-Ciocalteu's phenol reagent (10900105001730,Merck)

Sodium carbonate (61784490511730, Merck)

Potassium persulphate (RM7412-500G, HiMedia)

Gallic acid (RM233-500G, HiMedia)

Methanol (M0120, Ranbaxy)

(6). Media for analysis of occurrence of pathogenic bacteria

Bacillus cereus Agar Base (M833, HiMedia)

Baird Parker Agar Base (M043, HiMedia)

Egg Yolk Emulsion (FD045, HiMedia)

Egg Yolk Tellurite Emulsion (FD046, HiMedia)

Listeria Identification Agar Base (M 1064, HiMedia)

Listeria Selective Supplement (FD 061, HiMedia)

Salmonella–Shigella Agar (M108, HiMedia)

Violet Red Bile Glucose Agar w/o Lactose (M581, HiMedia)

METHODOLOGY

Field surveys were conducted in different regions of Sikkim covering all the four districts viz. North, South, West and East. The following villages and markets of Sikkim were surveyed for collection of information and samples. North district (Mangan, Kabi, Phensong, Phodong, Lachung and Chungthang); East district (Pangthang, Bhusuk, Rongli, Rhenock, Singtam, Aho, Pakyong, Assam Lingey, 6th mile Tadong, Lingding, Rawtey, Rumtek, 9th mile, Sang, Central Pendam, Gangtok, and Ranipool); South district (Namchi, Temi Tarku, Lingey Payoon, Ben, Rabong, Jorethang, Melli and Bermiok); West district (Pelling, Geylzing, Soreng, Reshi and Tashiding).

Based on personal observation and interviews with the key informants, village elders, farmers, vegetable vendors, consumers, vegetable middle man *Kharitey*, 26 species of wild leafy vegetables from the Sikkim Himalaya were documented, out of which, 5 less familiar and common wild leafy vegetable species, were prioritized for detail assessment. Prioritization was done, using a set of criteria, considered to be the main drivers of consumption and their availability in wild. These criteria are (a) taste, (b) frequency of occurrence, (c) ethnic consumer, (d) edibility acceptance, (e) medicinal value, (f) quantity used, (g) market demand, (h) supply volume, (i) supply source, (j) availability season and intensity and (k) preference by younger generation.

Survey was conducted in randomly selected 280 households in different villages located in all four districts of Sikkim. North (40 households), West (70 households), South (70 households) and East (100 households), representing the major ethnic communities, namely the Nepalese, Bhutias and Lepchas. Information was collected on ecological distribution, traditional knowledge, foraging, and mode of consumption, culinary and socio economy of wild leafy vegetables using questionnaire, semi-structured interviews, participant field collection and direct observation . Semi-structured interviews, participant field collection and direct observation were followed to record data on the details of WLVs local names, uses, availability season, collection, preparation and trade. Ethnobotanical information about leafy vegetables was gathered through personal observations and discussions with the villagers. Freelisting interviews with randomly selected informants were conducted. Freelists give information on salience, perception, classification and ranking of objects within a cultural domain in question, here WLVs. Ecological distribution of common and less familiar wild leafy vegetables, consumed by the ethnic people of Sikkim, were documented based on and both the primary and secondary data sources. The data were further enriched by minute details collected through scheduled field visits. Method described by Modi *et al.* (2006) was followed with some modification to collate data collection on wild leafy vegetables.

Collection of samples

The study was carried out in different villages and local periodical markets; locally called *haats,* through semi structured interviews, free listing and direct observation with, 120 Nepali, 90 Bhutia, 70 Lepcha individuals. Plant sample specimens were collected, photographed, and voucher specimens prepared for the herbarium and identified with the help of local taxonomists from Sikkim Government College, Tadong, Botanical survey of India, Gangtok and Sikkim University. Nomenclature follows Flora of Bhutan and local check list.

A total of 20 samples each of prioritized wild leafy vegetable species were collected from different natural habitats in different villages of Sikkim. Similarly, 6 market-samples each, of prioritized WLV species were collected from both rural and urban vegetables markets and periodical *haats* located in the 4 districts of Sikkim. The collected plant materials were placed in a polyethylene bag to prevent loss of moisture during transportation to the laboratory. The leafy parts of these vegetables were washed, cut and shade dried at room temperature. The dried leaves were pulverized, packed in airtight sterile bottles, labeled and stored in a dessicator until used.

Nutritional value

Moisture

Moisture content of the WLVs was determined by drying 2.0–3.0 g of well-mixed sample at 135 ± 1° C for 2 hour to constant weight (AOAC, 1990).

Ash

A sample (~2 g) was weighed into a previously dried and weighed porcelain crucible and placed in a muffle furnace, preheated to 550° C for 3 h. The crucible was transferred directly to desiccators, allowed to cool to room temperature and weighed immediately (AOAC, 1990). The process of heating for 30 min, cooling and weighing was repeated until the difference between two successive weighing was ≤ 1 mg.

Fat

Fat content of the sample was determined by ether extraction using glass soxhlet (AOAC, 1990). Flat-bottomed flask was oven dried and kept in desiccators for cooling. The weight (W_1) of the round-bottomed flask was taken. A cellulose thimble (dry and fat free) was taken and in which ~ 2 g of sample was placed and put in the soxhlet. Fat was extracted by using petroleum ether with boiling range 40-60° C, on a heating mantle at

60° C for 5 hour. The flat bottomed flask was dried for 1 h at 100° C to evaporate ether and moisture, cooled in desiccator and weighed (W_2).

Fat was calculated in percentage:

Fat (%) = W_2–W_1/Sample weight × 100

Crude fiber

Crude fiber was estimated by acid–base digestion with 1.25% H_2SO_4 (prepared by diluting 7.2 ml of 94% conc. Acid of specific gravity 1.835g/ml per 1000 ml distilled water) and 1.25% NaOH (12.5 g per 1000 ml distilled water) solutions. The residue after crude lipid extraction was put into a 600 ml beaker and 200 ml of boiling 1.25% H_2SO_4 added. The contents were boiled for 30 minutes, cooled, filtered through a filter paper and the residue was washed three times with 50 ml aliquots of boiling water. The washed residue was returned to the original beaker and further digested by boiling in 200 ml of 1.25% NAOH for 30 min. The digest was filtered to obtain the residue. This was washed three times with 50 ml aliquots of boiling water and finally with 25 ml ethanol. The washed residue was dried in an oven at 130 °C to constant weight and cooled in a dessicator. The residue was scraped into a pre-weighed porcelain crucible, weighed, ashed at 550°C for two hours, cooled in a dessicator and re-weighed. Crude fiber content was expressed as

percentage loss in weight on ignition (AOAC, 1990, Nesamvuni et al., 2001).

Protein

Total nitrogen of the sample was determined following the method described in AOAC (1990). Approximately 1 g of sample was taken in a digestion flask, 0.7 g catalyst ($CuSO_4$: K_2SO_4, 1:9) and 25 ml of concentrated H_2SO_4 were added to it. The flask was heated gently until frothing ceased, boiled briskly until the solution became clear and then continued the boiling for about 1 h. The solution was transferred quantitatively to a round-bottomed flask, and mixed with approximately 100 ml of distilled water and 25 ml 4 % w/v aqueous Na_2S to precipitate mercury. A pinch of zinc granules to prevent bumping and a layer of 40 % w/v NaOH were added carefully. The flask was immediately connected to a distillation apparatus and the tip of the condenser was immersed in standard 0.1 N H_2SO_4 containing about 5 drops of methyl red indicator (I007, HiMedia). The flask was rotated to mix the contents thoroughly and heated until all the ammonia had distilled. The receiver was removed and the tip of the condenser was washed with distilled water. The remaining acid in the receiver was titrated with standard 0.1 N NaOH solutions. The blank determination on reagents was considered for correction. Nitrogen was calculated in percentage.

Total nitrogen (%) =

[(ml of standard acid × N of standard acid) - (ml of standard NaOH - C.F.) × N of standard NaOH] × 1.4007/weight of sample (g).

Correction factor (C.F.) =

(titre of standard NaOH against blank - ml of standard acid).

Protein content was determined by multiplying total nitrogen value with 6.25 (AOAC, 1990). Protein (%) = Total Nitrogen (%) × 6.25

Carbohydrate

The carbohydrate content of the samples was calculated by difference: 100 - (% protein + % fat + % ash) (Standal, 1963).

Food Value

Food value of each batter sample was determined by multiplying the protein, fat and carbohydrate contents by the factors 4, 9 and 4, respectively, and adding all the multiplication values to get kcal per 100 g (Indrayan *et al.*, 2005).

Minerals

The method of AOAC (1990) for determination of mineral was followed. The ash after heating the sample at 550° C for 3 h was dissolved in 5 ml of 20 % HCl. The solution was evaporated to dryness on a hot plate at a temperature of 100-110° C and in an oven at 110° C for 1 h. The minerals in the dried residue were dissolved in about 10 ml of 100 % HCl and the solution was heated on a hot plate at a temperature of 100-110° C for 3-4 times. The solution was made up to 100 ml with 1 % HCl. Calcium, sodium and potassium were estimated in flame-photometer Thermo Scientific Chemito (Cat. no. ER15-941-20) at 623, 589 and 766 nm, respectively following the method of Ranganna (1986).

For analysis of magnesium, zinc, copper and iron, Triacid digestion method (Prasad and Bisht, 2011) was followed with modification. It was carried out using HNO_3: $HClO_4$: $H2SO_4$ in the ratio 9:4:1. The collected leaves were dried in an oven at 60-70° c for 2-4 h. The dried leaf samples for each plant material were ground separately in Willey's mill. One gram of ground sample of each plant material was digested in 15 ml of tri-acid mixture. The volume was made up to 100 ml by adding DDW to obtain the solution ready for determination of mineral elements through Atomic Absorption Spectroscopy (AAS) (AA, Perkin-Elmer AAnalyst 200). Standard solution of each element was prepared

and calibration curves were drawn for each element using AAS (Indrayan *et al.*, 2005).

Vitamin-C (Ascorbic Acid)

Vitamin-C was estimated following direct colorimetric determination (Rangana,1986) with some modifications. The direct colorimetric method is based on measurement of the extent to which a 2,6-dichlorophenol-indophenol solution is decolorized by ascorbic acid in sample extracts and in standard ascorbic acid solutions (Loeffler and Ponting, 1942). Since interfering substances reduce the dye slowly, rapid determination would be measuring mainly the ascorbic acid.

1. 2% Metaphosphoric acid in glass distilled water.
2. Dye solution: 100 mg of 2,6-dichlorophenol-indophenol and 84 mg of sodium bicarbonate were dissolved in hot (85-95^0 C) distilled water.
3. Standard ascorbic acid solution: 100 mg of ascorbic acid was accurately weighed and volume made up to 100ml with 2% HPO_3. 4 ml of this solution was diluted to 100ml with 2% HPO_3 (1ml = 40µg of ascorbic acid).
4. Preparation of sample: 10g of sample was accurately weighed and blended with 2% HPO_3 and volume made up to 100ml with HPO_3. The solution was filtered

5. Assay of extract: 2-10 ml aliquot of extract of HPO_3 of the sample was titrated with standard dye to pink end point which persisted for about 15 sec. The titration was done rapidly and a preliminary determination of the titre was made. In the next determination most of the dye required was added and titrated accurately.
6. To the dry cuvettes, the requisite volume of standard ascorbic acid solution - 1, 2, 2.5, 3, 4 and 5 ml was pipette out and the volume made up to 5 ml with requisite amount of 2% HPO_3. With the help of a rapid delivery pipette, 10 ml of dye was added and shaken. The reading was taken within 15-20 seconds. The instrument was set to 100 % transmission using blank consisting of 5 ml of 2% HPO_3 solution and 10 ml of water. The red colour was measured at 518 nm. The absorbance against concentration was plotted.
7. Sample: 5 ml of the extract were placed in a cuvette and 10 ml of dye was added and measured as in standard.
8. Calculation: The concentration of ascorbic acid was noted from the standard curve and the ascorbic acid content in the samples was calculated with the following formula.

   AA mg /100g = Ascorbic acid content x Volume made up to x 100 /ml of solution taken for estimation x 1000 x wt or volume of sample taken

Extract Preparation

The edible parts of leafy vegetables were washed in running water. The leaves were chopped into small pieces and shade dried in room temperature. The dried materials were ground to a coarse powder and extracted (20 g) successively with 200 ml methanol in a glass soxhlet extractor at 130^{0}C for 24–48 h. The extract was concentrated by using rotary evaporator. The extract was preserved in a dessicator till further use.

Total Phenolic Content

Total soluble phenolic compounds present in extracts were determined with the Folin-Ciocalteu reagent (Slinkard and Singleton, 1977) with modification. Calibration curve was prepared by mixing methanolic solution of gallic acid 1 ml, (10–100µg/ml) with 1ml Folin-Ciocalteu reagent, (diluted tenfold) and sodium carbonate (2%). The absorbance was measured at 760 nm using Lamda 25 UV Vis Spectrophotometer (Perkin Elmer/L 600-00 BB) and drew the calibration curve. 1 ml Methanol extract of the sample (100µg/ml) was also mixed with the reagents above and after 2 hrs the absorbance was measured to determine total plant phenolic contents. The total content of phenolic compounds in the extract of gallic acid equivalents (GAE) was calculated by the following formula: T= C.V/M

Where,

T= total content of phenolic compound, milligram per gram plant extract, in GAE.

C= the concentration of gallic acid established from the calibration curve, milligram per milliliter.

V= the volume of extract, milliliter.

M= the weight of methanolic plant extract, gram.

Antioxidant activity

The antioxidant activity was analyzed by estimating free radical scavenging activity following DPPH method of Macwaan and Patel (2010) with modifications.

0.1mM solution of DPPH (1, 1-diphenyl-2-picrylhydrazyl), in methanol was prepared and 1.0 ml of this solution was added to 3.0 ml of extract solution in methanol at different concentration (10-100 μg/ml). Thirty minutes later the absorbance was measured at 517 nm using Lamda 25 UV Vis Spectrophotometer (Perkin Elmer/L 600-00 BB). A blank was prepared without adding extract. Ascorbic acid at various concentrations (10-100 μg/ml) was used as standard. Lower absorbance of the reaction mixture indicates higher free radical scavenging activity. The capability to scavenge the DPPH radical was calculated using the following equation.

DPPH scavenged (%) = Abs (control) - Abs (test)/ Abs (control) x 100

Where Abs (control) is the absorbance of the control reaction and Abs (test) is the absorbance in the presence of the sample of the extracts. The antioxidant activity of the leaf extracts were expressed as IC_{50}. The IC_{50} value was defined as the concentration (in μg/ml) of extract that scavenges the DPPH radical by 50 %.

Microbiological safety analysis

Ten g of sample were homogenised with 90 ml of 0.85 % (w/v) sterile physiological saline in a stomacher lab-blender (400, Seward, UK) for 1 min. Serial dilutions (10-1 to 10-8) in the same diluents were made.

TVC: Total viable count (TVC) was determined in the plate count agar (M091A, HiMedia) plates which were incubated at 30° C for 48-72 h.

RESULTS

Survey on wild leafy vegetables

Survey was conducted in randomly selected 280 households in different villages located in all four districts of Sikkim: North (40 households), West (70 households), South (70 households) and East (100 households), representing the major ethnic communities, namely the Nepalis, Bhutias and Lepchas. The study was carried out in different villages and local periodical markets, locally called *haats* (Table 5), through semi structured interviews, free listing and direct observation with, 120 Nepali, 90 Bhutia, 70 Lepcha individuals. Information on ecological distribution and consumption of wild leafy vegetables (WLVs) were collected using questionnaire. Indigenous knowledge on traditional method of collection and preparation of WLVs by the ethnic people of Sikkim Himalaya, their mode of consumption, socio-economy and ethnic value of the products were also documented based on the information sought from the local people of the respective places and other secondary sources.

Documentation of traditional knowledge

In Sikkim, the ethnic people, usually the elderly men and women are generally able to identify the edibility of wild leafy vegetables and have developed the taste of such plants. 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. This is probably, due to the fact that, most of the present day younger generation in the villages are not much contributive in the field. They are rather, attracted by the urban lifestyles and living. The organic farming initiated by the department of Horticulture and cash crops, Government of Sikkim, generally focuses on the exotic and improved varieties of vegetables. Moreover, the tastes of exotic varieties are more preferred by the younger generation. This can be probably attributed to the globalization in trends and technology from present day gadgets to restaurant glass.

However, in such rural families, which are involved in the commercial foraging of WLVs, the traditional knowledge from plant identification, their natural habitat, foraging, mode of consumption, availability season, and even the minute marketing parameters, are effectively transmitted from one generation to the other. The pattern of such transmission is generally from mother to daughter or mother - in-law to daughter–in-law. Male members of the family are not much involved in this activity (Table 7). The vegetable middle man locally called *Kharitey*, who collects *en-masse* WLVs from the villages and supply to the vendors locally called *subjiwala*, at the vegetable markets, in the urban places, were

found to be equally informed about the geographical distribution and supply sources.

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

In Sikkim Himalaya, the natives cook and consume nearly 26 wild leafy vegetables belonging to 17 families (Table 1). Selection of a particular species, for inclusion in the diet, is location specific and influenced by the availability of plant material. Shown in table 2, 3, 8 and 9 few species qualified through the selection parameters such as (a) taste, (b) frequency of occurrence, (c) ethnic consumer, (d) edibility acceptance, (e) medicinal value, (f) quantity used, (g) market demand, (h) supply volume, (i) supply source, (j) availability season and intensity, (k) preference by younger generation, as designed for detailed assessment for the purpose of the present thesis.

As such, five common and less familiar wild leafy vegetables were prioritized for detailed assessment (Photo 1). Their ecological distribution, ethnic importance, socio-economy, mode of consumption, culinary, nutritional value, mineral content, antioxidant activity, phenolic content and microbial safety were studied and are well documented in this thesis.

Table 1: Wild leafy vegetables of Sikkim

Botanical name	Family	Local Name	Habit	Distribution (ft.)	Consumer
Amaranthus lividus Linn.	Amarantheceae	*Ginneri sag*	Herb	upto 6000	All
Amaranthus spinosus Linn.	Amarantheceae	*Ban lunde*	Herb	upto 5000	Nepali
Amaranthus viridis Linn.	Amarantheceae	*Lattey sag*	Herb	2500-6000	All
Asparagus recemosus Willd.	Liliaceae	*Kurilo*	Climbing shrub	upto 4000	Nepali Lepcha
Arundinaria maling (Gamble)	Poaceae	*Malingo*	Grass	5000-9000	All
Cassia fistula Linn.	Caesalpinaceae	*Rajbriksh*	Tree	upto 4000	All
Casearia glomerata Roxb.	Flacourtiaceae	*Barkunlay*	Tree	upto 5600	All
Chenopodium album Linn.	Chenopodiaceae	*Bethu sag*	Herb	upto 12000	All
Cissus adnata Roxb.	Vitaceae	*Charchare*	Herb	upto 3500	All
Dendrocalamus hamiltonii Nees.	Poaceae	*Tama*	Herb	upto 7000	All
Diplazium esculentum (Retz)Sw.	Athyriaceae	*Ningro*	Fern	4000-8000	All
Embelia undulate (DC.)Mez.	Myrsinaceae	*Amilpati*	Climbing shrub	2900-9800	Nepali
Girardiana diversifolia (Link) Friss.	Urticaceae	*Bhangrey sisnoo*	Shrub	4000-9000	All
Houttuynia cordata Thunb.	Sauraceae	*Hilay Jhar*	Herb	upto 5900	Nepali Lepcha
Indigofera atropurpurea Horn em.	Leguminosae	*Chiringi jhar*	Herb	upto 5000	All
Malva vericillata Linn.	Malvaceae	*Lapche sag*	Herb	600-9500	Nepali Lepcha

All, all ethnic groups of Sikkim; ft, feet

Continued (Table 1)

Nasturtium officinale Brown	Brassicaceae	*Simrayo*	Herb	upto 12000	All
Persicaria runcinata (Buch-Ham ex D.Don)H.Gross	Polygonaceae	*Ratnaulo*	Herb	8000-11500	All
Pouzolziz sanguinea (Bl.)Merr.	Urticaceae	*Chipley*	Tree	Upto 9800	Nepali Lepcha
Rumex nepaulensis Spreng.	Polygonaceae	*Halhalay*	Herb	6000-7000	All
Trichosanthes palmata Roxb.	Cucurbitaceae	*Indreyni*	Herb	upto 6000	Nepali
Urtica ardens Link.	Urticaceae	*Sisnoo*	Herb	upto 9800	All
Urtica dioica Linn.	Urticaceae	*Sisnoo*	Herb	upto 7000	All
Urtica hyperborea Jacq.	Urticaceae	*Sisnoo*	Under shrub	13000-16500	All
Urtica parviflora Roxb.	Urticaceae	*Sisnoo*	Herb	5000-12000	All
Wrightia arborea (Dennst.) Schluss.	Apocynaceae	*Lelemny-ok*	Tree	upto 3900	Lepcha

All, all ethnic group of Sikkim; ft, feet

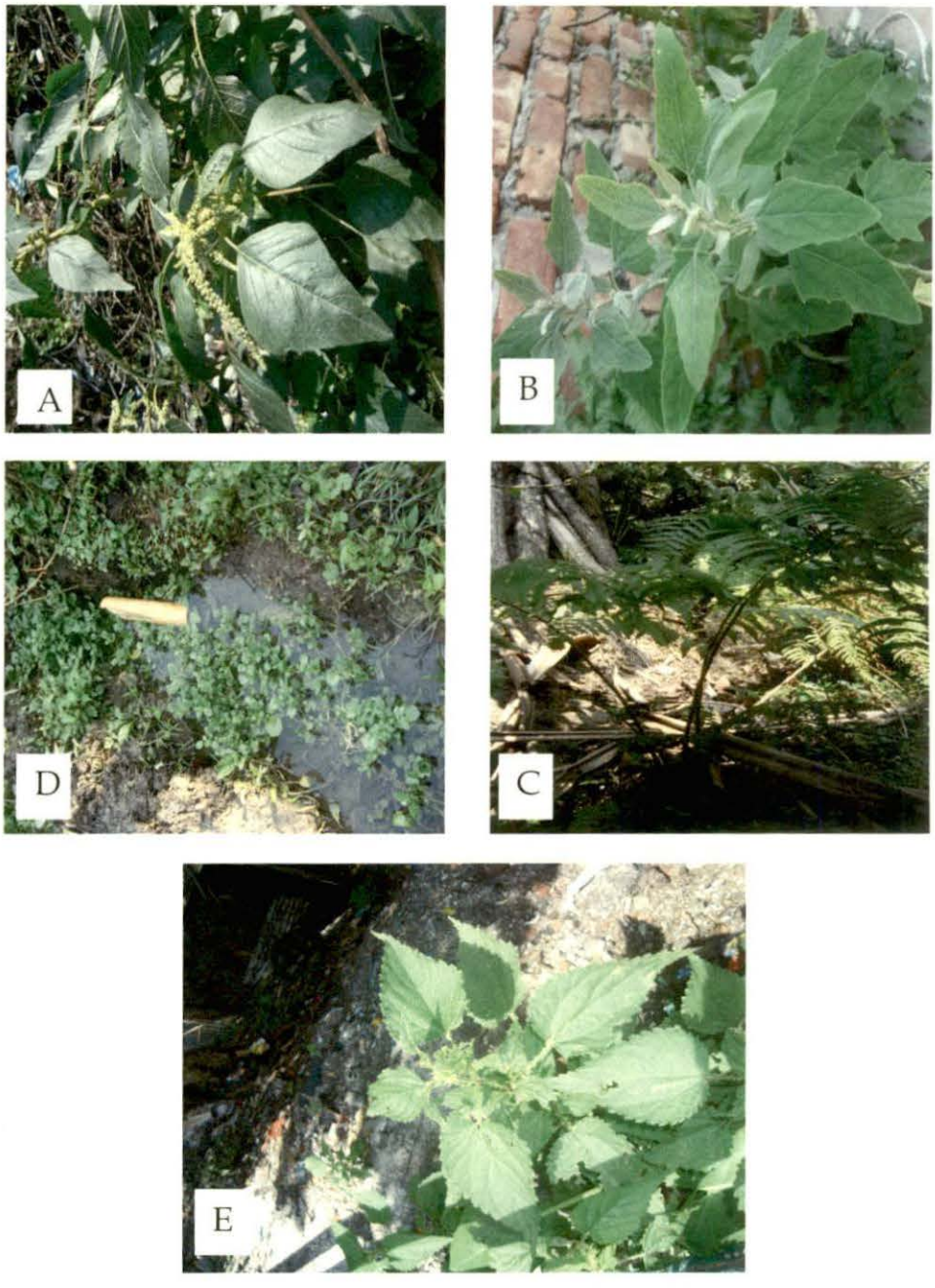

Photo 1. Selected common and less familiar wild leafy vegetables of Sikkim **(A)** *Amaranthus viridis* Linn.; **(B)** *Chenopodium album* Linn.; **(C)** *Diplazium esculentum* (Retz.)Sw; **(D)** *Nasturtium officinale* R.Br.; **(E)** *Urtica dioica* Linn.

Availability season

The selected common and less familiar wild leafy vegetables are available for local consumption in the Sikkim Himalayas from the month of March to August at different intensity (Table 8). Consumption of WLVs were found to be by choice, chance, tradition, taste, necessity, knowledge or any other ethnical values known to the natives of the Himalayas.

As such, the people of Sikkim face vegetable scarcity, during monsoon season, which generally commences from the month of June and lasts up to August/September. Monsoon brings with it, a prolonged torrential rain, raising the meteorological rain-gauge reading, every year. In the far flung remote villages of the state, the scarcity of food and exotic vegetables are further aggravated by series of landslides and natural calamities which occur due to the torrential, monsoon rain. It is fairly during these crucial hours, 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 *Bethu sag, Urtica dioica* Linn. locally known as *sisnoo* also enter into the food basket of the Sikkimese ethnic groups (Table 3 and 8).

Out of the five prioritized species, *Amaranthus viridis, Chenopodium album, Urtica dioica, Nasturtium officinale* has already entered into the medical food menu of Sikkimese people, while, *Diplanzium esculentum* and *Urtica dioica* has entered into the cultural, traditional, tourism and domestic food menu, of the Himalaya. *Amaranthus viridis* and *Chenopodium album* are of intermediate occurrence in terms of availability while *Diplazium esculentum, Nasturtium officinale* and *Urtica dioica* are of frequent occurrence. All the five WLVs are accepted for consumption by all the ethnic groups and are consumed by all age groups. Similarly all of them have medicinal value and are consumed in fairly large quantities during its availability season (Table 2).

A study on the seasonal calendar of selected common and less familiar wild leafy vegetables of Sikkim (Table 8), reveals the fact that all the five WLVs are heavily available in its vegetative stage during the month of April and May every year. Interesting to note that *simrayo* is available whole round the year with heavy availability during the months of March, April, May, July and August, moderate availability during the months of February and June and slightly available during rest of the months. Amongst the five selected WLVs *lattey sag* and *bethu sag* are those which are available for human consumption for a very short period of time. They make their appearance in the vegetable market in the month of

March which becomes heavily available in the month of April and May and becomes moderately available in June and slowly disappears for the rest of the months. *Sisnoo* and *ningro* has almost similar seasonal calendar where they appear in the month of late February, becomes moderately available in March. The availability reaches maximum in the month of April and May and becomes moderately available during the months of June and July and remain slightly available for rest of the months. During the month of June-July though these WLVs are available in their natural habitat, their collection volume drops to moderate (Table 8) or sometimes even to a slight intensity, mainly because of three reasons:

(i) Technical difficulties in foraging from the forest due monsoon rain and leeches,

(ii) High water content in the edible parts,

(iii) Presence of insect and insect larvae on the tender parts.

Ecological distribution

Out of 26 wild leafy vegetables documented, 16 were herb, 2 climbing shrubs, 1 shrub, 1 under shrub, 4 trees, 1 grass and 1 fern. In the Sikkim Himalayas, they are found growing at different altitudinal range and varied ecological habitat. *Urtica hyperborea* Jacq. is found growing at an altitude as high as 13000-16500ft. Based on the specific micro climate, the Sikkim Himalaya is divided into 3 important zones, viz., low hills (up

to 2900 ft, elevation), mid hills (2900-6500 ft) and upper hills (>6000 ft) . A few species showed broader distribution, therefore zones like low-mid hills, mid-upper hills and low-upper hills were also categorized, (Table 4 and 5). The selected common and less familiar wild leafy vegetables were found to be distributed across a wide altitudinal and climatic range from low hill to upper hill and in different ecological habitat (Table 3 and 4). *Chenopodium album* and *Nasturtium officinale* are found to be distributed up to an altitude as high as 12000 ft. The altitudinal range between 1000-6500 ft includes the major cultivable land and major human inhabited geographical range of Sikkim (Table 5).

Wild leafy vegetables in Sikkim, implies absence of sufficient human management and are generally consumed, when the other exotic varieties of vegetables are scarce, for any reason. In fact these vegetables result from the co-evolutionary relationship between human and environment. All the selected WLVs have wide range of adaptability and are found growing in diverse ecological habitats. *Amaranthus viridis* is found growing as a weed in the crop and vegetable fields mainly with maize and rye grass. Similarly, *Chenopodium album* has been observed to be growing as a weed in maize and wheat crop fields. *Nasturtium officinale* is identified as a plant that grows luxuriantly in the ditches, shallow streams and perennial water bodies. *Urtica dioica* is observed to be an aggressive plant growing in undisturbed places rich in nutrient while *Diplazium*

esculentum is a fern growing in the forest slopes and undisturbed places. (Table 3).

Table 2: Selected common and less familiar wild leafy vegetables of Sikkim

Botanical name and Family	Taste	Frequency of occurrence	Ethnic consumer	Edibility acceptance	Medicinal value	Quantity used
Amaranthus viridis Linn. Amarantheceae	Sweet with sharp flavour	Intermediate	Nepali, Bhutia, Lepcha	All	Yes	Large
Chenopodium album Linn. Chenopodiaceae	Sweet with sharp flavour	Intermediate	Nepali, Bhutia, Lepcha	All	Yes	Large
Diplazium esculantum (Retz.) Sw. Athyraceae	Sweet with mild flavour	Frequent	Nepali, Bhutia, Lepcha	All	Yes	Large
Nasturtium officinale Brown Brassicaceae	Sweet with typical brassica ceae flavour	Frequent	Nepali, Bhutia, Lepcha	All	Yes	Large
Urtica dioica Linn. Urticaceae	Sweet with mild flavour	Frequent	Nepali, Bhutia, Lepcha	All	Yes	Large

All, all age group

Table 3: Ecological distribution and market economy of selected common and less familiar wild leafy vegetables of Sikkim

Botanical name and Local name	Ecological habitat	Distribution	Market demand	Supply volume	Supply source
Amaranthus viridis Linn. Lattey sag	CCF/ FL/ UCF/ UCL/ RS/ FM/ HG/ DP/ NCS/ BY	2500- 6000 ft.	Moderate	Medium	Crop field weed
Chenopodium album Linn. Bethu sag	CCF/ UCF/ HG/ FL/ NCS/ BY	upto 12000 ft.	Moderate	Medium	Crop field weed
Diplazium esculantum (Retz.) Sw. Ningro	FR/ UCF/ FVM/ UCL/ RS/ RF	4000-8000 ft.	High	High.	Wild
Nasturtium officinale Brown Simrayo	MP/ AS/ SM/ HGWP/ RF/ FR/ CRKWC	upto 12000 ft.	High	High.	Wild
Urtica dioica Linn. Sisnoo	UCL/ RS/ SM/ DP/ RF/ FR/ RM	Upto 7000ft.	High	High.	Wild

H, herb; S, shrub; T, tree; CCF, cultivated crop fields; UCF, uncultivated crop fields; UCL, uncultivated lands; RS, road sides; FL, fallows; FM, field margins; FVM, field vertical margins; HG, home gardens; FR, forests; MP, marshy places; AS, along streams; SM, stream margins; RM, river margins; DP, disturbed places; HGWP, home garden wet places; UDP, undisturbed places; RF, reserve forests; NCS, near cow sheds; BY, back yards; CRKWC, conventional rural kitchen wash complex.

Table 4: Distribution of selected common and less familiar wild leafy vegetables of Sikkim in different altitudinal zones

Ecological zone	*A. viridis*	*C. album*	*D. esculentum*	*N. officinale*	*U. dioica*
Low hill	√√	√√	-	√	-
Mid hill	√	√√	√	√√	√
Low-mid hill	√√	√√	√	√√	√
Mid-upper hill	√	√√	√√	√	√√
Upper hill	-	√	√	√	√√

√, *moderate distribution;* √√, *High distribution;* -, *distribution rare.*

Low hill, 1000-2900 ft; Low-mid hill, 1000-4900 ft; Mid hill, 2900-6500 ft;

Mid-upper hill, 4900-8200 ft; Upper hill, > 6500 ft.

Table 5: Major villages and markets of Sikkim in different climatic zones

Climatic Zone	Altitude	Areas
Sub-tropical Zone (Low lands)	1000-2900 ft.	Rongpo, Mazitar, Kumrek, Kamling, *Singtam, Jorethang,* Jitlang, Mamring, Suntalay, Sirwani, *Ranipool,* 32 mile, *Melli, Rongli,* Legship, *Makha,* Samramsa, Rongli, *9th mile, Reshi*
Temperate Zone (Mid hills)	2900-6500 ft.	Khamdong, Namthang, Maniram, Sadam, Turuk, *Ahoe,* Rumtek, Mulukay, Ranka, *Namchi, Tadong, Linding,* Duga, *Rhenock, Bermoik,* Rakdong Tintek, *Central Pendam,* Martam, *Sang,* Dikchu, Pendam, *Assam Lingey, Bhusuk, Mangan, Phodong, Phensong, Chungthang, Kabi lungchok, Pangthang,* Aritaar, *Pakyong , Gangtok, 6th Mile, Rawtey, Rumtek,* Sang, *Tashiding, Soreng,* Sombaria, *Namchi, Temi Tarku, Lingey Payoong,* Kewzing, Kaluk, Darmadin, Hee-Bermiok, *Parts of Dzongu, Kabi,* Okhrey, *Geyzing,* Chujachen, Lamaten, Sombaria, Naga, Sipgyar, Kartok.
Temperate zone (High hills)	6500-9000 ft.	*Pelling, Rabongla, Ben,* Hilley
Alpine Zone	9000-16000 ft.	Lachen, *Lachung,* Barsey, Nathang, Changu, Phadamchen, Parts of Dzongu.

Areas with *italics* were surveyed for collection of data and information.

Socio Economy

In Sikkim, WLVs can be broadly divided into two groups on the basis of consumption, the one which are not consumed regularly on account of their limited seasonal availability while others are frequently consumed due to easy availability. Consumption and marketing of WLVs in Sikkim, is a seasonal practice (Table 8). None of these species has been domesticated for large scale commercial cultivation in the field through any regularized agency or method, yet, there are a few common and less familiar species which are consumed by almost all the ethnic communities of Sikkim (Table 2) and all of these selected WLVs are commercially viable (Photo 2). A study on the year-wise, market price of WLVs (maximum per bundle price in a season), in rural and urban markets of Sikkim, data collected for year 2001-2011 envisage their commercial viability (Table 6). A comparative analysis of urban and rural market price in rupees (maximum per bundle price in a season) per bundle of selected common and less familiar wild leafy vegetables of Sikkim has revealed the fact that within a span of 11 years there is a sharp rise in price rate of WLVs. In 2001, per bundle price of the selected five WLVs in urban market were Rs 2.00 and that in rural markets Rs.1.00-1.50. However, in 2011 the urban market price reached to Rs 15 and that in rural market it ranged from Rs.12.00-15.00 (Figure 2a-2k).

A study on the gender percentage profile of WLV vendors in four different districts of Sikkim (Table 7), reveals the fact that east district has 78.3 % female and 21.7 % male. In south district 79.3 % female and 20.7 % male. In north district 72 % female and 28% male while in west district 75.4 % female and 24.6 % male (Figure 4a-4e). The gender percentage figure of WLV vendors of the state is female 76.25 % and male 23.75 % (Figure 4f; Photo 3).

Though the younger generations are not much engaged in the foraging of wild leafy vegetables a study on the edibility acceptance percentage of selected common and less familiar wild leafy vegetables amongst the younger generation (18-24yrs age group) (n=90) of different ethnic groups of Sikkim reveals an interesting details (Table 9). *Ningro* is accepted by 90 % Bhutia, 86.6 % Nepali and 82.2 % Lepcha. 90 % of Nepali and Bhutia accept the consumption of *sisnoo* while the figure is 84.4 % for Lepcha. Edibility acceptance percentage of *simrayo* for all the three ethnic groups is above 85%. *Bethu sag* is consumed by 55.5 % Nepali, followed by 35.5 % Lepcha and only 27.7 % Bhutia. Similarly 42 % of Nepali younger generation accepts the edibility of *lattey sag* followed by 28.8 % of Lepcha and just 20 % of Bhutia (Figure 3).

Photo 2. WLV trade, knowledge sharing and financial independence through foraging of wild leafy vegetables. (**A-C**) foraging and marketing of wild leafy vegetables; **(D)** knowledge sharing through the response to the questionnaire; **(E)** financial return and ensuring economic security

Photo 3. Participation of females in the trade and marketing of wild leafy vegetables. (**A-D**) rural women selling vegetables along with wild leafy vegetables in the weekly periodical *haats* of Sikkim.

Table 6: Comparative analysis of urban and rural market price in Rupees (maximum price in a season) per bundle of selected common and less familiar wild leafy vegetables of Sikkim

Year	Market	Wild leafy vegetables (Rs.)				
		Lattey	*Bethu*	*Ningro*	*Simrayo*	*Sisnoo*
2001	Urban	2.00	2.00	2.00	2.00	2.00
	Rural	1.00	1.00	1.50	1.00	1.50
2002	Urban	2.00	2.00	2.50	2.00	2.00
	Rural	1.00	1.00	1.50	1.00	1.50
2003	Urban	2.00	2.00	2.50	2.50	2.50
	Rural	2.00	2.00	2.50	2.00	2.00
2004	Urban	2.50	2.50	2.50	2.50	2.50
	Rural	2.00	2.00	2.50	2.50	2.50
2005	Urban	2.50	2.50	3.00	2.50	5.00
	Rural	2.50	2.50	2.50	2.50	3.00
2006	Urban	3.00	3.00	3.00	2.50	5.00
	Rural	2.50	3.00	3.00	2.50	3.00
2007	Urban	5.00	5.00	5.00	5.00	5.00
	Rural	5.00	5.00	5.00	5.00	5.00
2008	Urban	5.00	5.00	5.00	5.00	5.00
	Rural	5.00	5.00	5.00	5.00	5.00
2009	Urban	7.50	7.50	8.00	8.00	8.00
	Rural	5.00	7.50	7.50	7.50	7.50
2010	Urban	10.00	10.00	10.00	10.00	10.00
	Rural	10.00	10.00	10.00	10.00	10.00
2011	Urban	15.00	15.00	15.00	15.00	15.00
	Rural	12	12	15.00	15.00	15.00

Table 7: Gender percentage profile of WLV vendors in four different districts of Sikkim

District	Vegetable periodical haat/ market	Total no of WLV vendors	No of male vendors	No of female vendors	Male %	Female %	Average male %	Average female %
East	Gangtok	57.0 ± 2.9	11.5 ± 1	45.5 ± 2.0	20.2 ± 0.9	79.8 ± 0.9	21.7	78.3
	Singtam	42.7 ± 2.5	7.5 ± 0.5	35.2 ± 2.6	17.6 ± 1.7	82.4 ± 1.7		
	Pakyong	16.0 ± 1.6	5.0 ± 0.8	11.0 ± 1.8	31.2 ± 1.2	68.8 ± 1.2		
	Ranipool	13.0 ± 1.4	2.0 ± 0.8	11.0 ± 0.8	15.3 ± 5.0	84.7 ± 5.0		
	Rhenock	16.0 ± 1.6	3.3 ± 0.5	12.7 ± 1.2	20.6 ± 0.5	79.4 ± 1.5		
	9th mile	6.7 ± 0.95	1.7 ± 0.5	5.0 ± 0.8	25.4 ± 7.0	74.6 ± 7.0		
North	Phodong	4.7 ± 0.5	1.5 ± 0.5	3.2 ± 0.5	31.9±10.3	68.1±10.3	28	72
	Mangan	11.2 ± 1.9	2.7 ± 0.5	8.5 ± 1.7	24.1 ± 6.6	75.9 ± 6.4		
South	Jorethang	25.2 ± 2.0	4.0 ± 1.8	21.2 ± 2.2	15.9 ± 6.8	84.1 ± 6.8	20.7	79.3
	Rabongla	19.0 ± 2.9	4.5 ± 2.0	14.5 ± 1.2	23.7 ± 8.0	76.3 ± 8.0		
	Namchi	24.7 ± 2.2	5 ± 1.4	19.7 ± 2.8	20.2 ± 6.6	79.8 ± 6.6		
	Melli	9.7 ± 0.9	2.2 ± 0.5	7.5 ± 1.0	22.7 ± 6.2	77.3 ± 6.2		
West	Geylzing	16.2 ± 1.8	4.2 ± 0.9	12.0 ± 1.4	26.0 ± 4.6	74.0 ± 4.6	24.6	75.4
	Pelling	9.0 ± 0.8	1.5 ± 0.5	7.5 ± 0.5	16.7 ± 5.4	83.3 ± 5.4		
	Legship	6.0 ± 0.8	1.5 ± 0.5	4.5 ± 0.5	25.0 ± 7.6	75.0 ± 7.6		
	Soreng	10.4 ± 1.7	3.2 ± 0.9	7.2 ± 1.5	30.8 ± 8.3	69.2 ± 8.3		

WLV, wild leafy vegetable.

Table 8: Seasonal calendar of selected common and less familiar wild leafy vegetables of Sikkim

	MONTH											
WLV	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Lattey	x	x	a	aaa	aaa	aa	a	x	x	x	x	x
Bethu	x	x	a	aaa	aaa	aa	a	x	x	x	x	x
Ningro	x	a	aa	aaa	aaa	aa	aa	a	a	a	a	x
Simrayo	a	aa	aaa	aaa	aaa	aa	aaa	aaa	a	a	a	a
Sisnoo	x	a	aa	aaa	aaa	aa	aa	aa	a	a	a	x

WLV, wild leafy vegetables;

x, not available; a, slightly available; aa, moderately available; aaa, heavily available.

Table 9: Edibility acceptance percentage of selected common and less familiar wild leafy vegetables amongst the younger generation of different ethnic groups of Sikkim

	Nepali		Bhutia		Lepcha	
WLV	n	%	n	%	n	%
Ningro	78	86.6	81	90	74	82.2
Sisnoo	81	90	81	90	76	84.4
Simrayo	79	87.7	80	88.8	77	85.5
Bethu	50	55.5	25	27.7	32	35.5
Lattey	38	42.2	18	20	26	28.8

n, values out of 90 samples.

***Amaranthus Viridis* Linn.**

Family: Amarantheceae.

English Name: Pig weed

Vernacular Name: Lattey sag/ Lunde sag (Nepali)

Ethnic importance:

Amaranthus viridis Linn. commonly called *lattey sag* or *lunde sag* in Nepali, has been used in the Sikkimese food culture, since time immemorial. The leaves are used as vegetables and seeds are nutritious. It is used, both for human nutrition and animal feed. The rural ethnic people of Sikkim consume *Amaranthus viridis, as* a non-conventional wild leafy vegetable, especially during the crucial time of vegetable scarcity (Table 8). This leafy vegetable is consumed by all the ethnic people of Sikkim, within an altitudinal range up to 2500-6000 ft. (Table 3). *Amaranthus viridis* is also used as medicine (Table 2). In traditional system, it is used to reduce labour pain. Ethno-medically, it is found to act as antipyretic, analgesic, laxative, encouragement of appetite, antifungal and in the treatment of asthma. The Nepalese of Sikkim use this plant to treat several ailments such as malaria, hepatic disorders, jaundice, scanty urine or wounds, body ache, diabetes and to induce abortion. The Lepchas in remote villages of Sikkim use the plant to treat diarrhoea, gastroenteritis and arthritis. *Lattey sag* has found its place in some folk songs of the hills,

Goht muni barima lattey ko sag, hami pani khaun hai ek dui chaak (Annonymous). In English, it means there are some *lattey sag* in the field below the cow shed, so, let us too, eat them for one or two meals. The Lepchas of Sikkim believe that, curry prepared from green *lattay* sag stop diarrhoea. Seeds, ground into powder, mixed with water and taken as an infusion to cure general gastric problems. Beaten seeds are fried with butter and fed to pregnant women to lessen pregnancy pains. Root paste is applied on minor bone fracture and dislocation. Root and seed decoction is taken to treat diarrhoea and cough. Elders in rural villages are proficient in identifying its edibility as leafy vegetable. It is otherwise discarded as weeds. The discarded weeds are used as feed for the livestock at home.

Ecological Distribution

Amaranthus viridis Linn. is found luxuriantly growing as weed, in the cereal and vegetable crop fields and around domestic livestock shed complex. It grows as a seasonal weed. The plant is also found growing in the waste lands, uncultivated fields, field margins and home gardens of urban, peri urban and rural ecological environments. It thus has wide range of adaptability. The plants germinate during early summer, after seed dormancy. It is reported to be distributed within an altitudinal range between 2500-6000 ft (Table 3). It is found growing in low hill, mid hill, low mid hill and mid upper hill (Table 4) and is found growing

luxuriantly in the organic manure deposits and soil with no standing water. In its natural habitat, it is observed to be generally associated with other weeds like *Drymeria cordata, Solanum nigrum, Cardamine hirsute, Galinsoga sp, Ipomia sp, Aegeratum sp etc.* It is found associated with crops such as maize and wheat. Even the folk song describes, its ecological habitat, to be in the field below the cow shed, which partially indicates that, it is found growing in the crop field and prefers soil rich in organic manure.

Foraging

Foraging of *Amaranthus viridis* is done from, waste lands, field margins, cultivated crop fields or vegetable fields and furrows. The edible part, being the tender shoots and young leaves, it is collected from its natural habitat during the month of April to July (varying at different places relative to the altitude and climatic conditions). Based on the requirement, whether for home consumption or sale in the vegetable market, two different patterns of collection are practiced by the ethnic people of Sikkim. For consumption at home, the tender shoots with leaves are collected by plucking them with hand. There is a faint belief, amongst some conservative elders in the villages, that, the edible part should not be harvested with a sickle or knife, as it will taste pungent. However, there is

no record of its experimental proof. Elderly women are expert in plucking the edible parts for consumption.

For sale or supply in the vegetable markets, plants are collected from the crop fields, when the plant is about one feet tall after germination. They are collected by uprooting the whole plant or plucking with hand. The collected plants or plant parts are then washed and tied into small bundles locally called *mutta* about 300-500 g in weight (Figure 7b). Generally, bundles are tied with dried paddy straw (*Oryzea sativa*) locally called *paraal* , matured maize (*Zea mays*) leaves locally called *makai ko paat, Poa* leaves locally called *siroo ko paat* et. chetera. *Lattey sag,* is an uncultivated wild leafy vegetable plant, and is available only during its favourable season, unless domesticated. It is a highly perishable plant. The left over *lattey sag* from the household and vegetable market are used as feed for the livestock and pig.

Prospects of *Amaranthus viridis*

Amaranthus viridis, though a crop-field weed, is a multi-prospective plant. It is found to be used as a leafy vegetable, fodder for domestic livestock and is traditionally used in the treatment of several illness and diseases (Figure 7a).

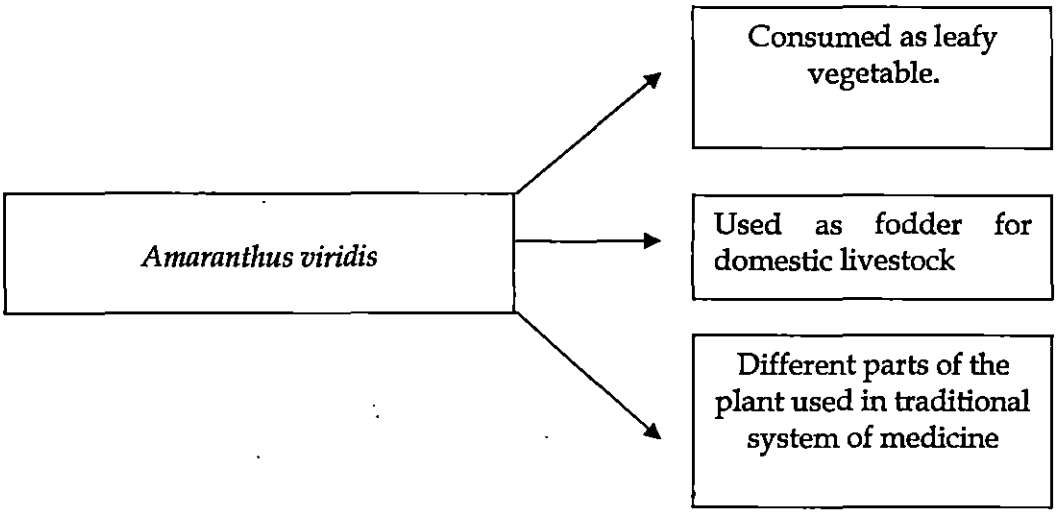

Fig 7a. Prospects of *Amaranthus viridis*

Market chain analysis and socio – economic profile

A detail study on the market chain and socio-economy of *Amaranthus viridis* Linn. was conducted. For high volume demand, *Lattey sag* foraging is done from the crop-field habitat. There is a proportionate, unidirectional socio-economic gain, involved in *lattey sag* market chain (Figure 7b).

For sale in the market and local periodical *haats,* the young plants are uprooted or plucked and carried to the tap water or *dhara* a traditionally designed, common washing and bathing place along, some nearby stream or kitchen courtyard. The washed materials are tied into bundles and inserted in a sack or bamboo-stripe made back-pack basket locally called *doko* and carried to the market, local *haat* and other places for sale (Photo 4). If the villager is not a vegetable seller then it is either sold to

vegetable vendor in the market or to the vegetable supplier, middle man locally called *kharitey* who purchases the vegetable in large scale from the villagers and supplies to the vendors at the market place. *Kharitey* transports the vegetable load, from village to the town by public carrier such as bus or taxi. *Kharitey* pays for the transport. From the terminus at the town, the load is transported to the vegetable vendor at the vegetable market place, manually by the porter and coolie (Photo 5). *Kharitey* pays for the manual labour. *Kharitey* supplies to the vegetable vendor at the market place and gets his return in cash. Consumer purchases from the vegetable vendor at the market place at the rate of Rs. 15-20 per bundle weighing about 300-500 g. Thus *lattey sag* completes its unidirectional market chain (Figure 7b).

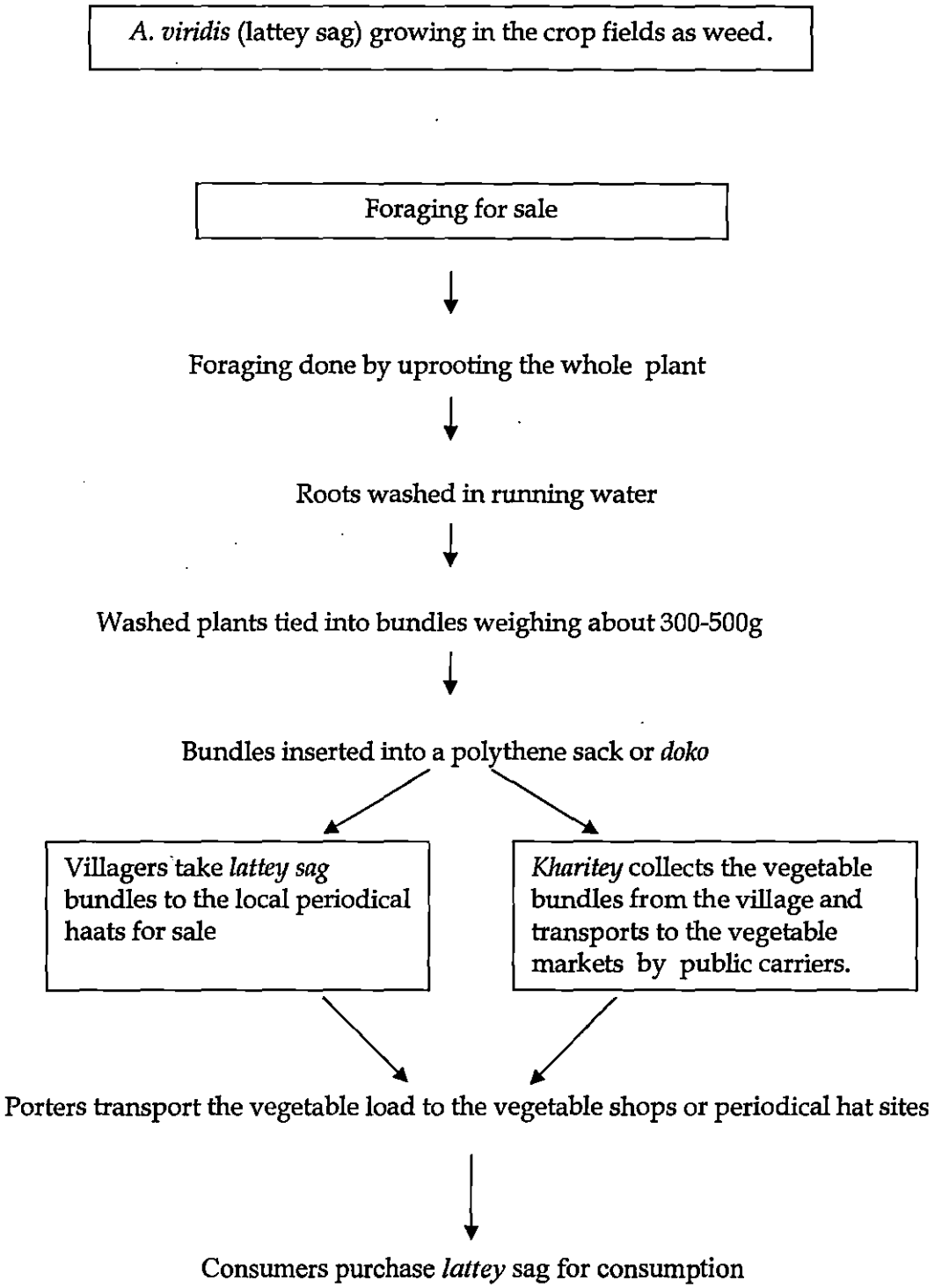

Fig 7b. Flow- sheet of market chain and socio-economic profile of *lattey sag*.

Photo 4. (A-E) Vegetable vendors, selling vegetables along with wild leafy vegetables along the road side stalls.

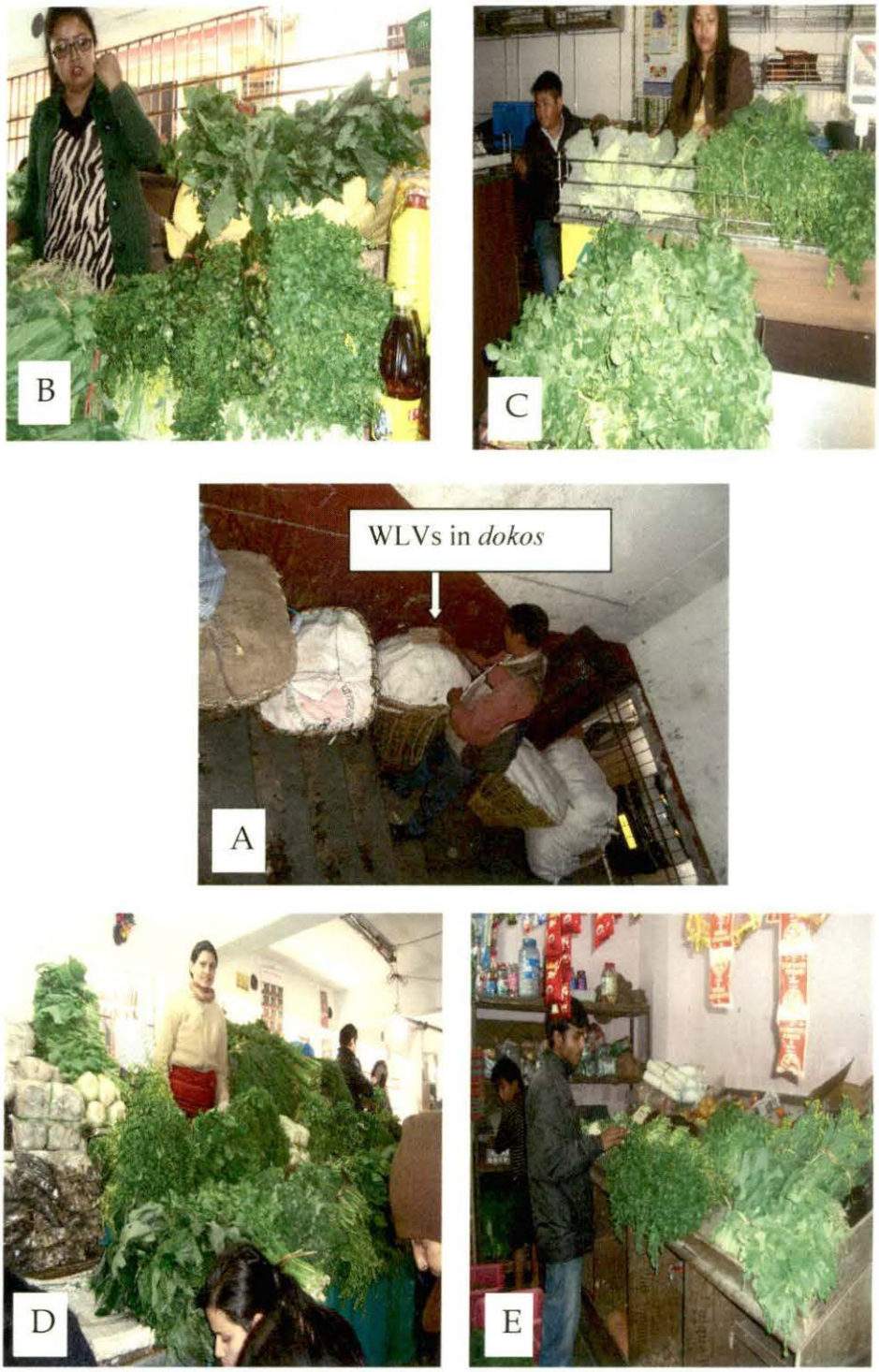

Photo 5. Role of porter in WLV market chain. **(A)** porter distributing the WLV load to the vegetable shops or vendors; **(B-E)** vegetable vendors in urban market place, selling vegetables along with wild leafy vegetables

Beneficiaries in the unidirectional market chain

The market chain (Fig 7b) is unidirectional, where, benefit flows from wild natural habitat to urban and rural consumers. Several stakeholders are benefited in this unidirectional chain of *lattey sag* marketing (Fig 7c).

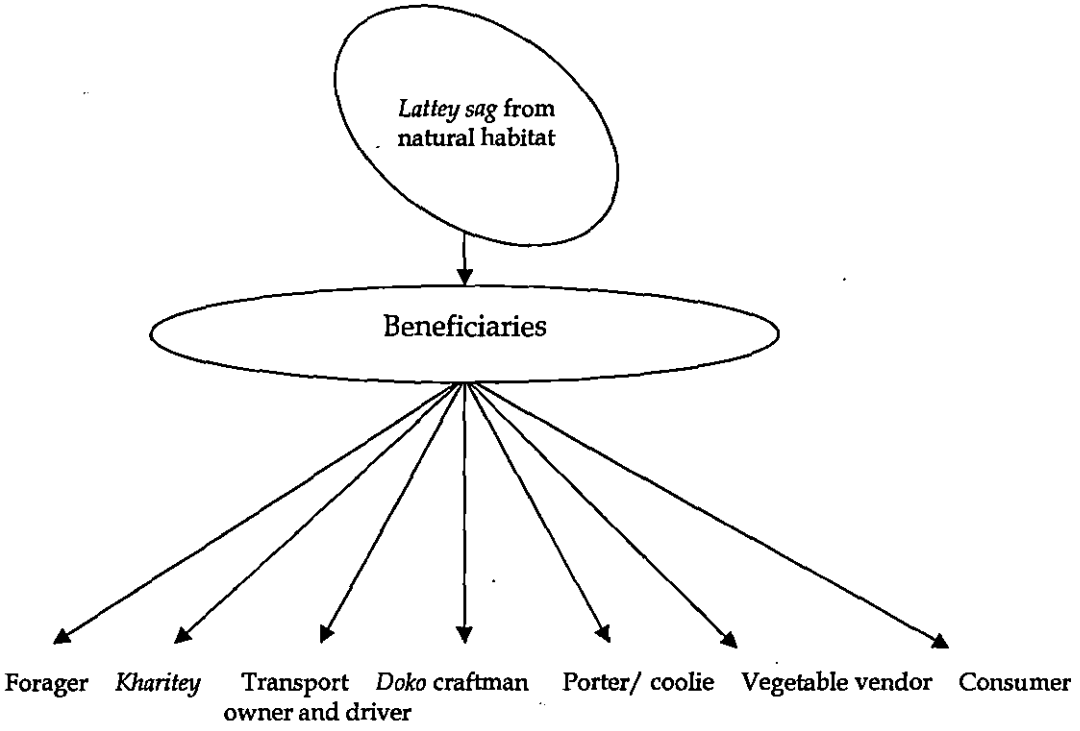

Fig 7c. Beneficiaries in a unidirectional market chain of *lattey sag*

Mode of consumption

Cooked *lattey sag* is consumed as a side dish. The village people prefer to cook *lattey sag*, either with potatoes or meat (Fig 7d). This gives typical, blended-taste, which most of the elderly people, prefer to eat.

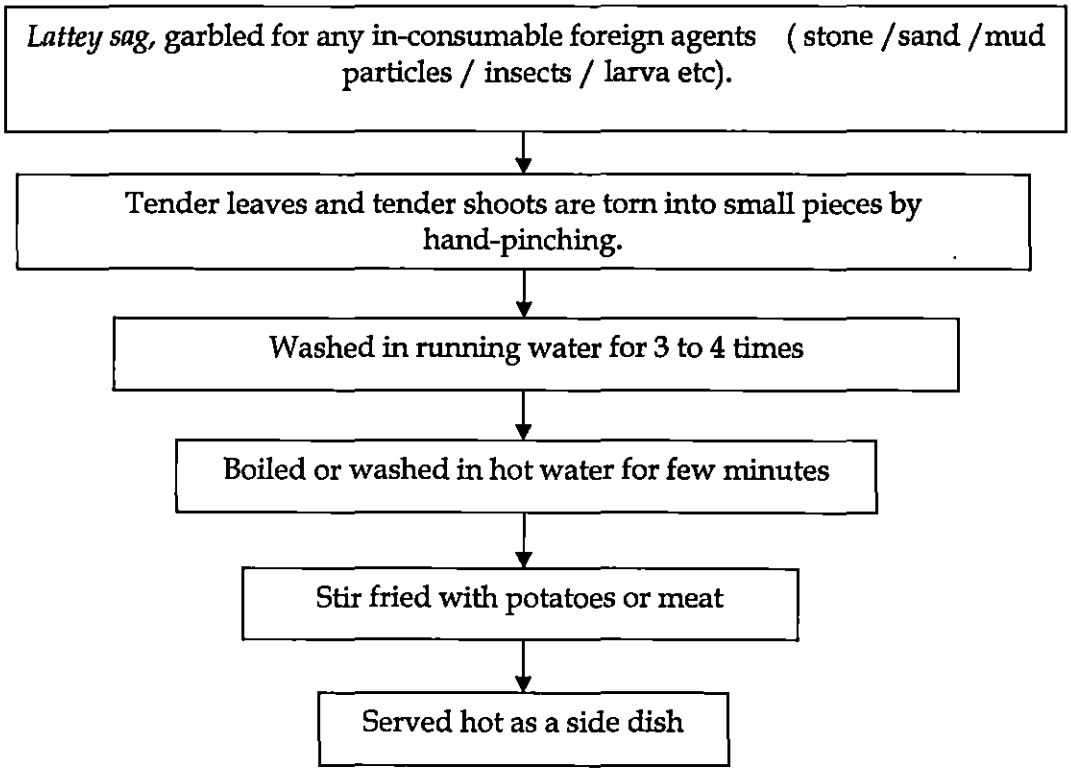

Fig 7d. Flow sheet of mode of consumption of *lattey sag*.

Culinary

Lattey sag culinary is almost a zero-spice culinary, as it generally, does not involve the use of spices, except garlic or ginger paste, which is also optional (Fig 7e; Photo 6). It is a health supporting culinary.

Photo 6. Preparation of *lattey sag* with meat as a side dish. **(A)** *lattey sag* bundle; **(B)** garbling of *lattey sag;* **(C)** boiled/hot water treated *lattey sag;* **(D)** *lattey sag* being cooked with meat; **(E)** *lattey sag* side dish, served hot

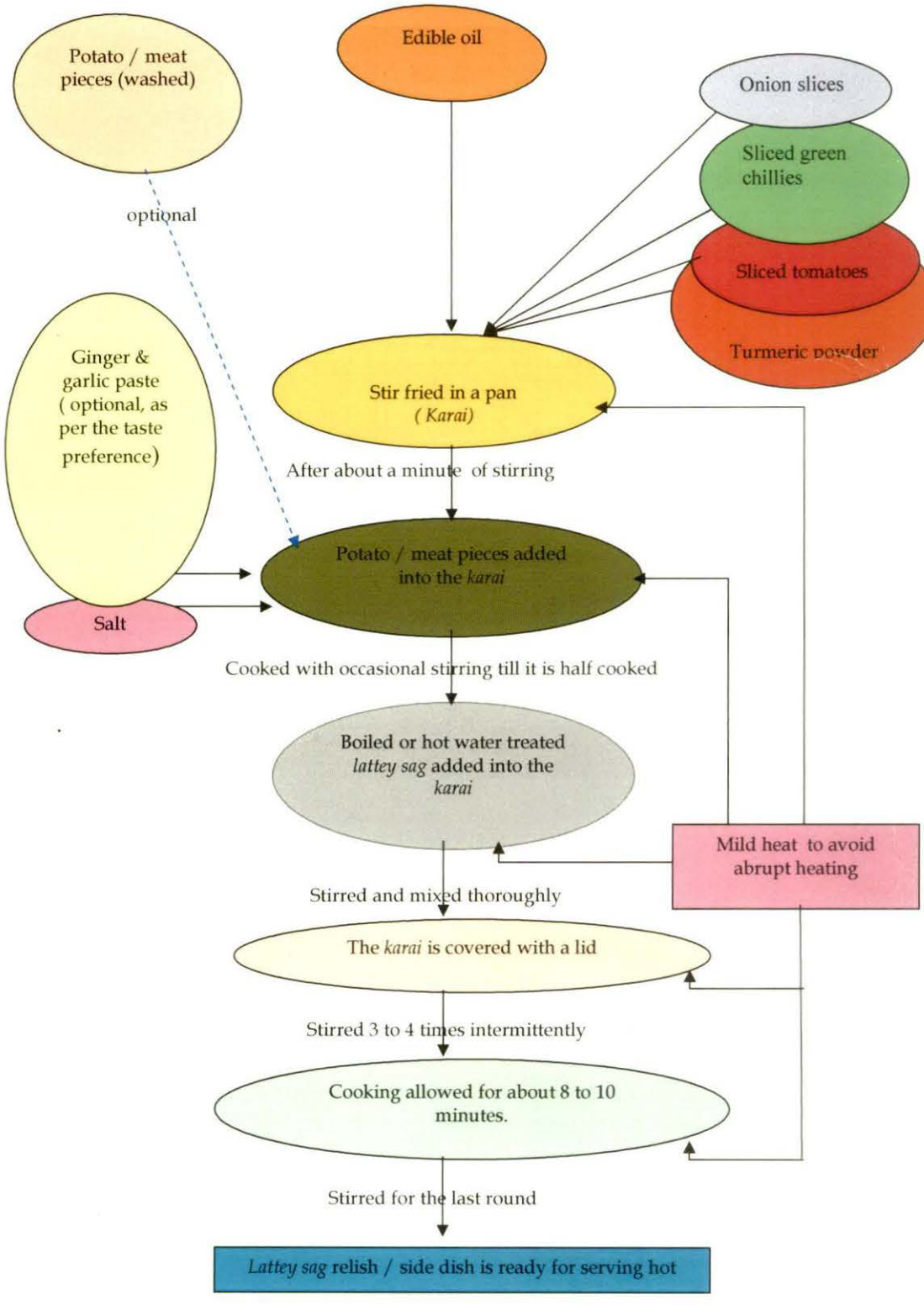

Fig 7e. Flow sheet of *lattey sag* culinary

Chenopodium album Linn.

Family: Chenopodiaceae

English Name: Lamb's quarters

Vernacular Name: Bethu sag (Nepali)

Ethnic importance

It is commonly called *bethu sag* in Nepali and *pigweed, fat hen* or *lamb-quarters'* in English. It is also called *white goose foot.* In the olden times, as reported by some elderly informants, seeds of this species were also used for baking bread. Lachungpas in lachung valley of North Sikkim use *C. album* seeds in the preparation of *chang,* a traditionally prepared alcoholic beverage. It is believed to enhance the taste of *chang. Chenopodium album* is commonly used both as food and medicine (Table 2). It is used to cure piles and clearing worms. It is also used to enhance digestive power, appetite, and strength of the body and to destroy all types of worms. Its use for the treatments of hepatic disorders, spleen enlargement, intestinal ulcers and burns are of wide acceptance amongst the rural people of Sikkim. *C. album* has often been reported in the folklore to be helpful in intestinal pains. *Bethu sag* is used in TSM to cure constipation, joint pain by the ethnic people of Sikkim.

Ecological distribution:

In Sikkim, it is found growing as a weed in maize, wheat and vegetable crop fields, within an altitudinal range up to 12000 ft. (Table 3). It multiplies at a very fast rate, because of a large number of small seeds, produced per plant. It is found growing as a seasonal weed, in the crop fields. It is also found growing in fallows, uncultivated fields and home gardens, in different parts of Sikkim (Table 3). It is found growing in low hill, mid hill, low mid hill, mid upper hill and upper hill at varying distribution density (Table 4). In its natural habitat it is seen growing in association with plant species such as *Amaranthus sp, Cepsella sp, Cardamine sp, Centella asiatica, Polygonum sp, Galinsoga sp* et. cetera. Like *Amaranthus viridis,* it is also found luxuriantly growing in the organic manure deposits and prefer a soil with no standing water. Some ethnic people in Sikkim, believe that, the *betu* seeds, fall to the ground from the sky. This could be attributed to its anemophilic mechanism of seed dispersal.

Foraging

Foraging of *Chenopodium album* is done from cultivated crop or vegetable fields and furrows. The tender shoots and young leaves are collected during the month of April to July (varying at different places relative to the altitude and climatic conditions). Based on the requirement, whether for home consumption or sale in the vegetable market, two

different patterns of collection are practiced by the ethnic people of Sikkim. For consumption at home, the tender shoots with leaves are collected by plucking them with hand. Elderly women are expert in plucking the edible parts for consumption.

For sale or supply in the vegetable markets, plants are collected from the field when the plant is about 8-12 inches tall, after germination. They are collected by uprooting the whole plant, with hand. The uprooted plants are washed and tied into small bundles locally called *mutta* about 300-500 g in weight. Generally, bundles are tied with dried paddy straw (*Oryzea sativa*) locally called *paraal* , matured maize (*Zea mays*) leaves locally called *makai ko paat, Poa* leaves locally called *siroo ko paat* etc. chetera. *Bethu sag* is an uncultivated wild leafy vegetable plant that grows as weed, and will be available only during its availability season, unless domesticated. In almost all parts of the state it is consumed as a leafy vegetable by all the ethnic people of Sikkim. *Betu sag* is a highly perishable plant. The left over *bethu sag* from the household and vegetable market is used as feed for the livestock and pig.

Prospects of *Chenopodium album*

Chenopodium album, though a crop-field weed, is a multi-prospective plant. It is used as a leafy vegetable, fodder for domestic

livestock and is traditionally used in the treatment of several illness and diseases (Fig 8a)

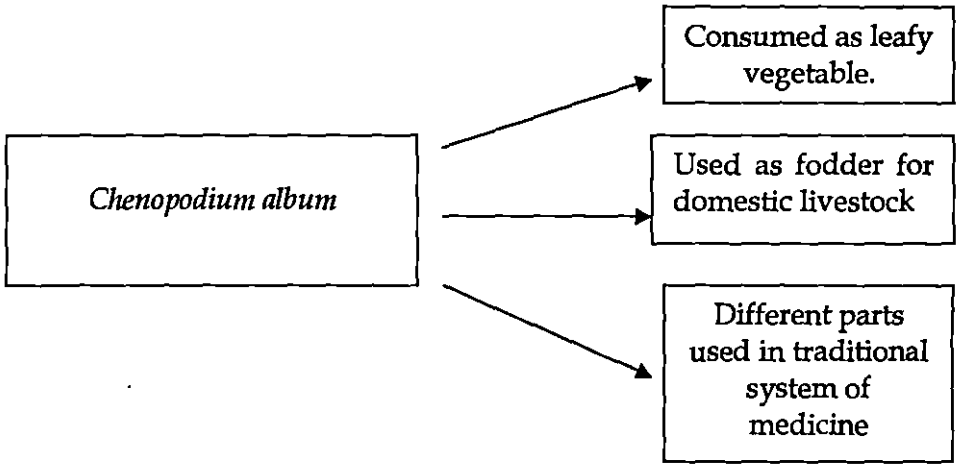

Fig 8a. Prospect of *Chenopodium album*

Market chain analysis and socio-economic profile

A detail study on the market chain and socio-economy of *Chenopodium album* was conducted. *Bethu sag,* foraging is done from the crop-field habitat. There is a proportionate unidirectional socio-economic gain involved in *bethu sag* market chain (Fig 8b).

For sale in the market and local periodical *haat,* the young plants are uprooted or plucked and carried to the tap water or *dhara,* a traditionally designed, washing and bathing place along, some nearby stream or kitchen courtyard. The washed materials are tied into bundles and inserted in a sack or bamboo-stripe made back-pack basket locally

called *doko* and carried to the vegetable market, local *haat* and other places for sale (Photo 4). If the villager is not a vegetable seller then it is either sold to vegetable vendor in the market place or to the vegetable supplier locally called *kharitey* who purchases the vegetable in large scale from the villagers and supply to the vendors at the market place. *Kharitey* transports the vegetable load, from village to the town by bus or taxi. *Kharitey* pays for the transport. From the terminus at the town, the load is transported to the vegetable vendor at the vegetable market place, manually by the porter and coolie (Photo 5). *Kharitey* pays for the manual labour. *Kharitey* supplies to the vegetable vendor at the market place and gets his return in cash. Consumer purchases from the vegetable vendor at the market place at the rate of Rs. 15-20 per bundle weighing about 300-500 g. Thus *bethu sag* completes its unidirectional market chain (Figure 8b).

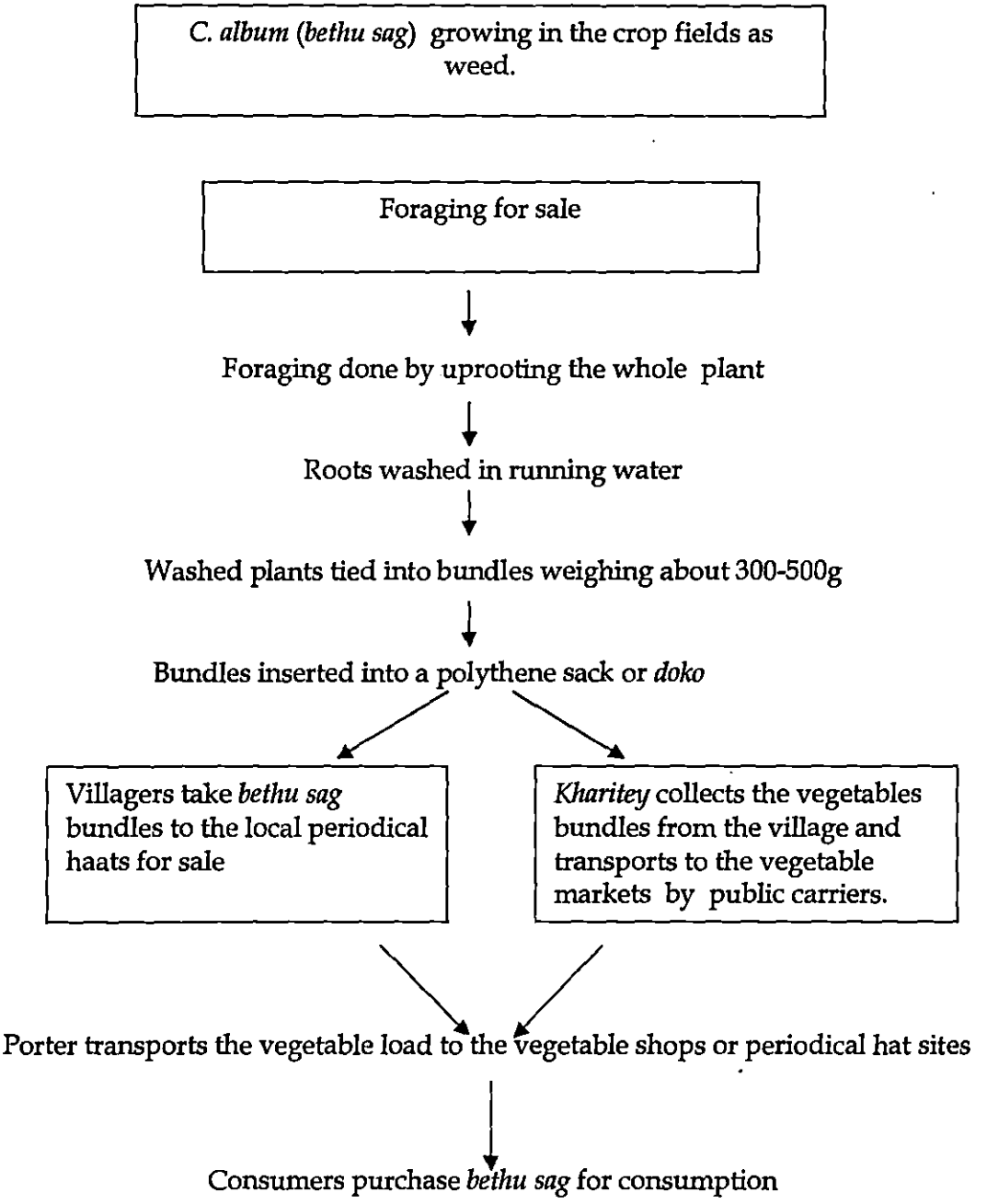

Fig 8b. Flow sheet of market chain and socio-economic profile of *bethu sag*.

Beneficiaries in the unidirectional market chain

The market chain (Fig 8b) is unidirectional, where, benefit flows from wild natural habitat to urban and rural consumers. Several stakeholders are benefited in this unidirectional chain of *bethu sag* marketing (Fig 8c).

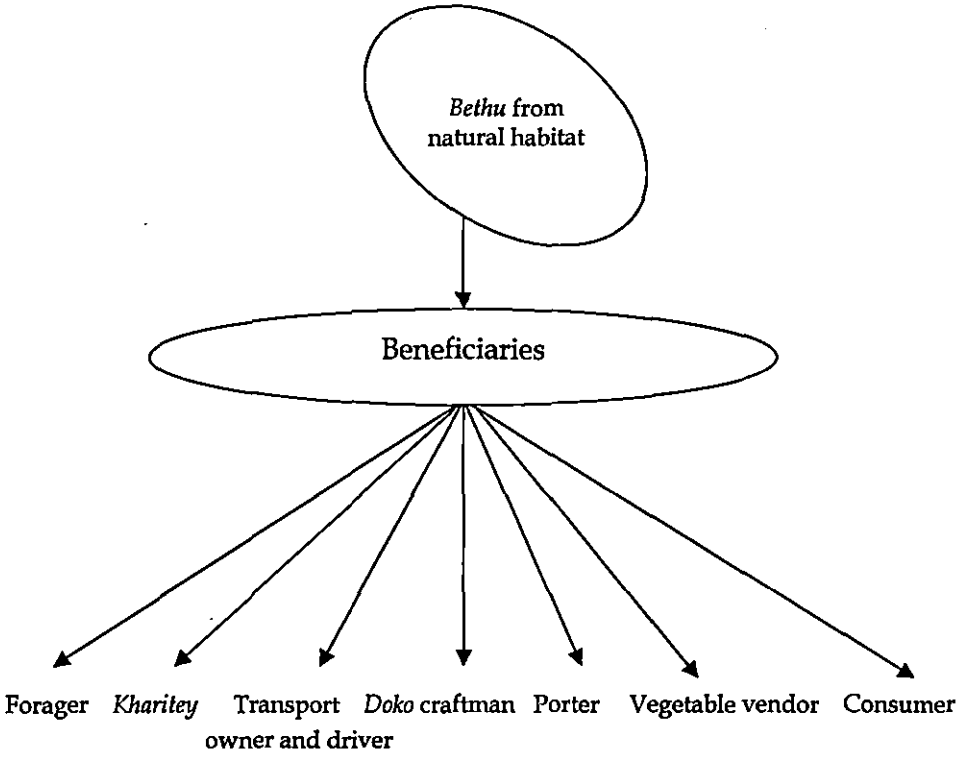

Fig 8c. Beneficiaries in a unidirectional market chain of *bethu sag*

Mode of consumption:

Bethu sag is cooked and consumed, as a side dish. It is best prepared with potatoes or meat (Fig 8d).

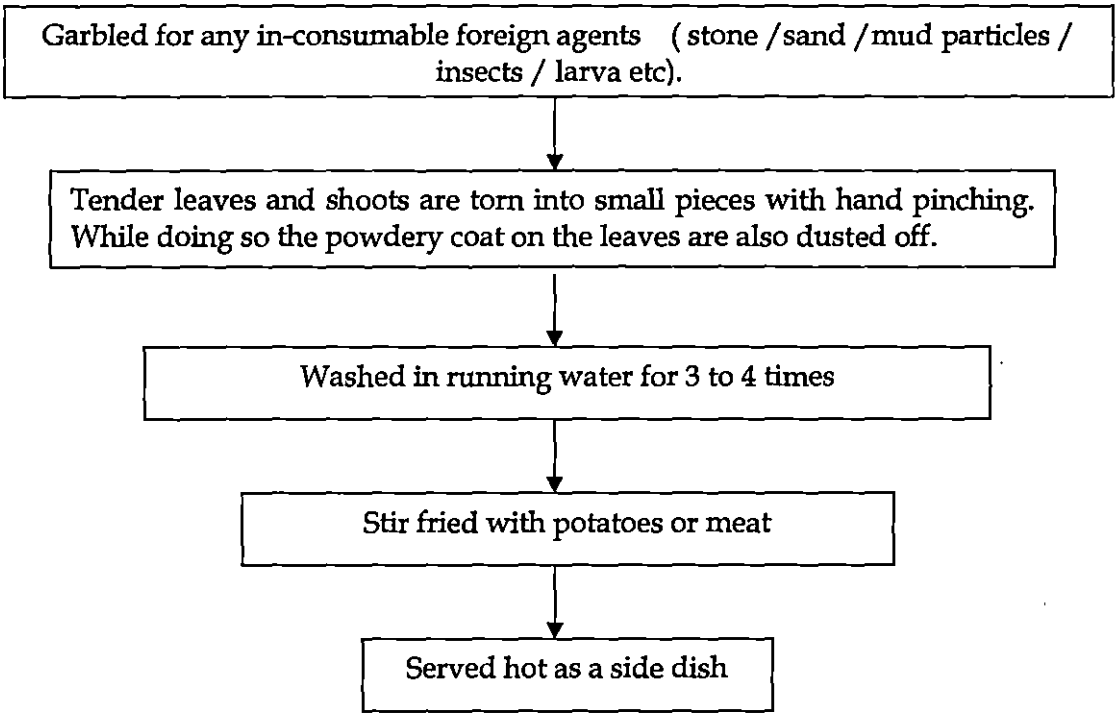

Fig 8d. Flow- sheet of mode of consumption of *bethu sag.*

Culinary

Bethu sag culinary, is almost a zero-spice culinary, as it does not engage, the use of spices, except garlic or ginger paste, which is also optional (Fig 8e; Photo 7). It is a health supporting culinary. The village people prefer to cook *bethu sag,* either with potatoes or meat. This gives a typical, blended-taste, which most of the elderly people prefer to eat.

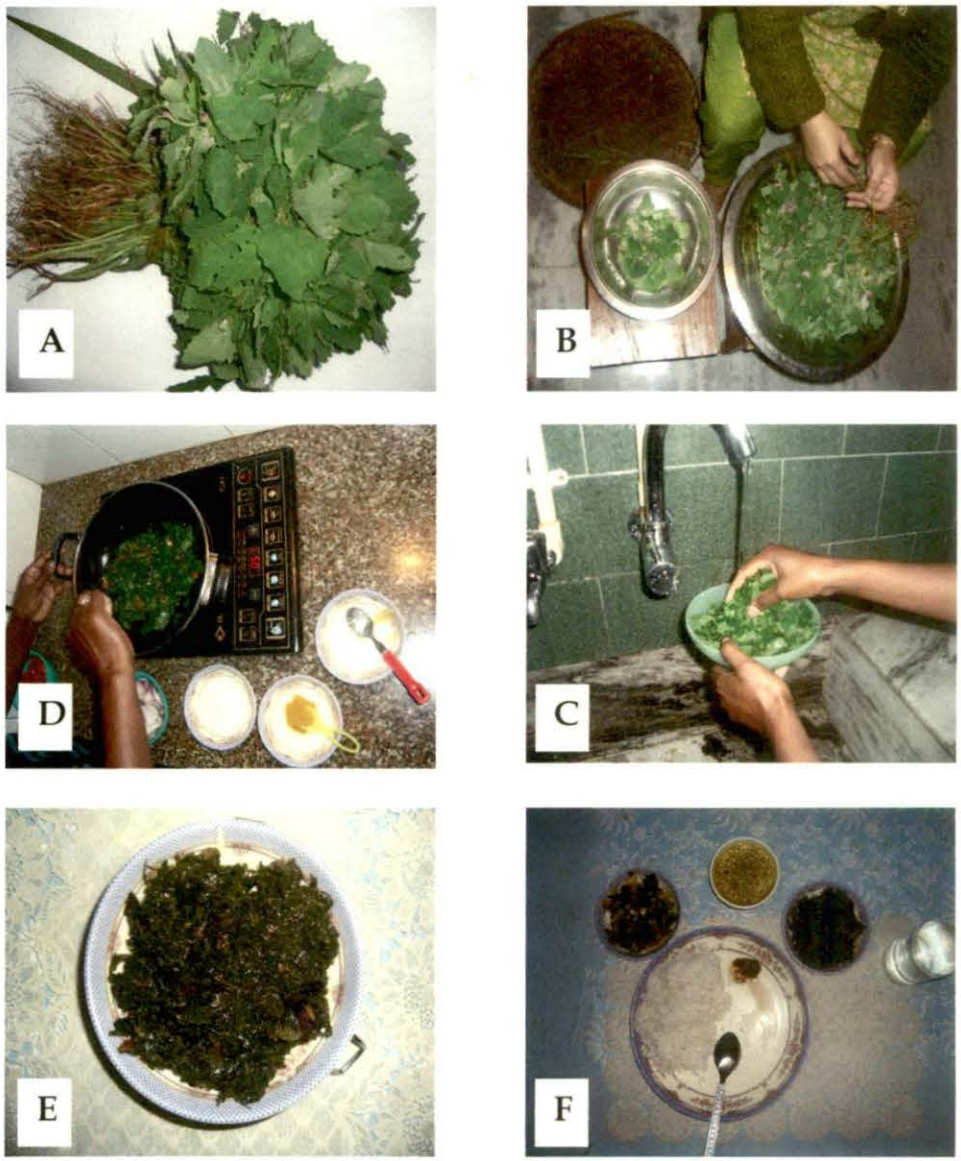

Photo 7. Preparation of bethu sag side dish. **(A)** *bethu sag* bundle; **(B)** garbling of *bethu sag*; **(C)** *bethu sag* being washed before cooking; **(D)** *bethu sag* being cooked; **(E)** *bethu sag* side dish ready **(F)** *bethu sag* side dish served hot

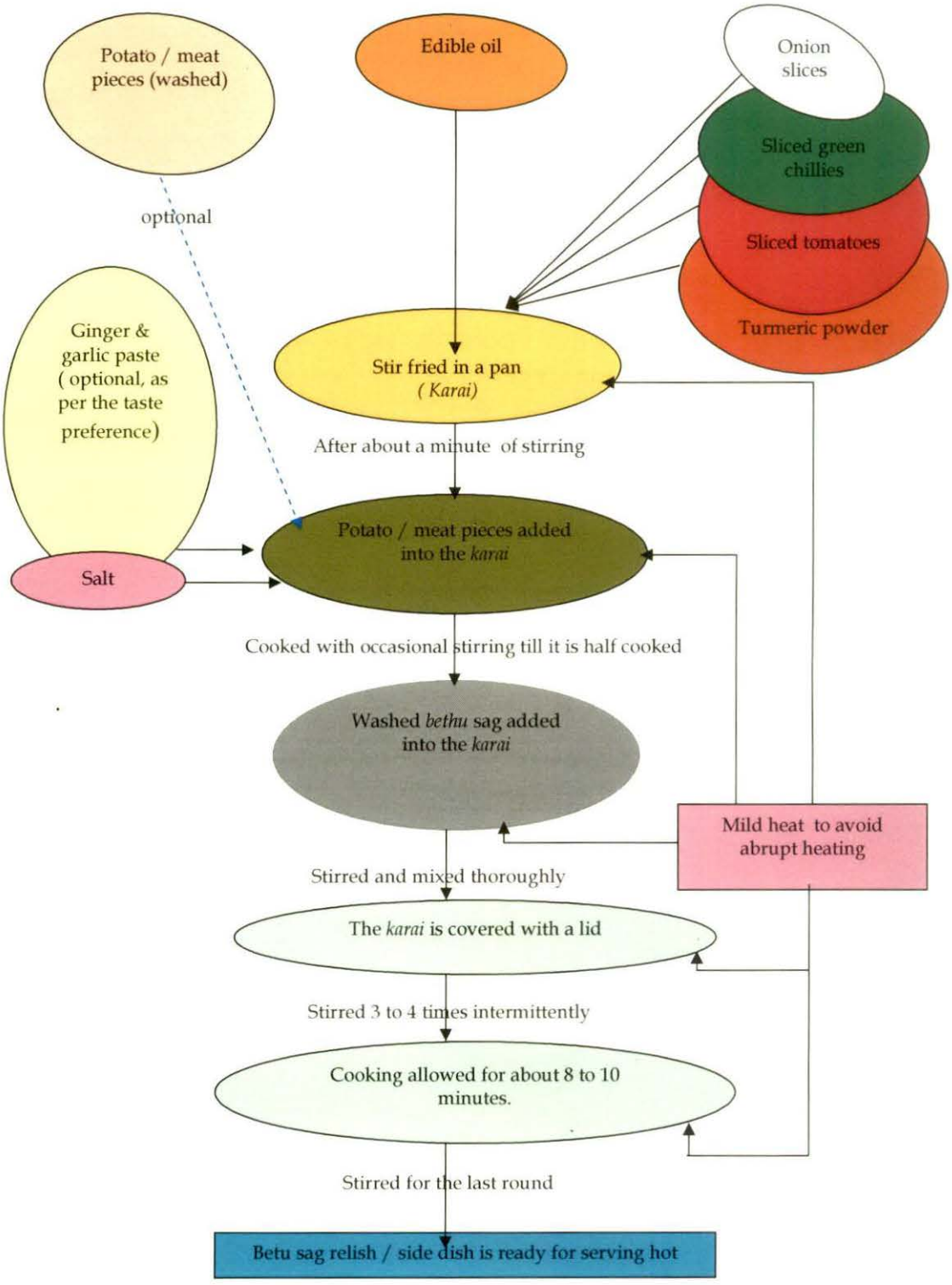

Fig 8e. Flow sheet of *bethu sag* culinary

Diplazium esculentum (Retz.) Sw

Family: Dryopteridaceae / Athyraceae.

English Name: Vegetable fern

Vernacular Name: Ningro (Nepali)

Ethnic importance:

Diplazium esculentum (Retz.) is locally called *ningro*. Young fronds (circinately coiled) are consumed as vegetable. The matured leaves, locally called *uneuw* are widely used as cattle bedding from the month of June to October/November. During these six months, *Diplazium sp* along with few other ferns are the major cattle bedding for the livestock of Sikkim. The organic manure prepared out of such cattle bedding are considered to be amongst the best manures for ginger crops and vegetable farming. The leaves are used as vegetables and the dried rhizomes used as insecticides. *Diplazium esculentum* has several medicinal values (Table 2). The decoction is used to cure haemoptysis and cough. Eating fresh and dry root helps stop dysentery. A folk song of the hill reads, *Nigurey pakha juhari bhaka yo sauney jhari ma, ankha ko bhaka ankhai ma rakha yo kamako ghari ma, (anonymous)* meaning, "do not disturb me with the gesture of your eyes at this time of my work during monsoon rain. I am busy in the hill slope, plucking *ningro*, singing folk song called *juhari*". The availability and use period varies for different species of edible fern. The study indicated that the knowledge is eroding due to changing social values and

non participation of younger generation in collection and processing of such wild leafy vegetables. During the study it was also recorded that, the temporary *welcome gates* constructed for several public or private occasion, from a political address to a marriage ceremony, used to be made up of leaves of some endangered species of *Cryptomeria sp,* locally known as *Dhupi.* With the strict implementation of several environmental and forest conservation laws in the state, the use of such endangered species were suddenly replaced by fern varieties, including *Diplazium esculentum.* This has positively contributed in the green mission of Sikkim. *Uneu* is also used for constructing roadside and forest huts locally called *dehra. Dehras* are used as temporary shelters by migrant labourers and cardamom field workers in the remote forests of Sikkim. *Uneu* is used by the ethnic people of Sikkim for incubating *Jaanr* and *marcha.* This indicates thermocoustic property of *Diplazium esculentum. Ningro* marketing is a seasonal family activity. Some families in the hills are economically dependent on the trade of *Diplazium esculentum* during its season time.

Ecological distribution

Diplazium esculentum is an aggressive fern of wasteland, forest and undisturbed areas in the forest and farm land proximities. It commonly grows in moist and shady places. It is also found growing in the field margins and vertical slopes of the terraced crop fields, within an

altitudinal range of 4000-8000 ft. in Sikkim (Table 3). It is found growing in mid hill, low mid hill, mid upper hill and upper hill (Table 4). The folk song also describes its ecological habitat being the hill slopes and its foraging season during the monsoon time.

Foraging

Foraging of *Diplazium esculentum* is done from its wild habitat. Tender fern crochets (from the scrolled tip to about 18 cm towards base or as far down as the shoot snaps easily) are much in demand in the market. It comes in small bundles containing 35-50 crochets and sold afresh. *Diplanzium esculentum is* the most commonly used and widely available vegetable fern which is locally called *lekhali ningro*. Young fronds and crochets of the plant are collected by the women folk of the rural villages, as they are experienced in identifying the edible fern species, growing along with poisonous ferns. The fronds are boiled and fried in oil after removing the red petiolar hairs. *Ningro* is considered high economic value fern amongst the ethnic people of Sikkim. As a vegetable, *ningro* is quite perishable; therefore it must be handled properly during transportation and preservation. *Diplazium esculentum* is prepared for home consumption and festivals or parties. The Sikkimese ethnic people prefer to consume it with *churpi* a fermented milk product. The Bhutia community in Sikkim prepares a very agreeable dish out of *ningro, churpi*

and animal fat called *ghew*. It is best preferred with potatoes or meat. *Ningro* is also used to prepare pickles for home consumption or festivals and marriages. Amongst many wild edible leafy vegetables, *ningro* has already entered into the cultural, traditional and tourism food market of Sikkimese cuisine. Most popular dish made out of *D. esculentum* is *churpy - ningro curry*.

Prospects of *Diplazium esculentum*

Diplazium esculentum, though a fern, is a multi -prospective plant. It is widely used as a leafy vegetable, used in traditional system of medicine, used in the preparation of pickles, used in making temporary huts and gates, used in the preparation of *jaanr* and *marchaa* and used in preparation of organic manure (Fig 9a).

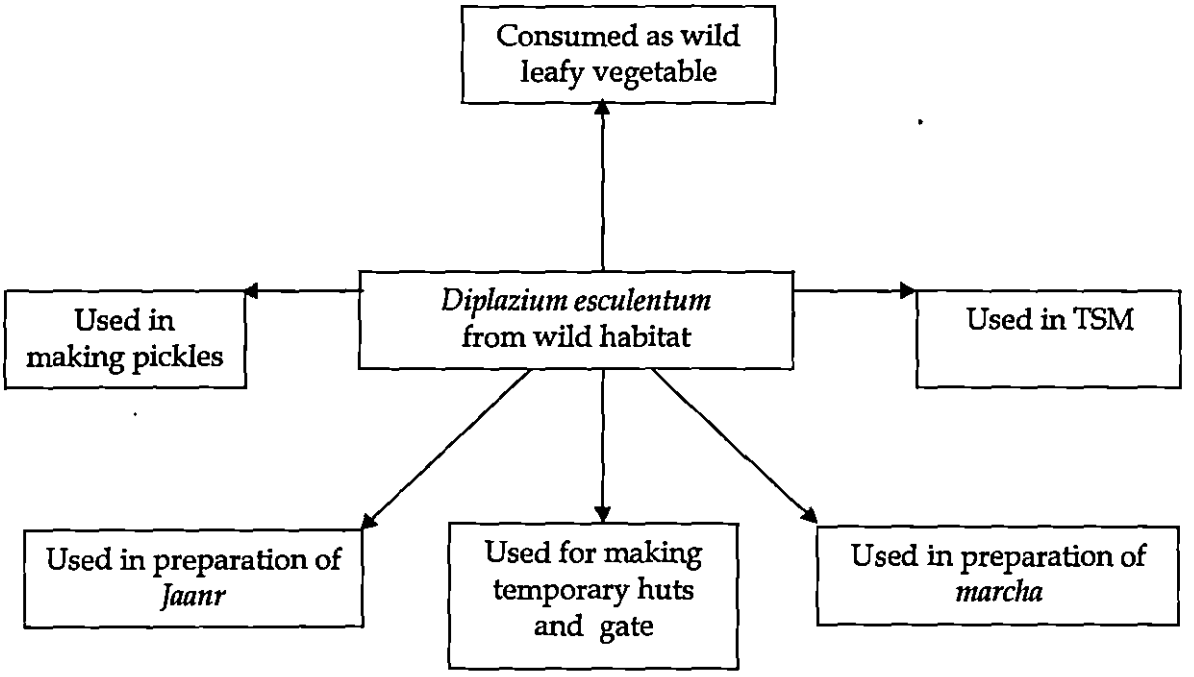

Fig 9a. Prospect of *Diplazium esculentum*

Market chain analysis and socio-economic profile

A detail study on the market chain and socio-economy of *Diplazium esculentum* reveals the fact that *ningro* foraging is not an easy task. Blood sucking leeches, summer burn and monsoon rain are the major hardships of *ningro* foraging in the forests. Despite of the hardships, there is a proportionate socio-economic gain involved in *ningro* market chain as shown in the (Fig 9b).

For sale in the vegetable market, roadside stall, local periodical *haat,* the young twigs with tender leaves and cercinate vernations are hand plucked and collected in a bamboo stripes woven basket, locally called *thumchey, daaloh* or cloth-made backpack. During collection, sufficient care

is taken not to break or damage the cercinate coil as because *ningro* shoots are highly perishable. The collected parts are tied into small bundles weighing about 250-500 g each, with the help of a strap drawn out of cardamom petiole or green straw. The bundles are then inserted into a sack or bamboo stripes woven basket locally called *doko* and carried to the market, local periodical *haat* or any other places for sale (Photo 4). If the villager is not a vegetable seller then it is either sold to vegetable vendor in the market or to the vegetable supplier locally known as *kharitey* who purchases the vegetable in large scale from the villagers and supply to the vegetable vendors at the market place. *Kharitey* transports the vegetable load, from village to the town by public carriers such as bus or taxis. *Kharitey* pays for the transport. From the terminus at the town, the load is transported to the vegetable vendor at the vegetable market place, manually by the porter and coolie (Photo 5). *Kharitey* pays for the manual labour. *Kharitey* supplies the WLV to the vegetable vendor at the market place and gets his return in cash. Consumer purchases from the vegetable vendor at the market place at the rate of Rs. 15-20 per bundle weighing about 300-500 g. Thus *ningro* completes its unidirectional market chain (Fig 9b).

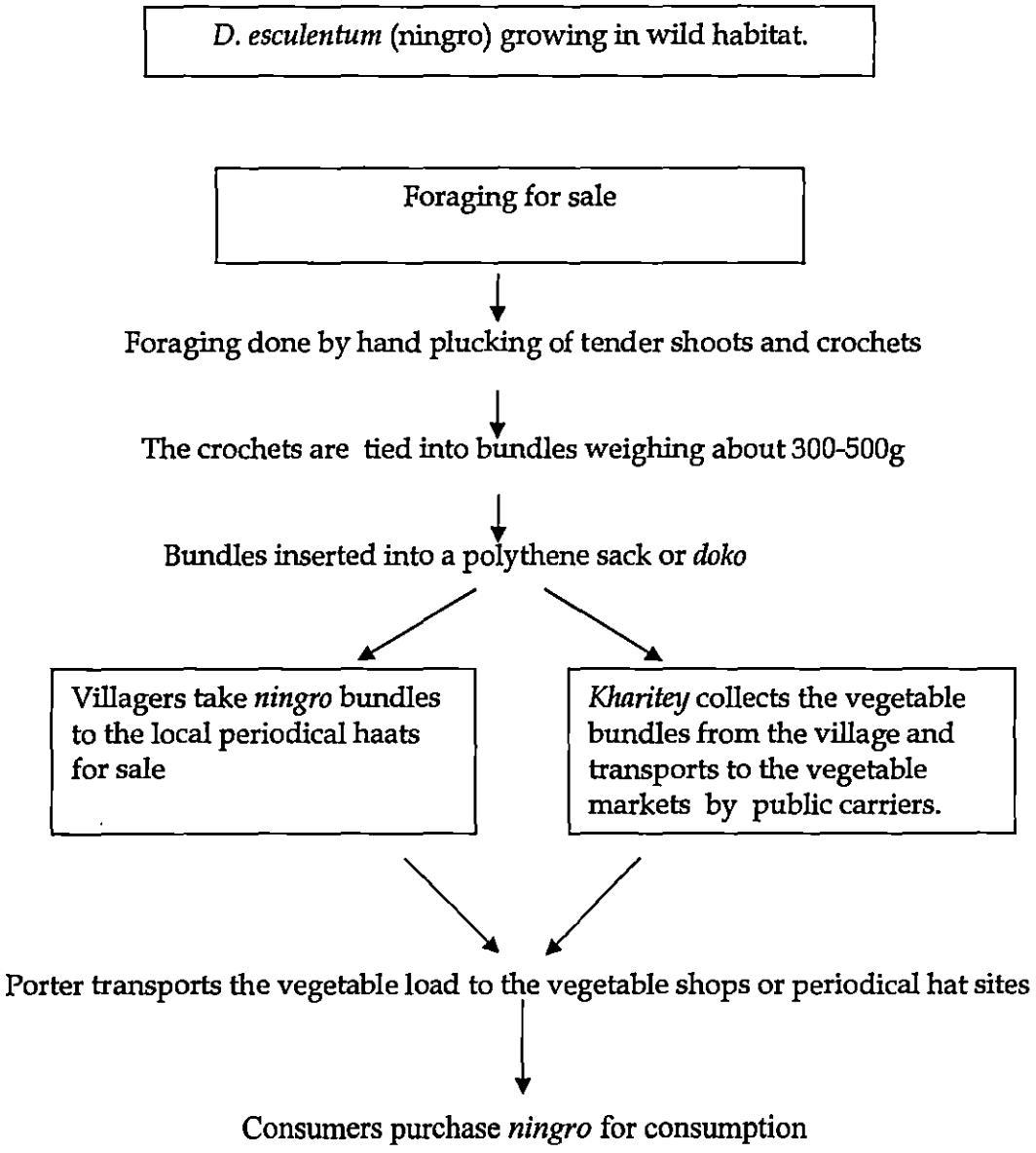

Fig 9b. Flow- sheet of market chain and socio-economic profile of *ningro.*

Beneficiaries in a unidirectional market chain of *ningro*

The market chain (Fig 9b), is unidirectional, where, benefit flows from wild natural habitat to urban and rural consumers. Several stakeholders are benefited in this unidirectional chain of *ningro* marketing (Fig 9c).

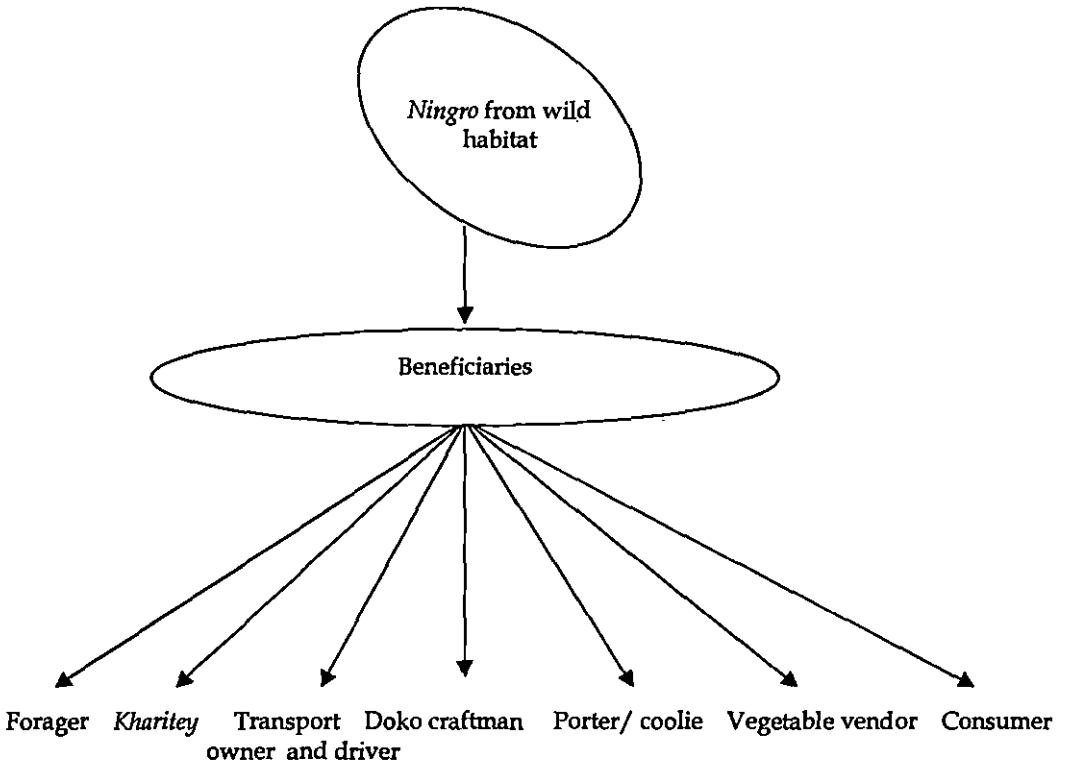

Fig 9c. Beneficiaries in a unidirectional market chain of *Diplazium esculentum*

Mode of consumption:

Though it is consumed both raw and cooked in other parts of the world, in Sikkim the ethnic people consume *ningro* only after cooking.

Ningro crochets and leaves are consumed as *ningro* curry. Garbling is done carefully for both foreign elements and the hairs present on its surface. A general mode of consumption is shown in (Fig 9d).

The tender shoots, fronds, crochets and leaves are garbled for elimination of unwanted, inconsumable materials attached to it. Only the uppermost portions, which are very tender and soft, are selected for consumption as vegetable. The lower portion of the bundle (stem) is discarded. The brown hairs on the surface of the frond and shoots are wiped out, with the help of a cloth or hand or sometimes knife. These are avoided as because it irritates the throat while eating even after cooking.

↓

The edible portions are fragmented and torn into small pieces by pinching between the thumb and first finger. This traditional technique is generally practiced to ensure complete elimination of hairy structures present on its surface and other foreign agents such as insects, larvae, muds and stone harvouring the cercinate vernation or other edible parts. Use of cutting implements such as knives are practiced only for dissecting the tender stems.

↓

Boiled or dipped in hot water for 3 to 5 minutes . The water used for boiling is decanted off.

↓

Spread on a flat surface or container such as aluminum or steel bowl, or "*Nanglo*",(a bamboo made home implement used for garbling grains and vegetables), till further course of preparation into a curry or side dish.

↓

The boiled stuff is cooked, stir fried or prepared into pickles as per the need and taste, like other vegetables. Preparation of *ningro* is preferred with potatoes or *churpi* or *ghew* by the ethnic people of Sikkim.

Fig 9d. Flow sheet of mode of consumption of *ningro*

Culinary

Ningro is the most widely consumed wild leafy vegetables in Sikkim. It is prepared and consumed as curry or pickle locally called *ningro ko achaar*. It is either prepared alone or with potatoes or *churpi* (Fig 9e; Photo 8). The most popular *ningro* culinary in Sikkim is *ningro-churpi* curry which is even served during festivals, social parties, food festivals and also in the hotels.

Photo 8. Preparation of *ningro-churpi* curry **(A)** *ningro* bundle; **(B-C)** garbling and fragmentation of *ningro;* **(D)** *churpi* being cooked; **(E)** *ningro* being cooked with *churpi;* **(F)** *ningro–churpi* curry ready; **(G)** ningro-churpi curry, served hot.

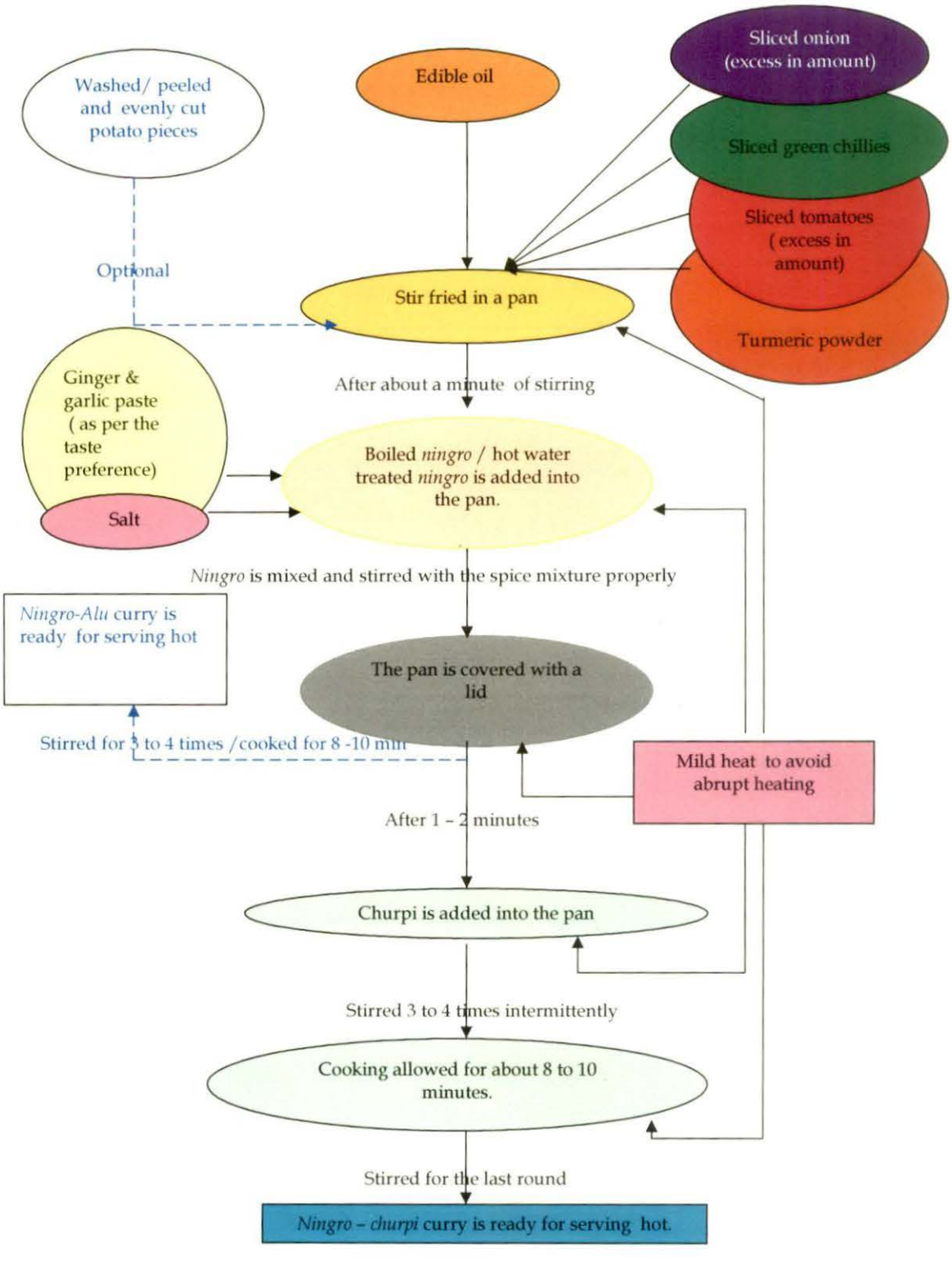

Fig 9e. Flow sheet of *ningro* culinary

Nasturtium officinale R.Br.

Family: Cruciferae

Common Name: Watercress

Vernacular Name: Simrayo (Nepali), Shamrock (Lepcha)

Ethnic importance:

Nasturtium officinale is commonly called *simrayo* in Nepali. It is boiled and cooked as vegetable and sometimes, consumed raw, as salad. It is used also as garnish for various dishes. *Nasturtium officinale* has several medicinal values (Table 2). The ethnic people of Sikkim believe that *simrayo* is useful in goiter. It is believed to possess antiscorbutic and stimulant properties and is eaten to improve appetite. A decoction of the plant is given as a blood purifier, vermifuge and diuretic. It is used for dry throat and cold in the head, asthma and tuberculosis. *N. officinale* is popular amongst all the ethnic people of Sikkim as it is believed to have anti cancer properties and is effective against high blood pressure. The aerial part decoction is given to relieve body pain.

Ecological distribution:

Nasturtium officinale is found naturalized in many parts of Sikkim and commonly grows in ditches, pools and margins of shallow streams, up to an altitude of 12,000 ft. (Table 3). It is distributed throughout Sikkim

Himalayas. It is found growing in low hill, mid hill, low mid hill, mid upper hill and upper hill (Table 4). It grows submerged, floating in water, or spread over sandy surfaces in flowing water. *N. officinale* is found in abundance near springs and open-running waterways. It is seen growing luxuriantly in some perennial ditches, where the kitchen wash constantly flows. *Simrayo* cluster is seen to form a soft green carpet along the drinking water sources locally called *pani ko muhaan* of rural villages and marshy places of the hill. The plant is also believed to purify the spring water sources in the villages of Sikkim. *Simrayo* occurs naturally along running water and grows floating in shallow water. Shallow ponds can rapidly become covered and the species is sometimes considered as an offensive weed. It is easy to establish a watercress crop wherever conditions are cool and wet. It requires running water for vigorous growth and high yield of tender and sweet shoots. At higher latitudes in the summer abundant flowering will impede the harvest. Watercress likes sandy or gravelly soils. Watercress tolerates polluted soil and water, contaminated by heavy metals. The reduced water current velocities due to watercress appear to be important for the distribution of small invertebrates, creating a variety of living conditions in the water column. Watercress cover provides a very good shelter to the crabs and snails of aquatic habitat.

Foraging

Foraging of *Nasturtium officinale* is done from its natural habitat, marshy places in the wild, ditches and homesteads. It is collected from the wild habitat by the women and children folk. *Simrayo* as a vegetable dish, though liked by all the ethnic communities in Sikkim, has not yet entered into the food menu of elites and festivals of Sikkimese. One of the reasons of this, could be the natural habitat of *simrayo*, as it, also grows in several polluted marshy places. This fact perhaps, dissuades its wider acceptability. The hill people are therefore very selective in terms of its wild source of foraging. It was observed during the present study that *simrayo* is being cultivated in some fringe areas of the state and is being produced for commercial economic return.

Prospects of *Nasturtium officinale*

Nasturtium officinale though a wild plant is a multi-prospective plant. It is consumed and marketed as a wild leafy vegetable, used in traditional system of medicine and used as a natural water purifier at the natural water sources (Fig 10a).

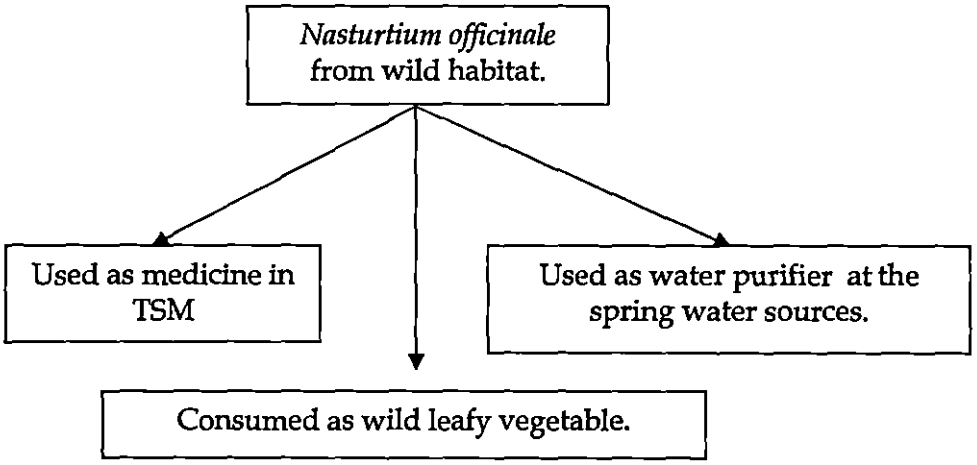

Fig 10a. Prospect of *Nasturtium officinale*

Market chain analysis and socio-economic profile

A detail study on the market chain and socio-economy of *Nasturtium officinale,* reveals the fact that, *Simrayo* foraging is done from the natural habitat, semi-domesticated or wild. There is a proportionate unidirectional, socio-economic gain, involved in *simrayo* market chain as shown in the (Fig 10b).

For sale in the vegetable market, roadside stalls or local periodical *haats,* whole plant is collected by uprooting them. The collected parts are washed thoroughly in the running water, *dhara* and streams. The roots are removed with the help of any cutting implements such as sickle or knife. The upper edible parts, tender stem and leaves are separated minutely by eliminating the matured stem, root and root hair. The selected edible portions are tied into bundles weighing about 250-500 g. Green straw or

lacerated cardamom leaves and petioles are used to tie the bundles. The bundles are then inserted in a bamboo made back-pack carrier basket called *doko* and carried to the market, local periodical *haats* or any other places for sale (Photo 4). If the villager is not a vegetable seller then it is either sold to vegetable vendor in the market place or sold to the vegetable supplier locally known as *Kharitey,* who collects the vegetable in large scale from the village. *Kharitey* transports the vegetable by public carrier service from the village to market terminus. *Kharitay* pays for the transport. From the terminus, coolie and porter, transfer the load to the vegetable vendor in the market (Photo 5). *Kharitey* pays for the manual service. *Kharitey* supplies to the vegetable vendor at the market place and gets his return in cash. Consumer purchases from the vegetable vendor at the market place @ Rs.15-20. *Simrayo* bundles brought home for consumption (Table 6). Thus, *simrayo* completes its commercial transaction, path way (Fig 10b).

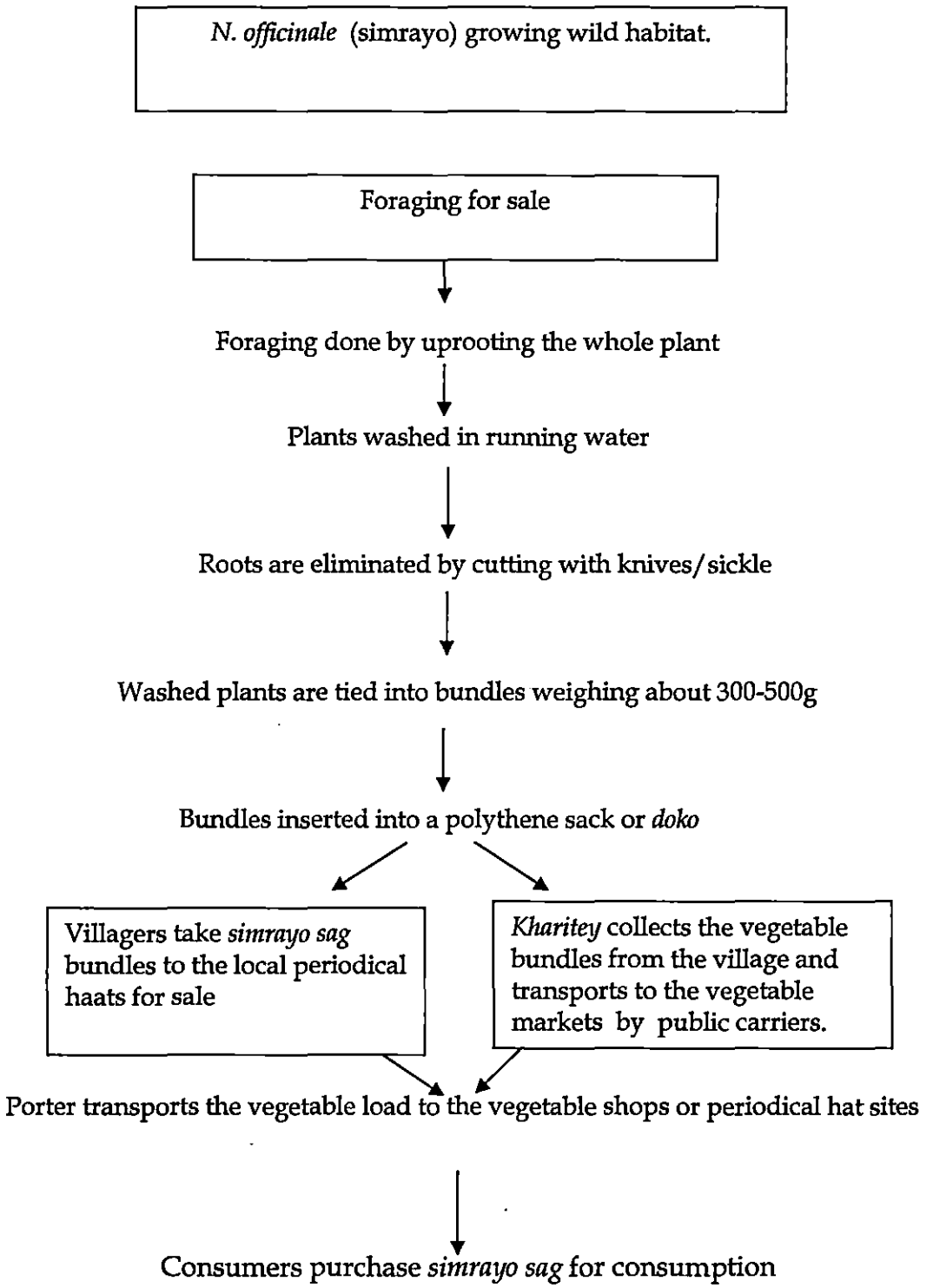

Fig 10b. Flow- sheet of market chain and socio-economic profile of *simrayo*.

Beneficiaries in the unidirectional market chain of *simrayo*

The market chain (Fig 10b), is unidirectional, where, benefit flows from wild natural habitat to the rural and urban consumers. Several stakeholders are benefited in this unidirectional chain of *ningro* marketing (Fig 10c).

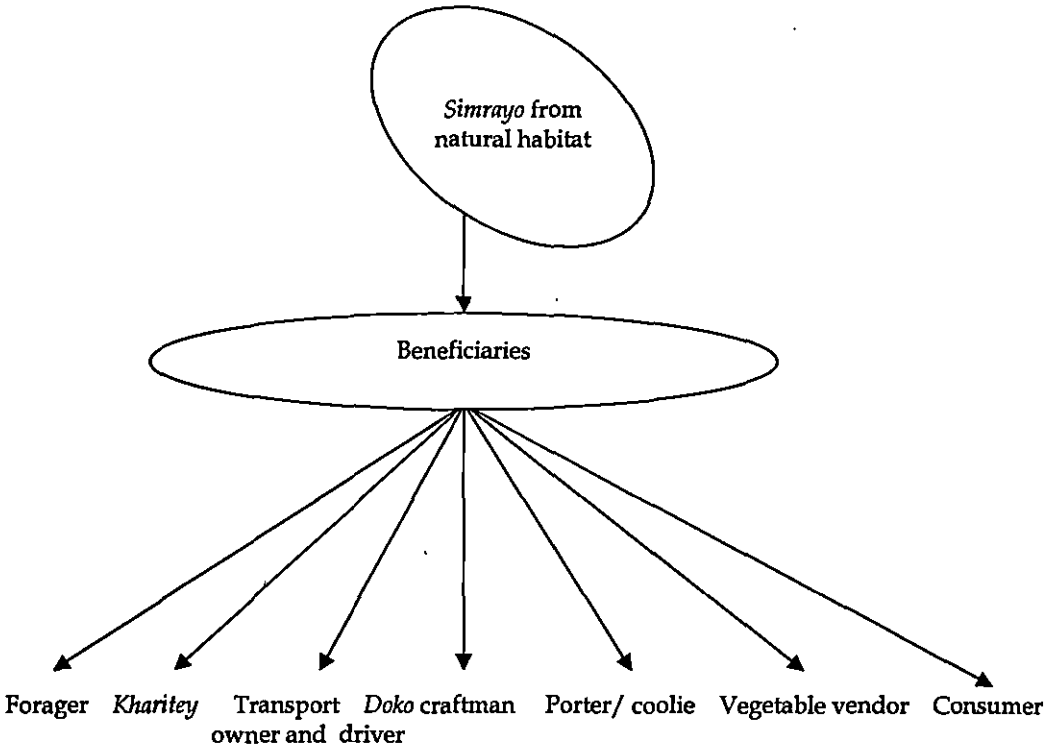

Fig 10c. Beneficiaries in the unidirectional market chain of *Nasturtium officinale*

Mode of consumption

Though it is consumed both raw and cooked in other parts of the world, in Sikkim the ethnic people consume *simrayo* only after cooking. *Simrayo* leaves are consumed as a side dish or vegetables soup. Garbling is

done carefully for both foreign elements and the root hairs present on its stem surface. A general mode of consumption is shown in (Fig 10d).

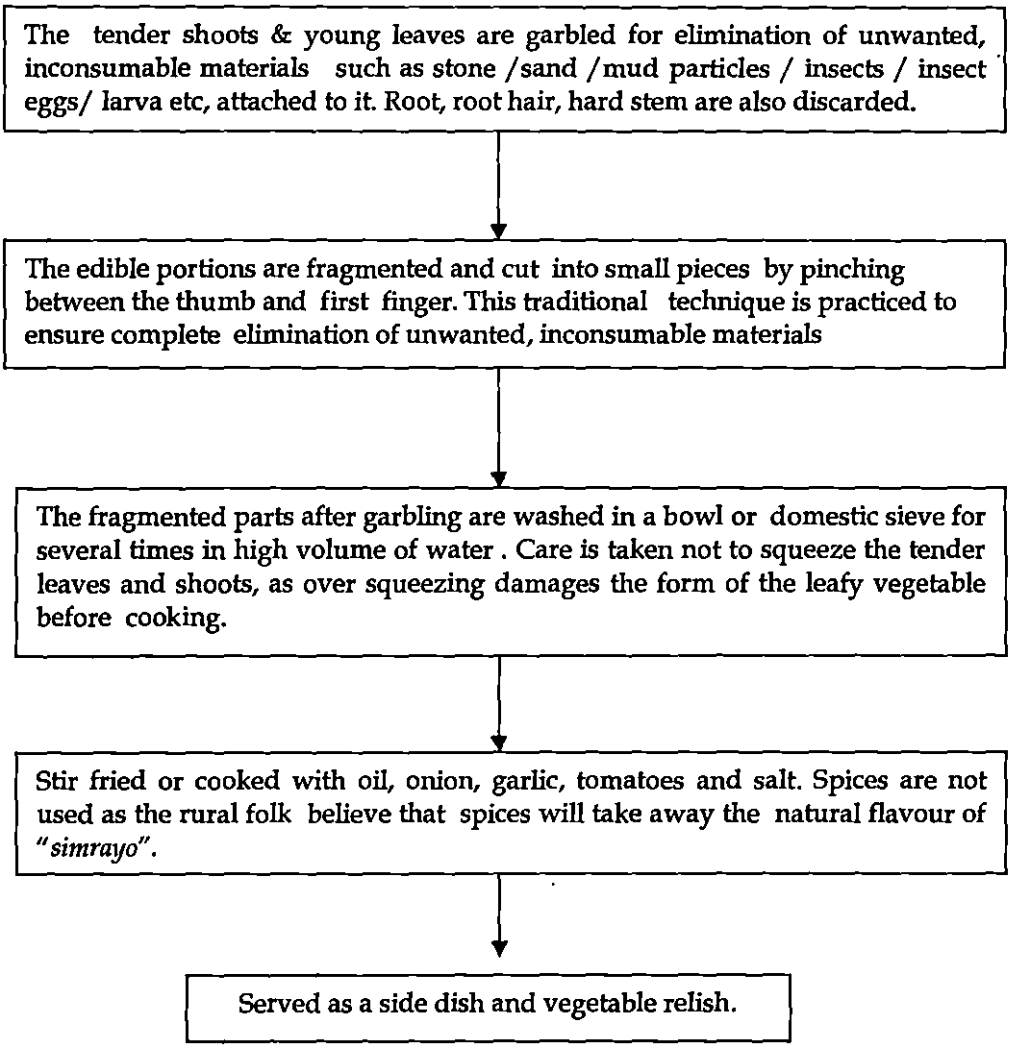

Fig 10d. Flow-sheet of mode of consumption of *simrayo*

Culinary

Simrayo is cooked and consumed as a side dish or a relish by the ethnic people of Sikkim. Unlike European societies, the hill communities in Sikkim do not consume *simrayo* as a component of salad. It is consumed

cooked either alone or with potatoes or meat (Fig 10e; Photo 9). This type of preparations taste good if the water content of the vegetables is extracted out to its maximum, while cooking with constant stir frying. Consumption of very fresh *simrayo* leaves sometimes cause diarrhea or dysentery amongst the children, during summer. The elderly people therefore partially shade-dry the *simrayo* leaves at least for a day before cooking. Partial shade drying is also believed to enhance the taste and medicinal value of the plant. *Simrayo* is also consumed as a potherb and soup. The hill people generally go nostalgic with the sudden smell of *simrayo* flavour being cooked anywhere in the vicinity. The flavour also spells a typical ethnic feel of the hills in the morning and evening. The aroma liberated while cooking of *simrayo* is very tempting and it also indicates partially to ensure that the inhabitant in the house is certainly one of the ethnic communities of the Himalaya. Bhutia community of Sikkim prefers to cook *simrayo* with meat. This combination is slowly getting popular also amongst other ethnic communities.

Photo 9. Preparation of *simrayo* side dish.

(A) *simrayo* bundle; **(B)** garbling and fragmentation of *simrayo* leaves; **(C-D)** *simrayo* being cooked; **(E)** *simrayo* side dish ready; **(F)** *simrayo* side dish served hot

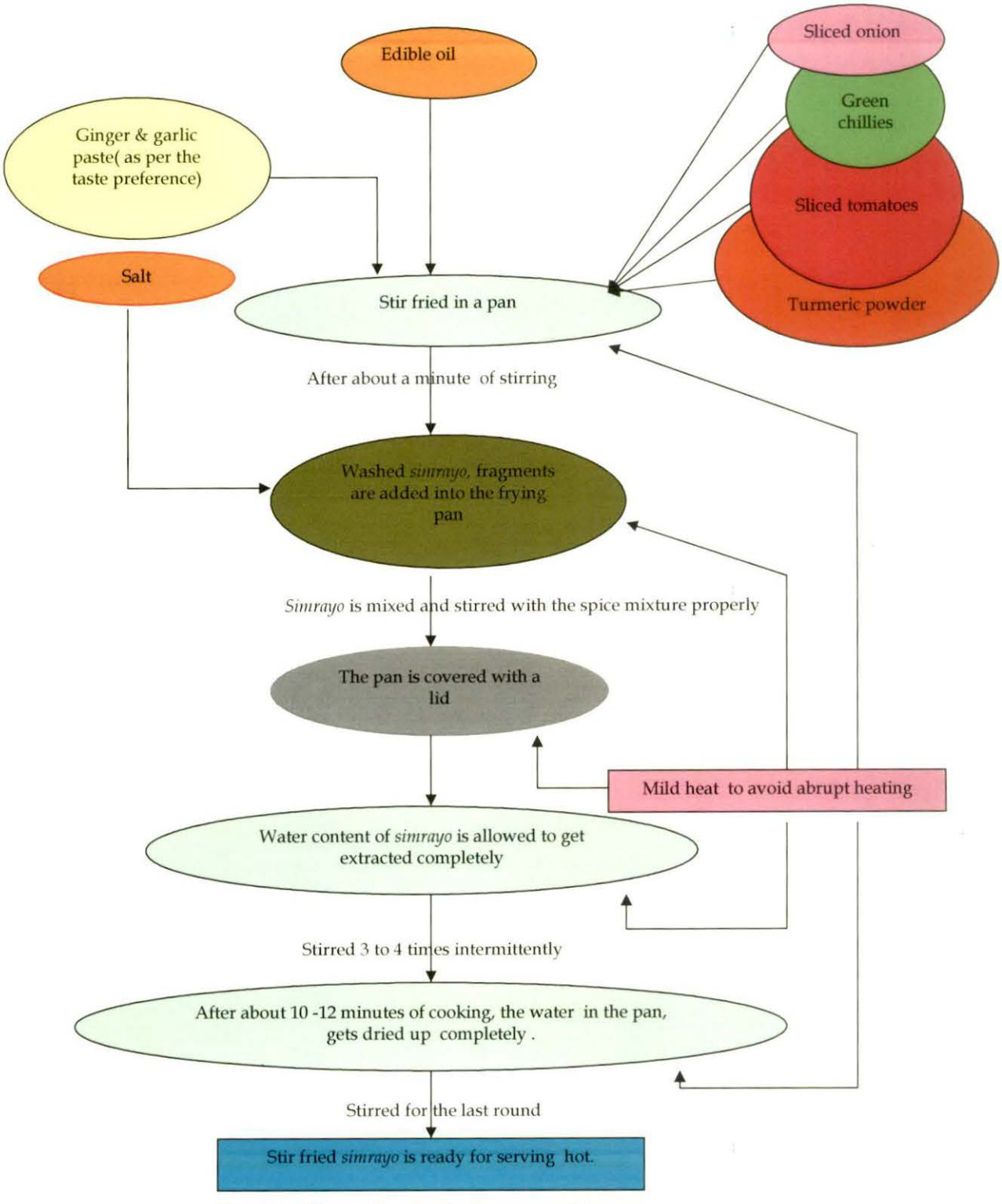

Fig 10e. Flow sheet of *simrayo* culinary

Urtica dioica **Linn. Urticaceae**

Family: Urticaceae

Common Name: Stinging nettle

Vernacular Name: sisnoo (Nepali), sarong (Lepcha)

Ethnic importance:

Urtica dioica Linn. commonly called *sisnoo* in Nepali and *sarong* in Lepcha has been used in the Sikkimese food culture since time immemorable. *Urtica dioica* is a common stinging nettle of the region. *Urtica dioica* is the most widely known member of the genus. The leafy parts are sold in small bunches and flowers are sold by weighing. A very popular wild leafy vegetable, the *sisnoo,* is in high demand during the late winter when the plant loses its watery consistency. *Sisnoo* leaves and flowers are consumed as potherb or soup. The plant has a long history of use as a medicine and food. The local populace, use *sisnoo* in the treatment of several illnesses such as arthritis, anaemia, rheumatism, skin complaints, problems of bone, diabetes. Externally the plant is used to treat gout, sciatica, skin complaints. Lepchas in remote villages use it in the treatment of arthritis and rheumatism or joint ache by beating the fresh *sisnoo* leaves on to the skin. The ethnic people in remote villages use *sisnoo* in the treatment of bone fracture and sprains. Beside food and medicine, *sisnoo* is also a component of several traditions and culture of Sikkim. The

Nepali and Bhutia community of Sikkim use *sisnoo* for fun play, during arranged marriages. It is also used by ethnic folk healers (*jhankri, bejuwa, bungthing, phedangma*) of Sikkim. Many traditional healers of the hill use *sisnoo* in their healing practices. Many believe that *sisnoo* keeps evil spirit away from a person or house. It is also used when the new born babies are ill. All the ethnic communities of Sikkim forbid the use of *sisnoo* during demise at home or during death mourning. *Sisnoo* is one of the most preferred plants of insects, larvae, butterflies and moths. *Sisnoo* ghari (a jungle of *sisnoo*) is sometimes, used by the himalayan beer for taking rest during the time of food hunt. *Sisnoo* is not eaten by elderly conservative *bahun* community of Nepali ethnic group. The conservative elders of this community not even let it enter inside their home. They consider *sisnoo,* as food of *matwalis* meaning those who drink alcohol. Thus consumption of sisnoo can be identified as one of the socially visible parameter for differentiating *non-matwali* and *matwali* communities of the hills from the context of conservative belief. However, the younger generations does not give any concern to this concept as it is consumed by all. In contrary, *sisnoo* also finds its place in the enthic folk songs of the hill community, *sunako thaila haatko maila ke garnu dhana ley, saga ra sisnoo kheyera basa ananda mana ley (quote: Anshu Kabi, Laximi Prasad Deokota)* meaning, what do we do with the treasure of gold and silver, as they are like the dirt of our hands which goes away as we wash, so do not run after it, rather,

cultivate rye and *sisnoo* and serve them in your daily meals, it makes your life peaceful and happy. This reflects the philosophy of a simple and peaceful life style of ethnic communities in the hills. In the rural villages, it is also believed that a person who has been bitten by a dog should not consume *sisnoo*. It is believed to enhance hydrophobia. The reason needs a clinical confirmation. *Sisnoo* is used in poultice and problems related to bones of the body. *Sisnoo* is a popular pig feed in the hills. Root paste is applied on minor bone fracture and dislocation. Root and seed decoction is taken to treat diarrhoea and cough. Curry, prepared using shoot tips, is given to female during child delivery as their slipperiness is believed to help delivering child. It should not be taken by a person who has been bitten by rabid dogs which is believed to aggravate the problem. Stems are beaten, dried and boiled to make threads and woven into traditional nettle clothing. Spines are believed to stimulate milk production, when cows do not lactate. *Shamans* beat humans during exorcism rituals with nettles in a belief to drive away evil spirits from body. There is a strong belief amongst the natives of Sikkim that *sisnoo* should not be touched or eaten by family members of deceased person on the day of death. If the decease is one's father or mother, this prohibition remains for one year. Nettle is planted on the child's grave in a belief that the evil spirit of child will not come out to trouble other family members.

Ecological distribution:

Urtica dioica, is found luxuriantly growing in wasteland, roadside verges, hedgerows, walls, compost heaps, damp spots in the forest, along the margins of streams and river side, uncultivated fields, field margins and home gardens, undisturbed damp places or waste disposed areas in urban, peri urban and rural ecological habitat. Presence of *sisnoo* population in a particular location, indicates, fertile or damp soil. Nettles generally appear in the same locations every year. They thrive in rich soil, moist woodlands, thickets, disturbed areas, along partially shaded trails and riversides within an altitudinal range of 4000-9500 ft (Table 3). It is found growing in mid hill, low mid hill, mid upper hill and upper hill (Table 4).

Foraging

Among all the wild leafy vegetables consumed by the different ethnic communities of Sikkim, *Urtica dioica* and *Diplazium esculentum,* are the first two WLV which has already entered into the cultural, traditional, tourism and domestic food menu of Sikkimese people. *Sisnoo,* which was once, considered to be the food of poor, illiterates and marginalized people, have now become a favorite dish of several elites and literates. It is also exhibited as a traditional Sikkimese food item during the food festival, conducted by the department of Tourism,

Government of Sikkim every year at Gangtok. It is served during food festival, marriage parties, and festival parties and has also entered into the food menu of star category hotels of Sikkim on special occasions. Often *sisnoo* is discarded as weeds, the most deterrent factor being its stinging nettle. Every age group wants to keep themselves away from a *sisnoo* plant. *Sisnoo* is the first WLV to enter into the vegetable market after the cold freezing winter of Sikkim Himalaya. It is sold as small bundles, each bundle with about 20-25 twigs with tender leaves. *Sisnoo* needs technical approach from collection to culinary. It is collected by experienced women folk of rural villages, sometimes accompanied by children. For a large scale collection, a pair of hand gloves, a traditionally designed metallic tongue called *chimta,* a bamboo stripe made basket called *thumchey* and a sickle are the essential appliances. The tender shoots are held with the help of metallic tongue at a length of about 12-18 inches down the apex along the base. At this point, the next hand holding the sickle cuts the tender shoot at a gap of about 1-2 inches below the point where the metallic tongue has held. With the metallic tongue still holding the cut end is then cautiously moved parabolically above and across the head and the tender shoot is dropped into the *thumchey* carried at the back. *Sisnoo* marketing is a seasonal family activity. The knowledge of foraging is transmitted from the elders to the younger generation and also the market chain parameters.

Prospects of *Urtica dioica*

Urtica dioica, though a weed, is a multi -prospective plant. It is consumed as a leafy vegetable, used as fodder for domestic pig, *sisnoo* fiber is used in making handicrafts. The plant is also used in traditional system of medicine and used in ethnic culture and tradition (Fig 11a)

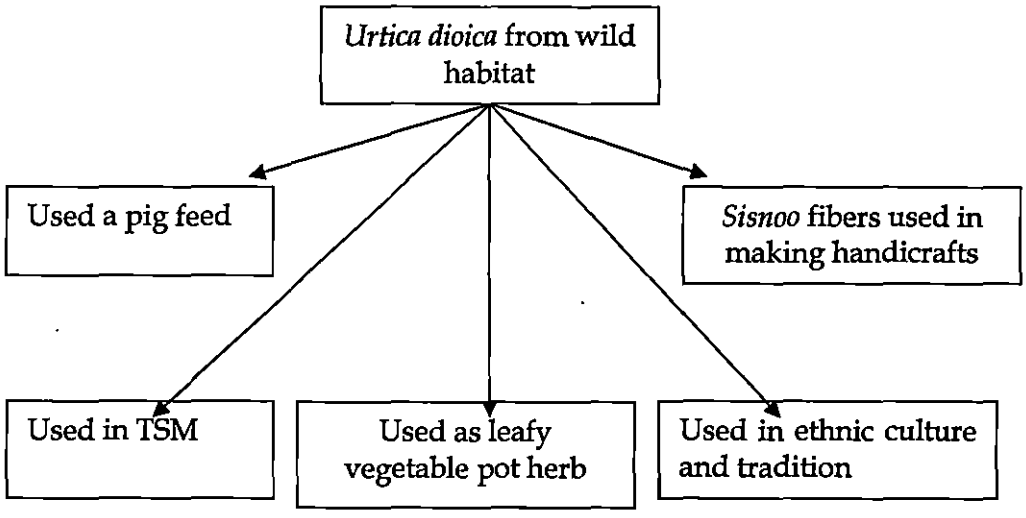

Fig 11.a Prospect of *Urtica dioica*

Market chain analysis and socio-economic profile

A detail study on the market chain and socio-economy of *Urtica dioica* has revealed the fact that *sisnoo* foraging is not an easy task. Bloodsucking leeches, snakes, *sisnoo* stinging hairs, summer burn and monsoon rain are the major hardships of *sisnoo* foraging in the forests. Despite of the hardship, there is a proportionate socio-economic gain involved in *sisnoo* market chain as shown in the (Fig 11b).

For collection for sale in the rural and urban vegetable markets, roadside stalls and local *haats,* skilled foragers collect the edible parts from the forest. The collected twigs are tied into small bundles with the help of straw or lacerated cardamom leaves or petioles bundles of 250-400 g each. Each bundle containing 20-25 twigs with young leaves. These bundles are inserted into a bamboo stripe made back-pack basket locally called *doko* and carried to the market, local *haats* and places for sale (Photo 4). If the villager is not a vegetable seller then it is either sold to vegetable vendor in the market place or sold to the vegetable supplier locally called *kharitey,* who collects vegetables in a large scale from the village. *Kharitey* transports the vegetable by public carrier service from the village to market terminus. *Kharitay* pays for the transport. From the terminus, coolie and porter, transfer the load to the vegetable vendor in the market (Photo 5). *Kharitey* pays for the manual service. *Kharitey* supplies to the vegetable vendor at the market place and gets his return in cash. Consumer purchases from the vegetable vendor at the market place @ Rs. 15-20.00 and *sisnoo* bundles brought home for consumption. Thus, *sisnoo* completes its commercial transaction path way (Table 11b).

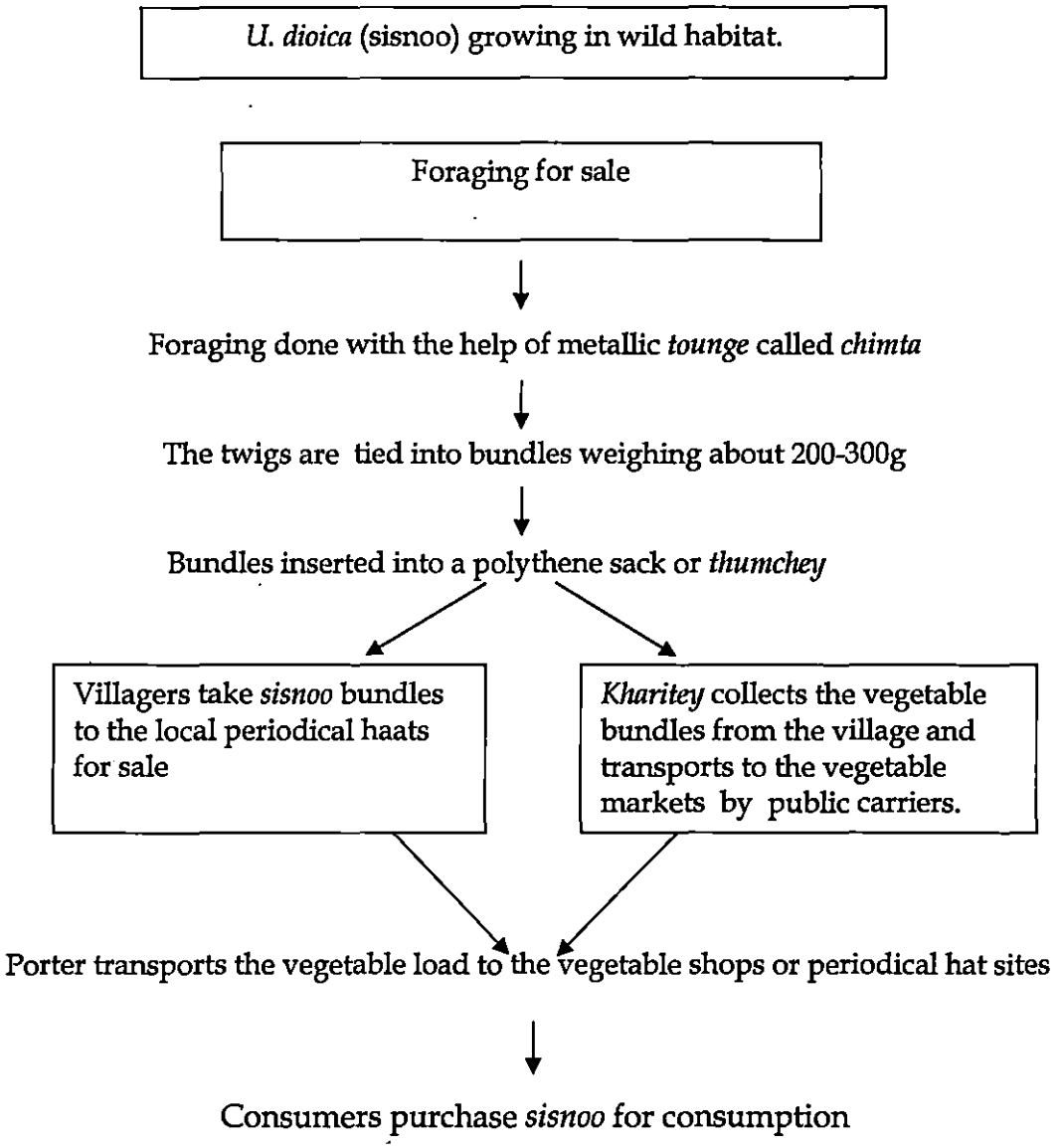

Fig 11b. Flow- sheet of market chain and socio-economic profile of *sisnoo*.

Beneficiaries in the unidirectional market chain of *sisnoo*

The market chain (Fig 11b), is unidirectional, where benefit flows from wild natural habitat to rural and urban consumer. Several stakeholders are benefited in this unidirectional chain of *sisnoo* marketing (Fig 11c).

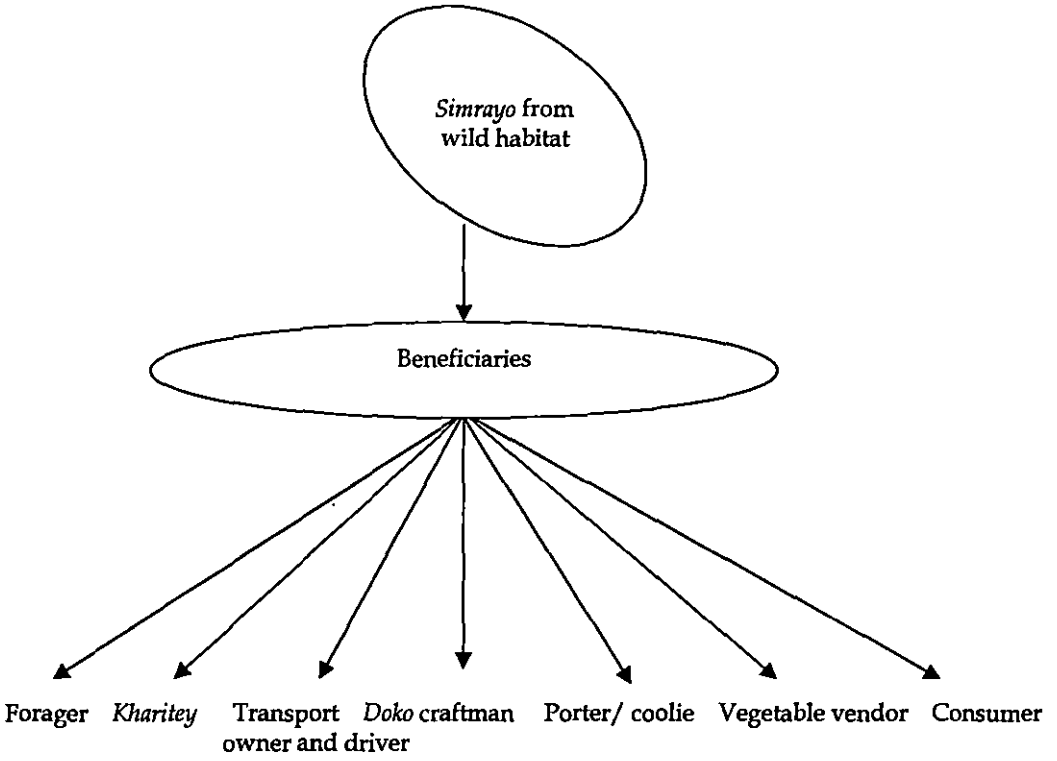

Fig 11c. Beneficiaries in the unidirectional market chain of *sisnoo*

Mode of consumption:

Sisnoo is never consumed raw as salad. This is due to the presence of stinging hair on its stems and leaves. Boiling and cooking destroys the stinging effect of *sisnoo* stinging hairs. It is therefore, consumed, only after cooking. *Sisnoo* leaves are consumed as soup or potherb (Fig 11d).

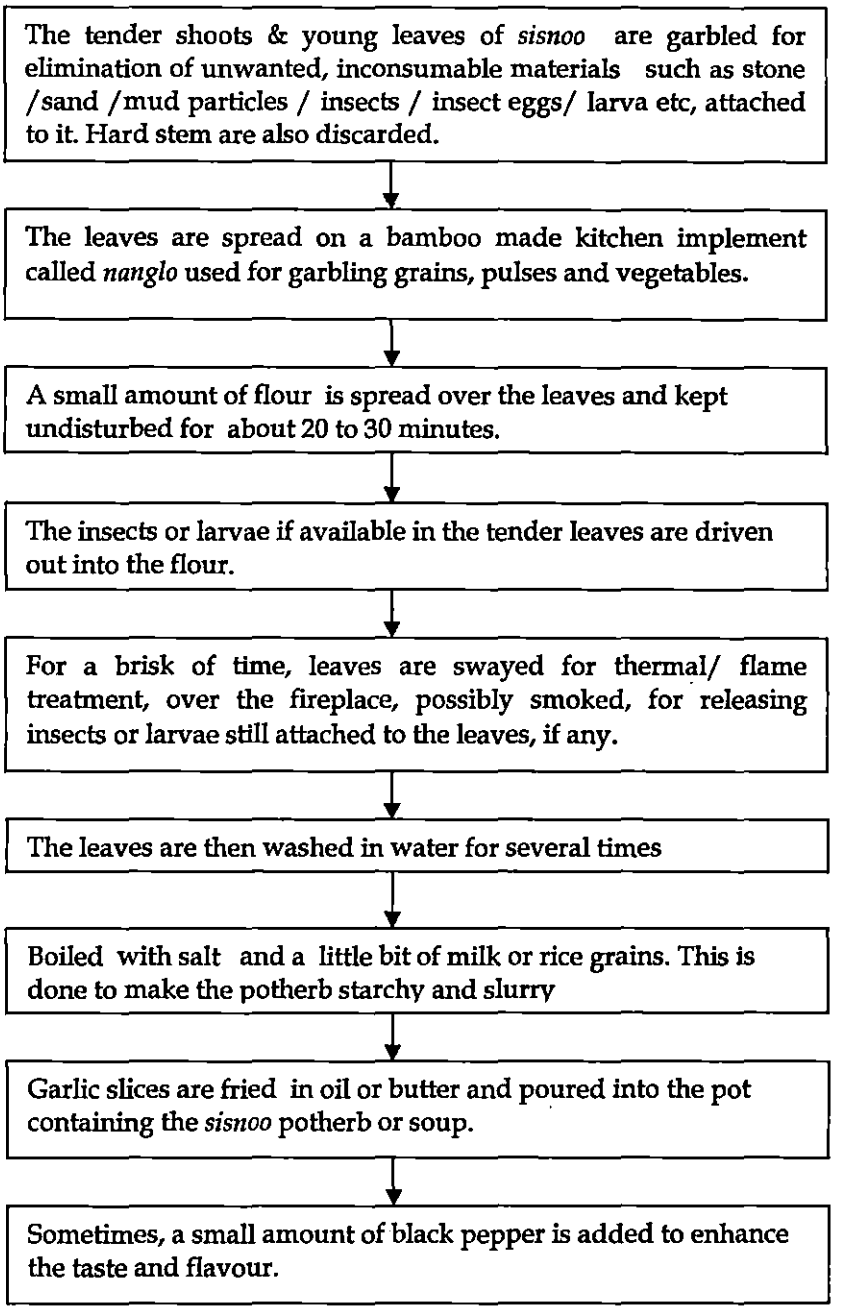

Fig 11d. Flow-sheet of mode of consumption of *sisnoo*.

Culinary

Both leaves and flowers of *sisnoo* are consumed as vegetables in the form of potherb and soup. The Bhutia ethnic community prefers

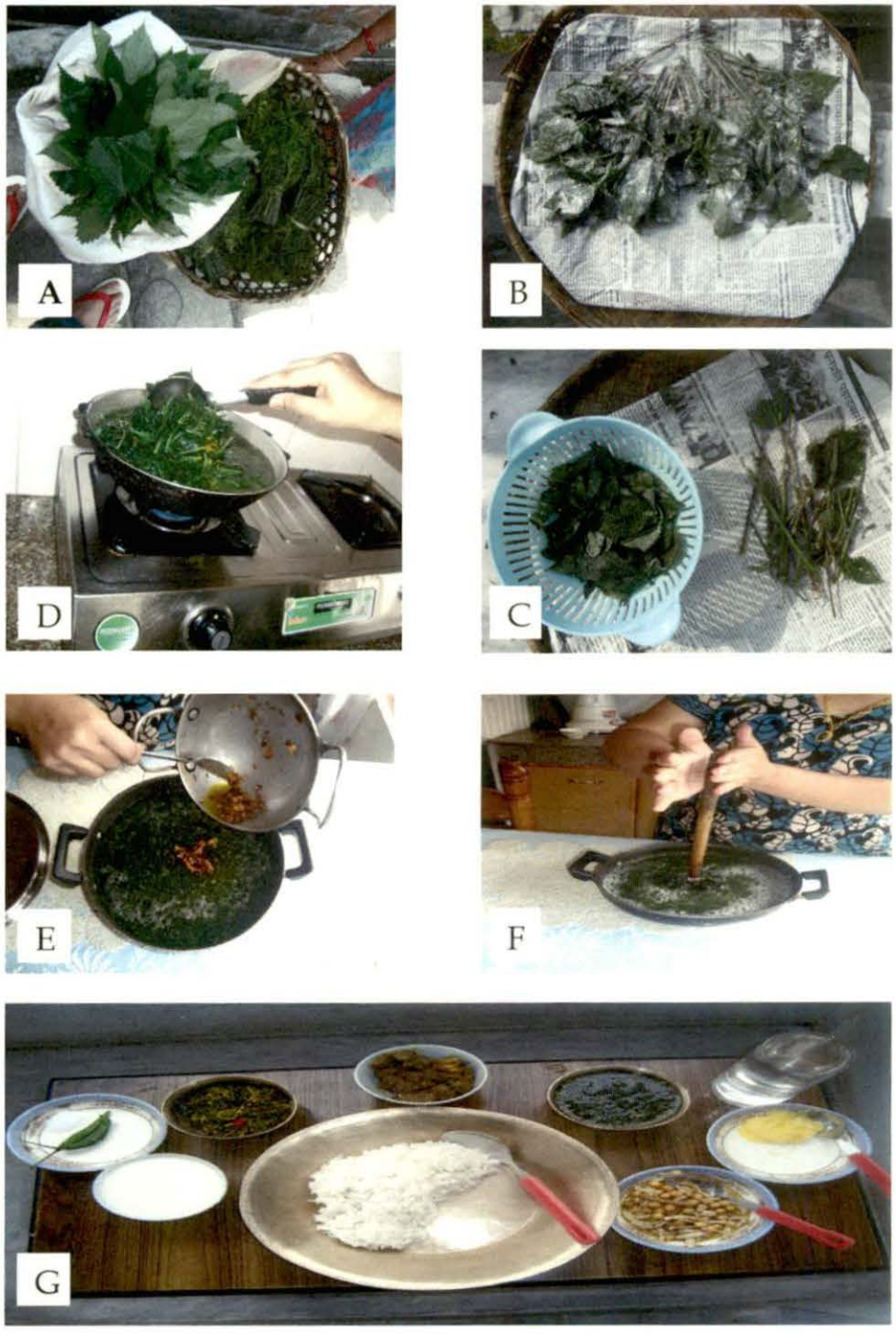

Photo 10. Preparation of *sisnoo* potherb **(A)** *sisnoo* bundle; **(B)** *sisnoo* treated with flour; **(C)** garbling of *sisnoo;* **(D)** *sisnoo* leaves being bolied; **(E)** addition of fried garlic into the *sisnoo* potherb; **(F)** stirring with the help of *firkey;* **(G)** *sisnoo* pot herb, served hot.

consumption of *sisnoo* with meat. *Sisnoo* potherb is prepared free of oil and spices (Fig 11e; Photo16).

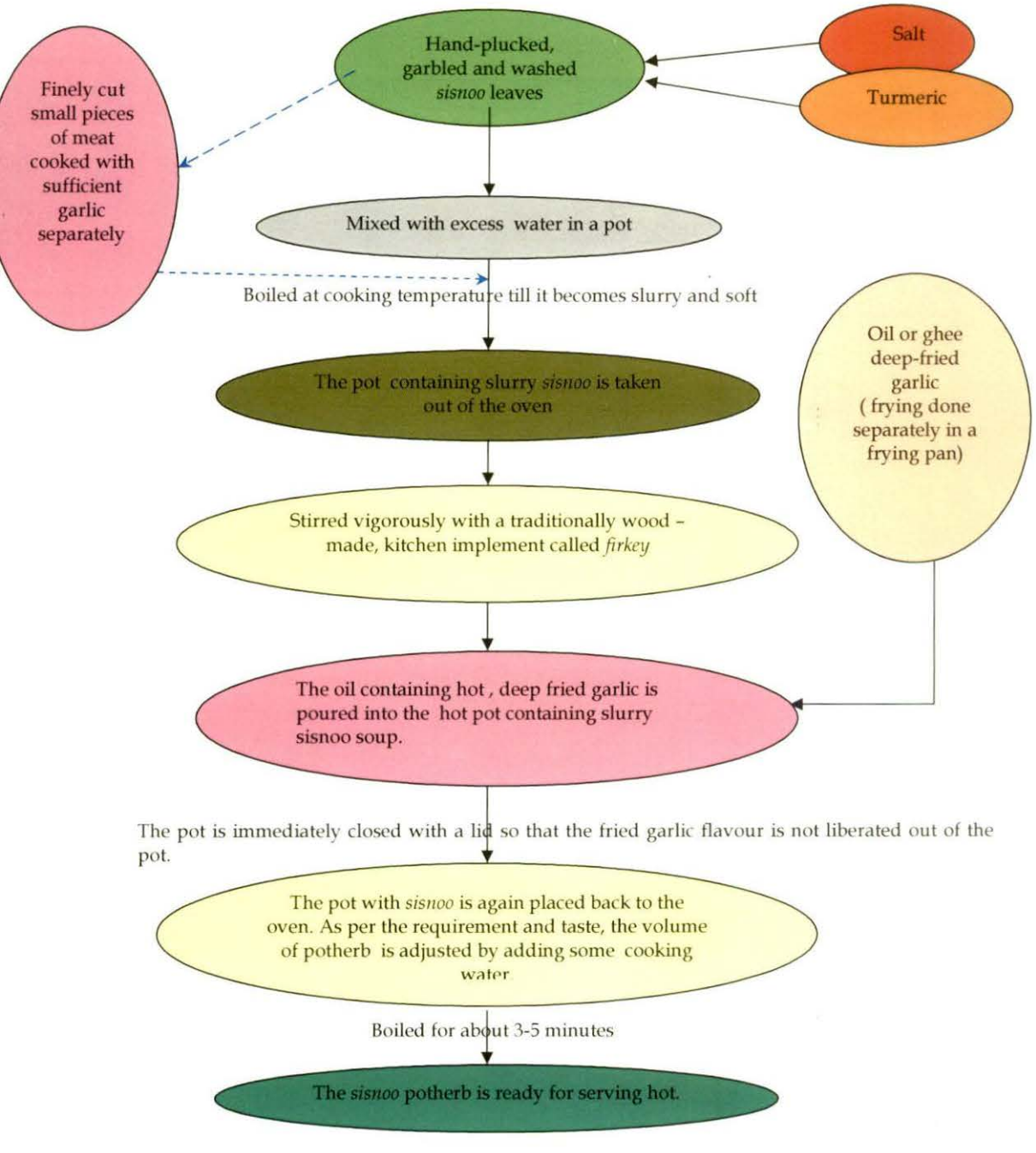

Fig 11e. Flow-sheet of *sisnoo* culinary

Nutritional composition

All the five selected wild leafy vegetables were analyzed to know their nutritional composition and expressed in terms of percentage (Table 11). Moisture content was determined within the range of 84.5-92.4 %. Highest moisture content was recorded in *Diplazium esculentum* while lowest was recorded in *Urtica dioica.* All other features except moisture and food value were expressed in terms of dry matter percentage. Food value was expressed as kcal/100 g DM. Dry matter percentage of ash content was recorded as high as 24.9 % in *Nasturtium officinale* followed by 19.5 % in *chenopodium album,* 18.9 % in *Urtica dioica,* and 16.2 % in *Diplazium esculentum* and 12.2 % in *Amaranthus viridis. Nasturtium officinale* showed highest protein content of 33.8 % while *Diplazium esculentum, Urtica dioica, Chenopodium album and Amaranthus viridis* showed 31.2, 28.5, 23.0 and 19.8 % respectively. All the five WLVs showed quite low fat percentage within a range of 3.4-9.6 DM %. Carbohydrate was estimated highest in *Amaranthus viridis* 64.6 DM % while lowest percentage was recorded in *Nasturtium officinale* with 31.7 DM %. Percentage of crude fiber was estimated as high as 13.2 DM % in *Urtica dioica* while lowest crude fiber was recorded in *Diplazium esculentum* with 4.6 %. The food value (calorific value) of the selected WLVs varied from 343.0-376.7 kcal/100 g DM. Highest food value was recorded in *Diplazium esculentum* (376.7 kcal/100 g DM) followed by *Amaranthus viridis* (368.2 kcal/100 g DM),

Urtica dioica (353.4 kcal/100 g DM), *Nasturtium officinale* (348.4 kcal/100 g DM) and *Chenopodium album* (343.0 kcal/100 g DM).

Table 11: Proximate composition of selected common and less familiar wild leafy vegetables of Sikkim

	Selected wild leafy vegetables				
Parameters	***Amaranthus viridis***	***Chenopodium album***	***Diplazium esculentum***	***Nasturtium officinale***	***Urtica dioica***
Moisture %	86.7 ± 0.5	84.8 ± 0.2	92.4 ± 0.1	90.6 ± 0.3	84.5 ± 0.1
Ash (% DM)	12.2 ± 0.9	19.5 ± 0.05	16.2 ± 0.7	24.9 ± 0.9	18.9 ± 0.3
Protein (% DM)	19.8 ± 0.6	23.0 ± 0.4	31.2 ± 1.0	33.8 ± 1.6	28.5 ± 1.3
Fat (% DM)	3.4 ± 0.5	4.2 ± 0.4	8.3 ± 1.3	9.6 ± 1.7	5.2 ± 0.4
Carbohydrate (% DM)	64.6 ± 1.7	53.3 ± 0.8	44.3 ± 1.5	31.7 ± 0.8	47.4 ± 1.3
Crude fibre (% DM)	8.2 ± 1.8	12.9 ± 0.1	4.6 ± 0.75	9.9 ± 0.7	13.2 ± 1.2
Food value (K cal/100g DM)	368.2 ± 1.3	343.0 ± 2.4	376.7 ± 1.9	348.4 ± 2.4	353.4 ± 3.0

DM, dry matter; Data represents the means (± SD) of 10 samples each.

Elemental analysis

The macro mineral content of selected five wild leafy vegetables were analyzed using flame photometer and the values expressed in mg/100 g (Table 12). Sodium content was recorded highest in *Nasturtium officinale* (68.8 mg/100 g) followed by *Amaranthus viridis* (11.2 mg/100 g),

Urtica dioica (10.3 mg/100 g), *Diplazium esculentum* (9.5 mg/100 g), *Chenopodium album* (7.4 mg/100 g) (Figure 13a). Potassium content values varied from (382-917.2 mg/100 g). Elemental potassium was recorded highest in *Urtica dioica* and lowest in *Amaranthus viridis* (Figure 13b). Calcium content was estimated highest in *Diplazium esculentum* (192.7 mg/100 g) and lowest in *Amaranthus viridis* (24.7 mg/100 g) (Fig 13c).

The micro mineral content was determined by triacid digestion method and measurement carried out using Atomic Absorption Spectrophotometer (Perkin Elmer Analyst 200), (Table 12). For elemental Iron, Copper and Zinc, the values were expressed as mg/100 g. Iron content values varied from 5.4-11.2 mg/100 g. highest value was recorded in *Amaranthus viridis* and lowest in *Chenopodium album* (Fig 13d). Copper content was recorded as 1.22, 1.11, 0.67, 0.58, and 0.32 mg/100 g in *Chenopodium album, Amaranthus viridis, Urtica dioica, Nasturtium officinale* and *Diplazium esculentum,* respectively (Fig 13e). Similarly, the elemental Zinc was recorded highest in *Amaranthus viridis* (9.73 mg/100 g) followed by *Chenopodium album* (8.44 mg/100 g). *Diplazium esculentum, Urtica dioica and Nasturtium officinale* showed Zinc content values within the range of 2.04-2.73 mg/100g (Fig 13f). The Magnesium content values were expressed in percentage which was determined within the range of 0.22-0.48 %. Highest magnesium content was recorded in *Amaranthus viridis* while lowest was recorded in *Urtica dioica* (Fig 13g).

Table 12: Mineral contents of some common and less familiar wild leafy vegetables of Sikkim

	Wild leafy vegetables (mg/100 g)				
Parameters	***Amaranthus viridis***	***Chenopodium album***	***Diplazium esculentum***	***Nasturtium officinale***	***Urtica dioica***
Na	11.2 ± 3.5	7.4 ± 1.6	9.5 ± 2.2	68.8 ± 4.4	10.3 ± 2.8
K	382.0 ± 15.4	848.32 ± 22.2	914.4 ± 23.5	465.2 ± 13.2	917.2 ± 26.3
Ca	24.7 ± 2.1	155.75 ± 3.6	192.7 ± 5.2	65.6 ± 3.6	113.2 ± 7.5
Fe	10.8 ± 2.2	5.4 ± 1.3	11.2 ± 1.8	7.0 ± 0.92	8.1 ± 1.8
Cu	1.11 ± 0.23	1.22 ± .07	0.32 ± 0.04	0.58 ± 0.06	0.67 ± 0.03
Zn	9.73 ± 1.02	8.44 ± 0.91	2.73 ± 0.08	2.04 ± 0.03	2.32 ± 0.12
Mg %	0.48 ± 0.06	0.31 ± 0.05	0.36 ± 0.02	0.41 ± 0.06	0.22 ± 0.04

Data represents the mean value of 3 replications.

Vitamin-C content

Vitamin-C was estimated by direct colorimetric method and the measurement was done at 518 nm (Table 13). The vitamin-C content of five WLVs were recorded as 44 mg/100 g (*Amaranthus viridis*), 21 mg /100 g (*Diplazium esculentum*), and 13 mg/100 g (*Nasturtium officinale*). Less than 10 mg/100 g values of vitamin-C were recorded in *Urtica dioica* and *Chenopodium album* (Fig 14a).

Table 13: Vitamin-C content of some common and less familiar wild leafy vegetables of Sikkim

Wild leafy vegetables	Local name	Vitamin-C content mg/100g
Amaranthus viridis	Lattey sag	44
Chenopodium album	Bethu sag	03
Diplazium esculentum	Ningro	21
Nasturtium officinale	Simrayo	13
Urtica dioica	Sisnoo	07

Data represents the mean value of 3 determinants estimated by colorimetric method at 518 nm.

Antioxidant activity

The antioxidant activity was analyzed by estimating free radical scavenging activity following DPPH method of Macwaan and Patel 2010, with modifications. The absorbance was measured at 517 nm using Lamda 25 UV Vis Spectrophotometer (Perkin Elmer/L 600-00 BB). The extents of DPPH radical scavenging at different concentrations (10-100 µg/ml) of the methanolic extracts were measured with ascorbic acid as standard. The DPPH free radical scavenging activities (inhibition percentage) were found to increase with increasing concentration and were estimated to be quite less than the standard (97.03 % at 100 µg/ml). The results obtained in Table 14 indicated moderate potential of all the plant extracts, in

scavenging DPPH free radicals. The inhibition percentage values, varied within the range of 53.19-64.47% (Table-14) as observed at 100 µg/ml for the methanolic extracts of the selected five WLV species. At 100 µg/ml, maximum activity was observed in *Chenopodium album* (64.47 %) followed by *Amaranthus viridis* (61.87 %), *Nasturtium officinale* (58.40 %), *Diplazium esculentum* (57.95 %), *Urtica dioica* (53.19 %) and 97.03 µg/ml for ascorbic acid standard (Fig 5a-5e).

The IC_{50} values were recorded as 46 µg/ml(*Chenopodium album*), 38 µg/ml (*Amaranthus viridis*), 70 µg/ml (*Nasturtium officinale*), 52 µg/ml (*Diplazium esculentum*), 87 µg/ml (*Urtica dioica*). The result of the present investigation shows that *Amaranthus viridis* and *Chenopodium album* are higher in antioxidant activity in comparison to *Nasturtium officinale, Diplazium officinale and Urtica dioica* and accordingly lowest IC_{50} value was determined in *Amaranthus viridis* and highest value was determined in *Urtica dioica* which has least antioxidant activity. An IC_{50} value is the concentration of the sample required to scavenge 50% of the free radicals present in the system. IC_{50} value is inversely related to the activity.

Table 14: Estimation of DPPH free radical scavenging activities (Inhibition %) of methanolic extracts of selected common and less familiar wild leafy vegetables of Sikkim

Concentration of extracts (µg/ml)	Inhibition (%)					
	A. viridis	*C. album*	*D. esculentum*	*N. officinale*	*U. dioica*	Ascorbic Acid standard
10	38.39 ± 0.96	33.50 ± 0.15	31.35 ± 3.02	29.09 ± 0.17	27.24 ± 0.50	91.99
20	43.25 ± 2.5	42.89 ± 1.74	42.98 ± 1.84	35.11 ± 1.09	32.05 ± 0.45	93.48
40	52.24 ± 2.4	47.93 ± 2.0	46.31 ± 0.44	43.83 ± 2.76	36.55 ± 0.39	96.58
60	56.56 ± 1.84	54.54 ± 3.21	52.02 ± 0.85	47.66 ± 2.69	41.95 ± 0.83	96.62
80	57.59 ± 2.71	58.63 ± 1.47	56.47 ± 1.30	53.19 ± 0.15	47.43 ± 1.54	96.76
100	61.87 ± 2.42	64.47 ± 0.81	57.95 ± 3.67	58.40 ± 1.15	53.19 ± 2.14	97.03

DPPH, 1,1-diphenyl-2-picryl hydrazyl; Data represents, mean (±.S.D) of 3 samples each

Total phenolic content

Total phenolic compounds (TPC) present in extracts were determined with the Folin-Ciocalteu reagent (Slinkard and Singleton, 1977) with modification. The absorbance was measured at 760 nm using Lamda 25 UV Vis Spectrophotometer (Perkin Elmer/L 600-00 BB) and the calibration curve was drawn. In the quantitative analysis of total phenolic contents in methanolic extracts of five selected wild leafy vegetables, the TPC was determined within a range of 18-176 mg/g in GAE (Table 15). Highest TPC was determined in *Urtica dioica* (176 mg/g in GAE) followed by *Chenopodium album* (98 mg/g in GAE), *Amaranthus viridis* (98 mg/g in

GAE), *Nasturtium officinale* (68 mg/g in GAE) and *Diplazium esculentum* (18 mg/g in GAE) (Fig 6a and 6b).

Table 15: Estimation of Total Phenol Content of methanolic extracts of selected common and less familiar wild leafy vegetables of Sikkim

Wild leafy vegetable	Absorbance at 760 nm	TPC mg/g in GAE
Amaranthus viridis	2.1 ± 0.07	80.6
Chenopodium album	2.2 ± 0.01	98.0
Diplazium esculentum	1.5 ± 0.21	18.0
Nasturtium officinale	1.9 ± 0.05	63.0
Urtica dioica	2.9 ± 0.03	176.0

Data represents, mean (±.S.D) of 3 samples each.

Occurrence of pathogenic bacteria

Samples of wild leafy vegetables were examined for the presence of *Listeria* sp., *Salmonella* sp., and *Shigella* sp. using the selective media. None of these pathogenic bacteria were detected in samples analysed. 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 (Table 16).

Table 16. Microbial load of pathogenic bacteria in selected common and less familiar wild leafy vegetables of Sikkim

Wild leafy vegetable	Log cfu/g sample					
	Bacillus cereus	Enterobacteriaceae	*Listeria* sp.	*Salmonella* sp.	*Shigella* sp.	*Staphylococcus aureus*
Amaranthu virdis Linn. (n = 7)	0	1.0 ± 0.6	0	0	0	1.1 ± 0.4
Chenopodium album Linn. (n = 8)	0	1.2 ± 0.1	0	0	0	1.0 ± 0.1
Diplanzium esculentum (Retz.) (n = 6)	0	0	0	0	0	0
Nasturtium officinale Brown (n = 7)	0	0	0	0	0	0
Urtica dioica Linn. (n = 6)	0	0	0	0	0	0

n, number of samples collected.

0, less than detection limit of 10 cfu per gm

Data represents the means (± SD) of number of samples.

Domestication Model:

Foraging from wild is a seasonal activity, yet, it is a necessary activity in many remote villages of Sikkim. As such, foraging from wild induces several adverse effects on the environment. A study on the adverse effects of existing traditional practice of foraging from wild has shown the results as reflected in (Table 10).

Table 10: Intensity of the adverse effects of foraging of selected common and less familiar wild leafy vegetables of Sikkim

	Adverse effects						
WLV	**Over exploitation**	**Indiscriminative foraging**	**Wild life damage**	**Wild life disturbance.**	**Edible part spoilage**	**Environmental laws violation**	**Life risk**
Sisnoo	AAA	AA	AAA	AAA	AA	AAA	AAA
Ningro	AAA	AA	AA	AA	AAA	AAA	AA
Simrayo	AA	AA	AA	AA	AA	AA	AA
Lattey sag	O	O	O	O	A	O	O
Bethu sag	O	O	O	O	A	O	O

A, low intensity; AA, medium intensity; AAA ,high intensity; O, not prominent

1. ***Over exploitation of the species in their natural habitat.***

Due to high market demand of WLVs such as *Urtica dioica, Diplazium esculentum* and *Nasturtium officinale* the collectors with an intention to maximize the collection volume within a given time,

intentionally or un-intentionally over exploit the species causing an imbalance to the natural homeostasis of a particular ecosystem. Moreover, WLVs are collected at their immature stage of growth as the edible parts are tender leaves and tender shoots.

2. *Unscientific and indiscriminative foraging.*

Due to the lack of proper awareness, orientation and scientific approach, the collectors still practice the traditional method of collection of WLVs which could sometimes be unscientific and indiscriminative. The percentage of adulterant in the commercial variety of WLVs, often noticed in the market could be attributed to this. Poisonous adulterants, if ignored, may also result to food poisoning of the consumers.

3. *Damage of other floral and faunal wealth in the collection site.*

The collections of WLVs generally engage both women folk and children. Due to the innocence and ignorance of the collectors, a visible degree of damage is caused to the floral and faunal wealth in the collection site. Moreover, collection is massive during spring season whereas, it is at this time the wild habitat in the Himalaya is under, series of regenerative activities of floral and faunal population.

4. ***Pollution of drinking water sources***

The natural habitat of *Nasturtium officinale* is marshy places and streams. They are found luxuriantly growing in the spring water sources locally called *pani ko muhan* of the rural villages which in many situation solely support the drinking water need of several rural villages. Moreover, *Nasturtium officinale* is traditionally believed to help purify water at such drinking water sources. However, the indiscriminate human access and indulgence for foraging, at such drinking water sources, pollute both the water and surrounding environment which subsequently make the water unsafe for drinking to whole of the village.

5. ***Distraction of wild faunal population***

Collection of WLVs from its natural habitat indirectly encourages invasion to the forest and restricted areas of the state demarcated for wild life conservation. It is therefore observed that due to uncontrolled human invasion the wild animals are distracted at their natural habitat. The appearance of wild animals in the human inhabited areas, as observed quite often in the hills, could partly be attributed to this.

6. ***Spoilage of edible parts due to improper method of collection, packaging and transportation***

The collectors adopt the traditional method of collection, packaging and transportation protocol, without being much aware of the intensity of loss and damage to the nutrients, taste, texture and self life of the species collected and marketed subsequently.

7. ***Involvement in violation of several environmental conservation laws***

Several biodiversity conservation and protection laws are strictly enforced in the state. Human trespass are strictly prohibited in many restricted and biodiversity conservation areas yet sometimes the WLV collectors are involved in the violation of such laws.

8. ***Risk factors on the lives of gatherers and collectors***

WLV collectors and gatherers are often subjected to several risk factors of a wild environment such as accidents, attacks by wild animals and poisoning. These, altogether necessitates an urgent need for domestication of WLVs in the hills and thus an Ethnic Food, Health and Environment (EFHE) domestication model of WLV species, is proposed (Fig 12a & 12b).

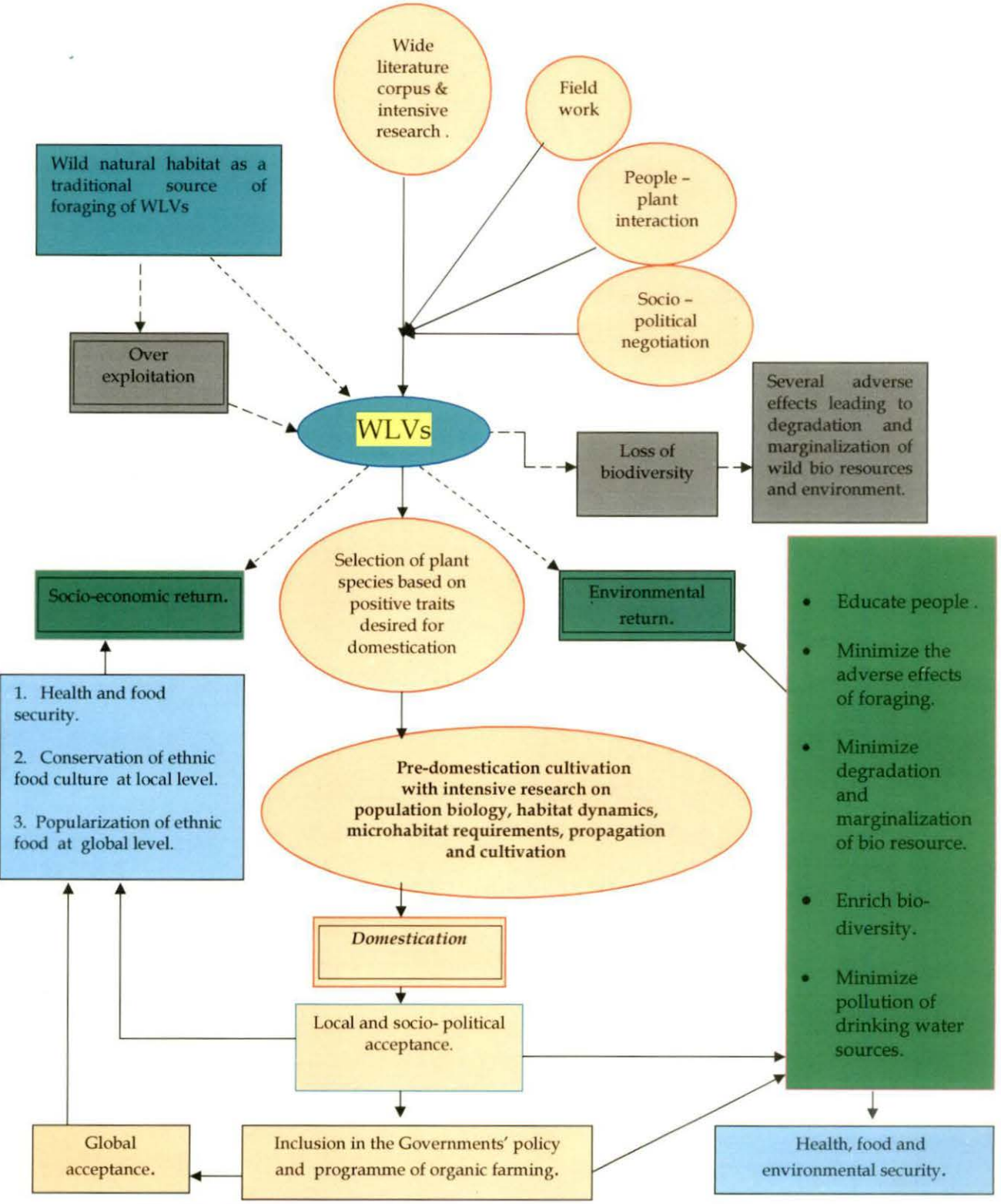

Fig 12a. EFHE domestication model of WLVs.

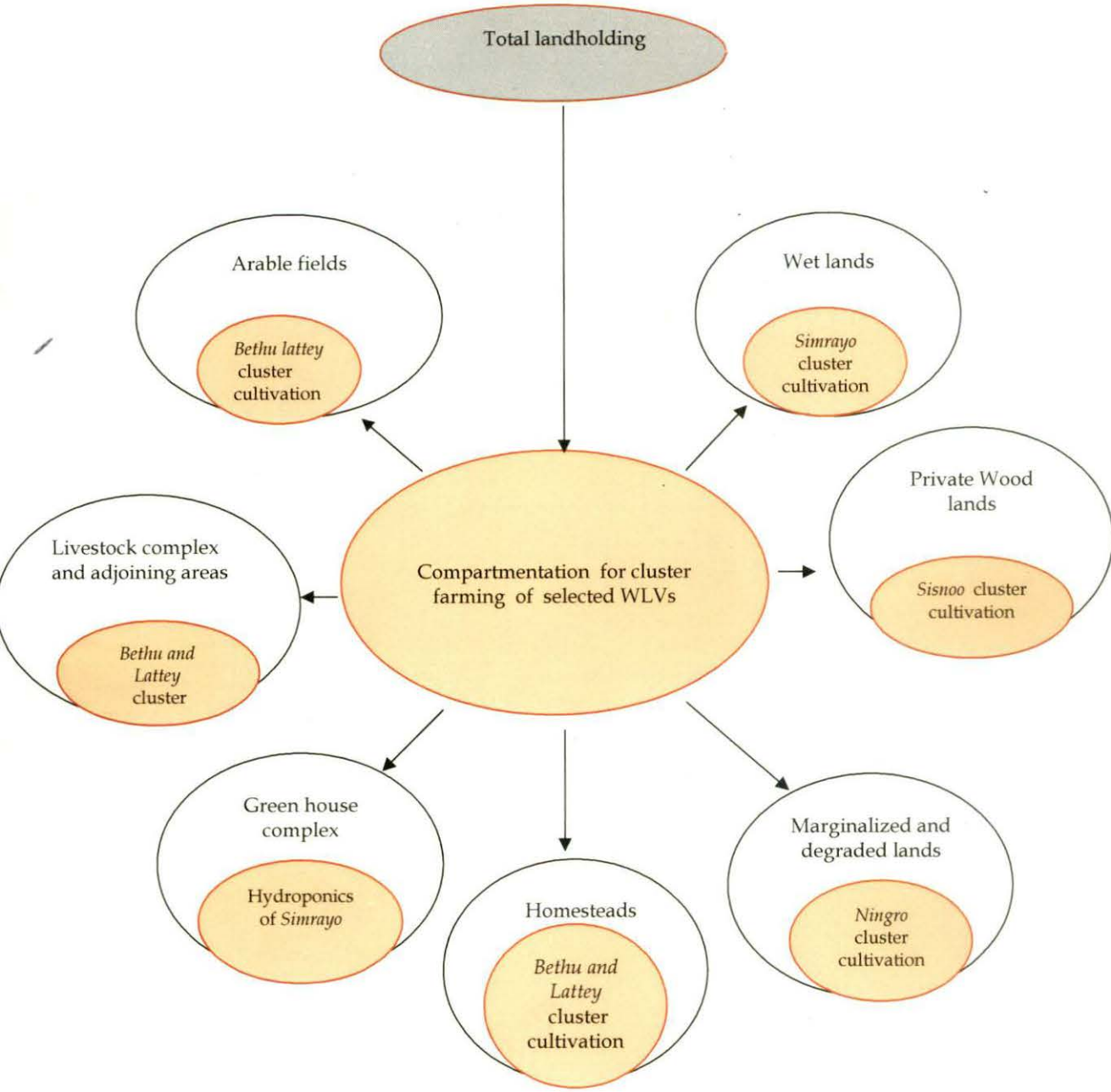

Fig: 12b. (*continued*) EFHE domestication model of WLV.

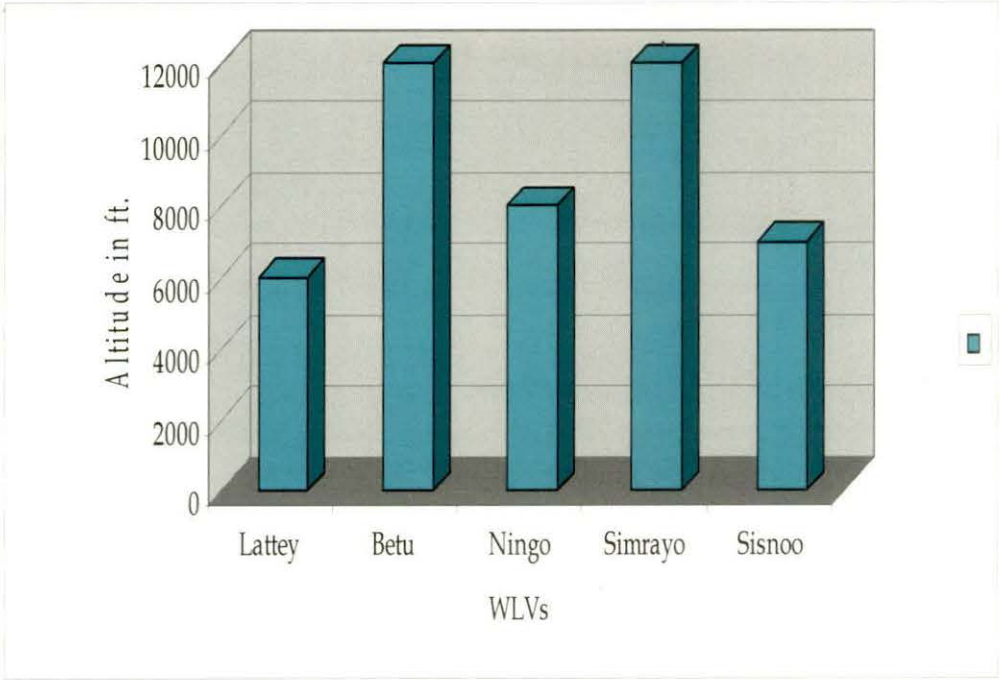

Fig 1. Graphic representation of altitudinal distribution range of selected common and less familiar WLVs of Sikkim

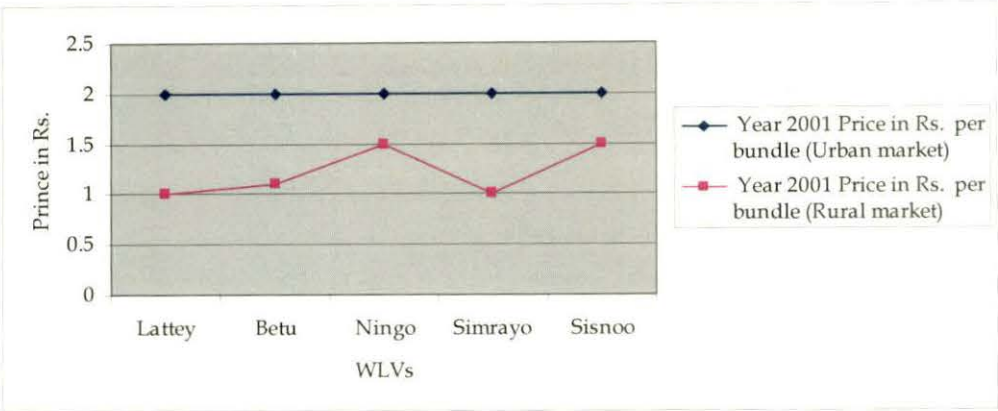

Fig 2a. Graphic representation of urban and rural market price of selected common and less familiar WLVs of Sikkim (Year 2001)

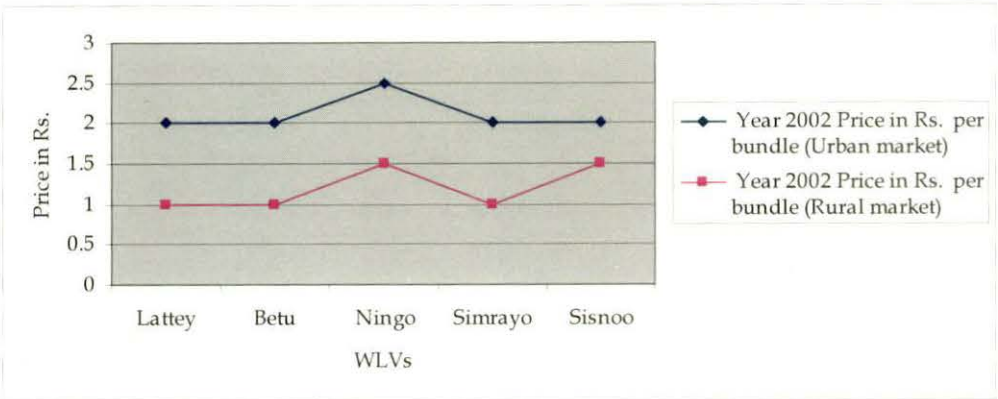

Fig 2b. Graphic representation of urban and rural market price of selected common and less familiar WLVs of Sikkim (Year 2002)

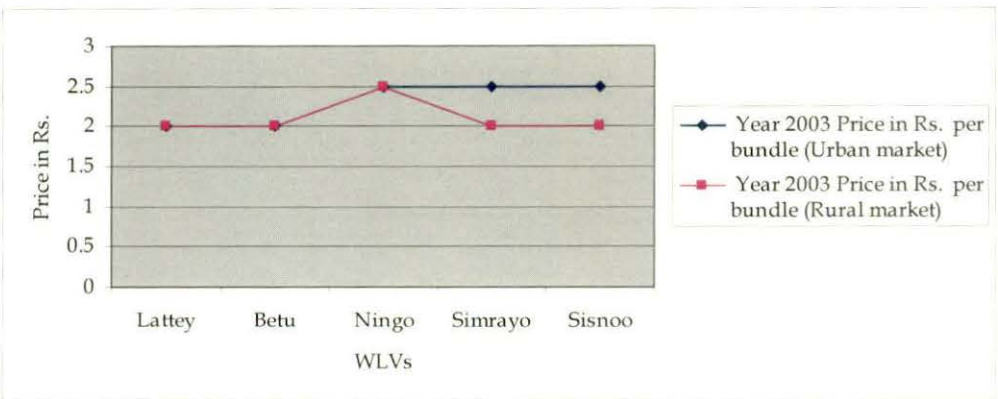

Fig 2c. Graphic representation of urban and rural market price of selected common and less familiar WLVs of Sikkim (Year 2003)

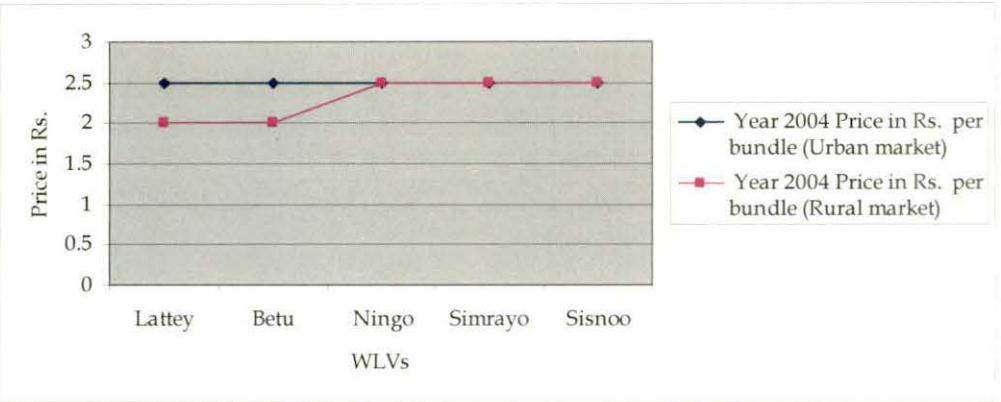

Fig 2d. Graphic representation of urban and rural market price of selected common and less familiar WLVs of Sikkim (Year 2004)

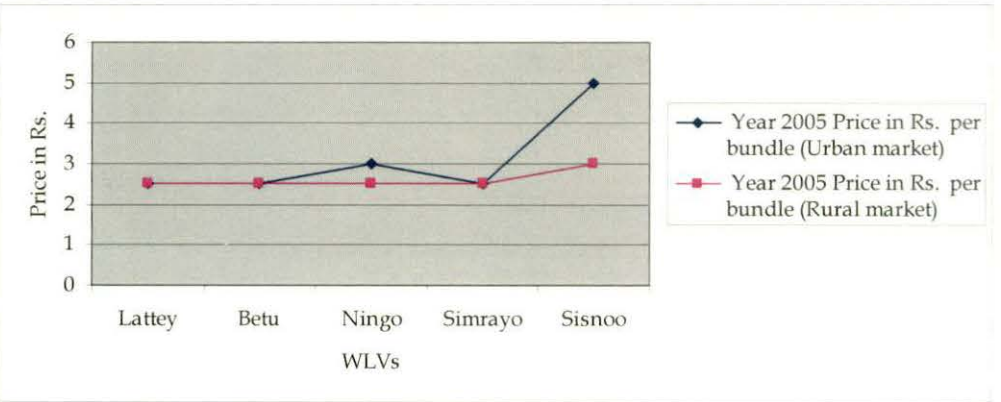

Fig 2e. Graphic representation of urban and rural market price of selected common and less familiar WLVs of Sikkim (Year 2005)

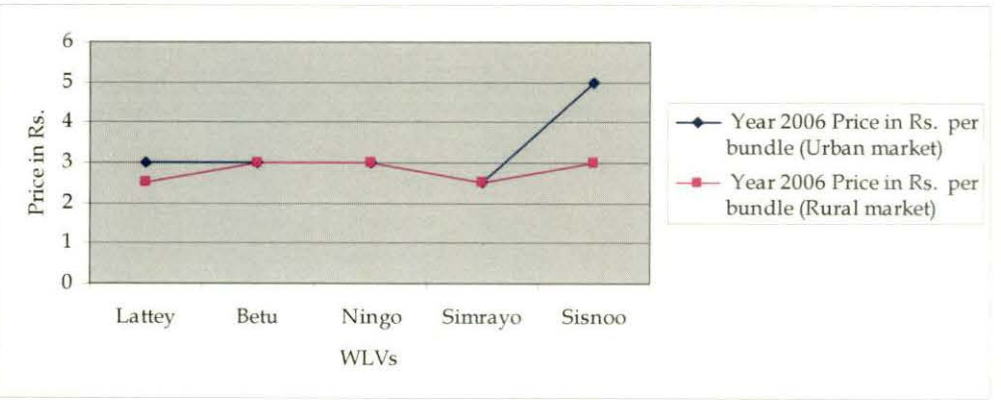

Fig 2f. Graphic representation of urban and rural market price of selected common and less familiar WLVs of Sikkim (Year 2006)

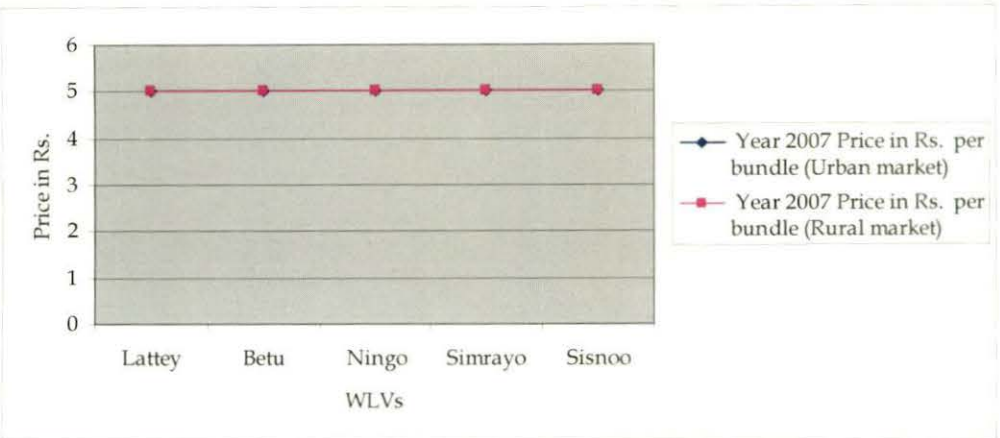

Fig 2g. Graphic representation of urban and rural market price of selected common and less familiar WLVs of Sikkim (Year 2007)

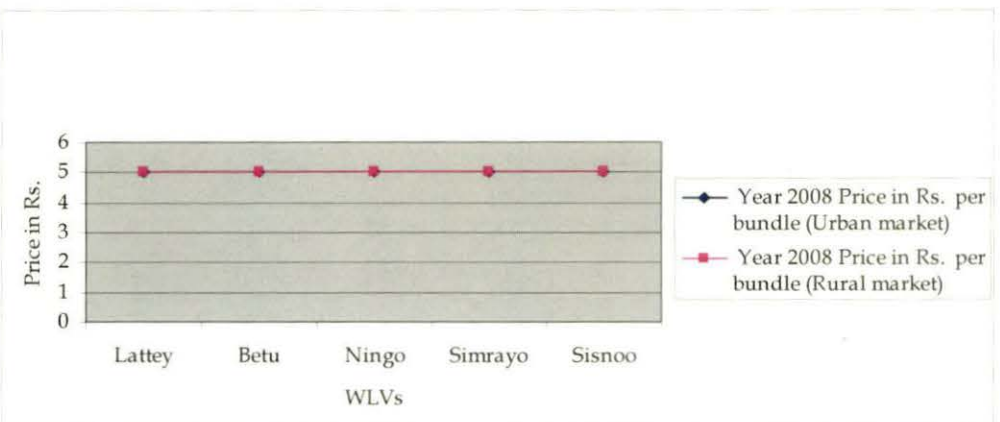

Fig 2h. Graphic representation of urban and rural market price of selected common and less familiar WLVs of Sikkim (Year 2008)

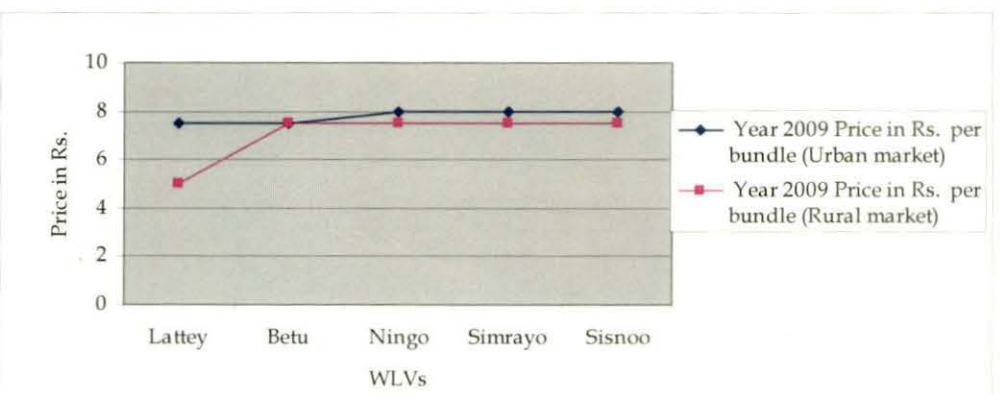

Fig 2i. Graphic representation of urban and rural market price of selected common and less familiar WLVs of Sikkim (Year 2009)

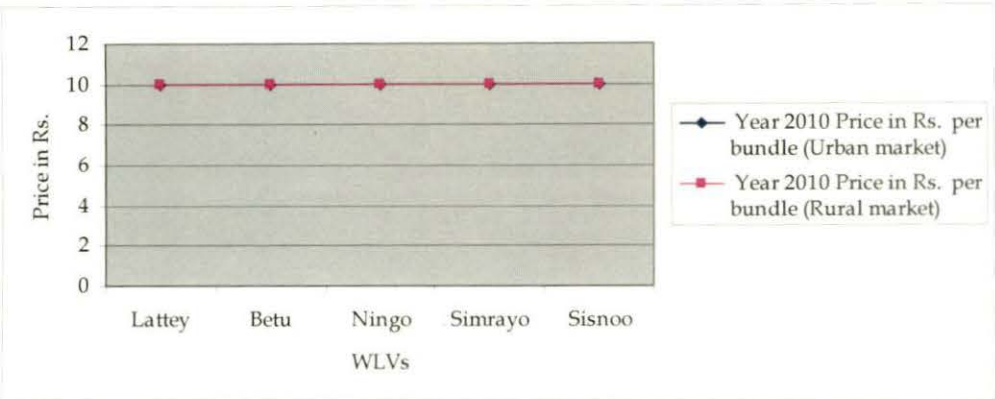

Fig 2j. Graphic representation of urban and rural market price of selected common and less familiar WLVs of Sikkim (Year 2010)

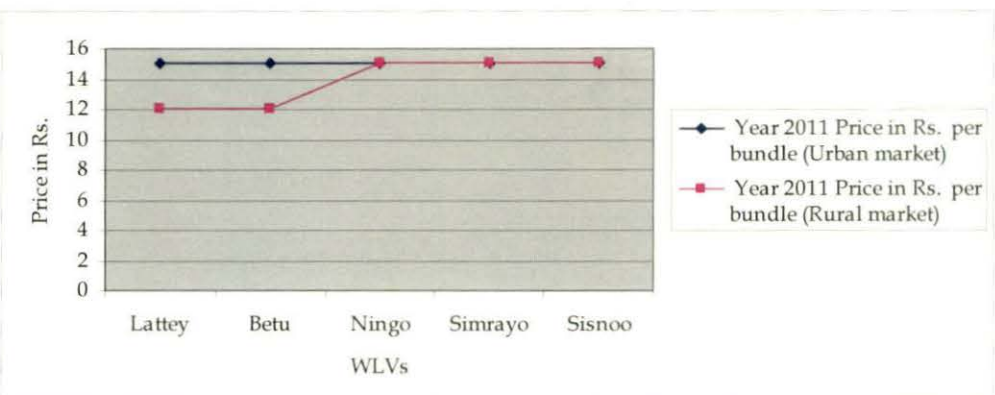

Fig 2k. Graphic representation of urban and rural market price of selected common and less familiar WLVs of Sikkim (Year 2011)

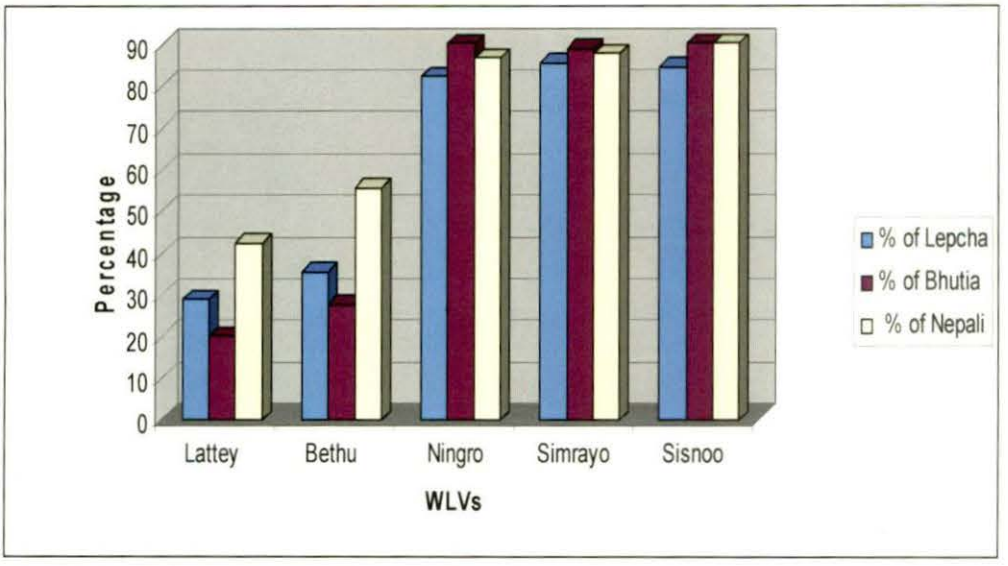

Fig 3. Graphic representation of edibility acceptance percentage of selected WLVs amongst the younger generation of different ethnic communities of Sikkim

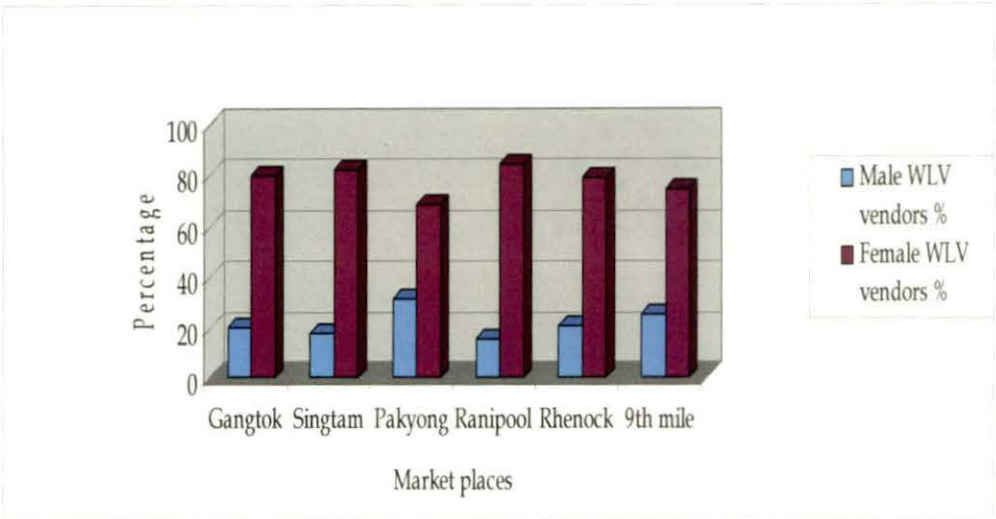

Fig 4a. Graphic representation of gender percentage profile of WLV vendors in East Sikkim

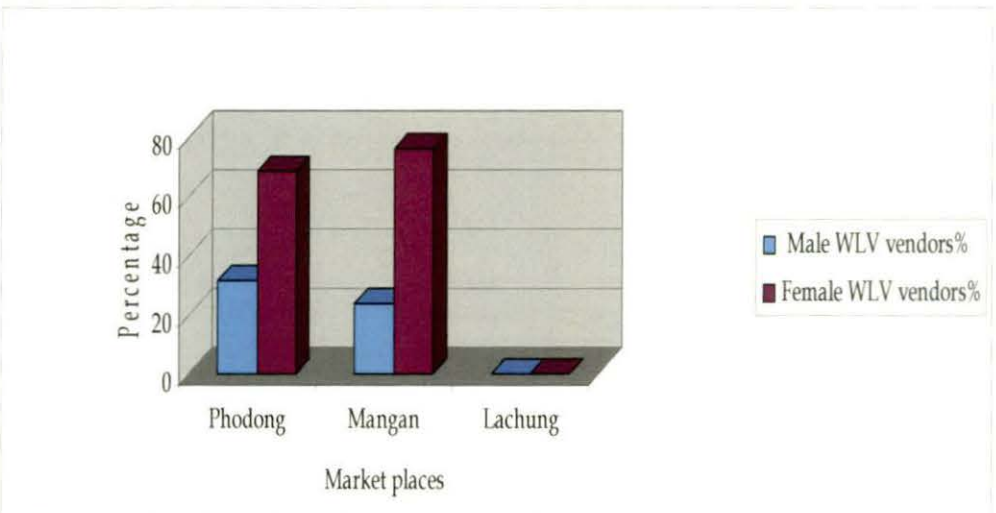

Fig 4b. Graphic representation of gender percentage profile of WLV vendors in North Sikkim

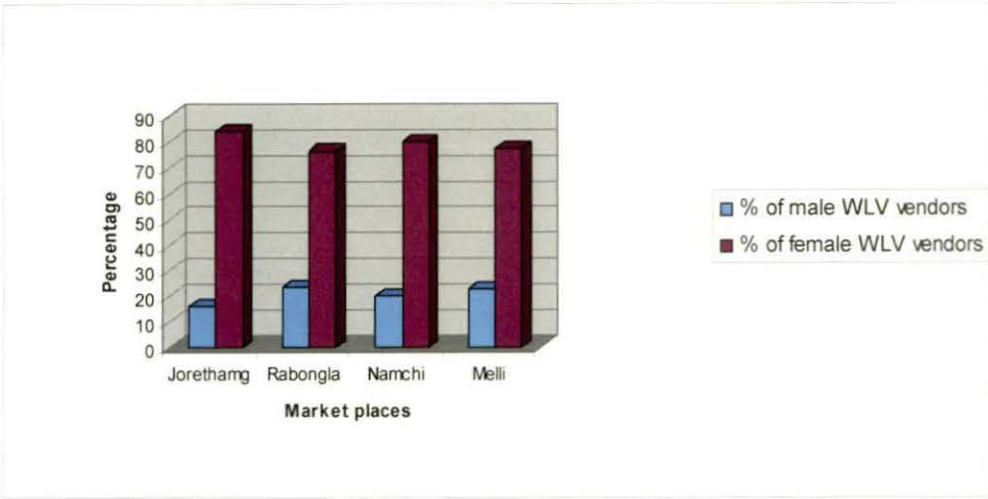

Fig 4c. Graphic representation of gender percentage profile of WLV vendors in South Sikkim

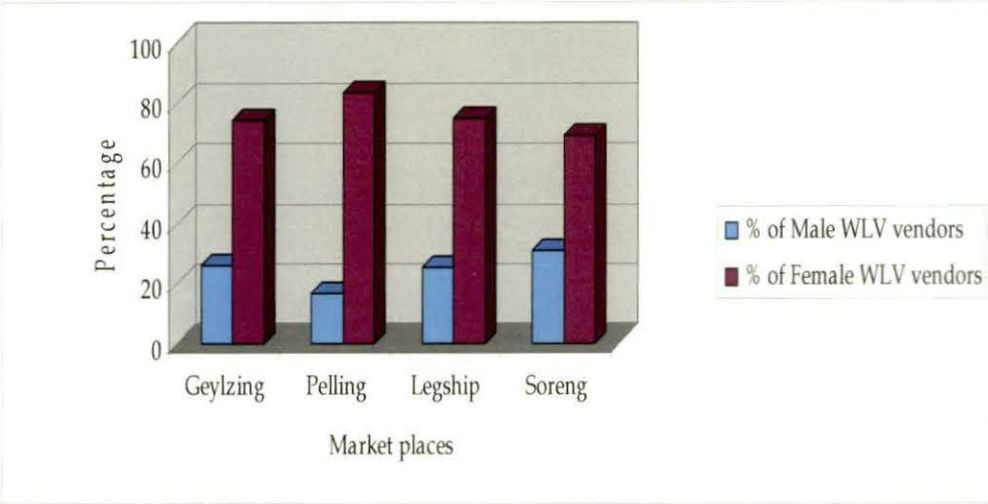

Fig 4d. Graphic representation of gender percentage profile of WLV vendors in West Sikkim

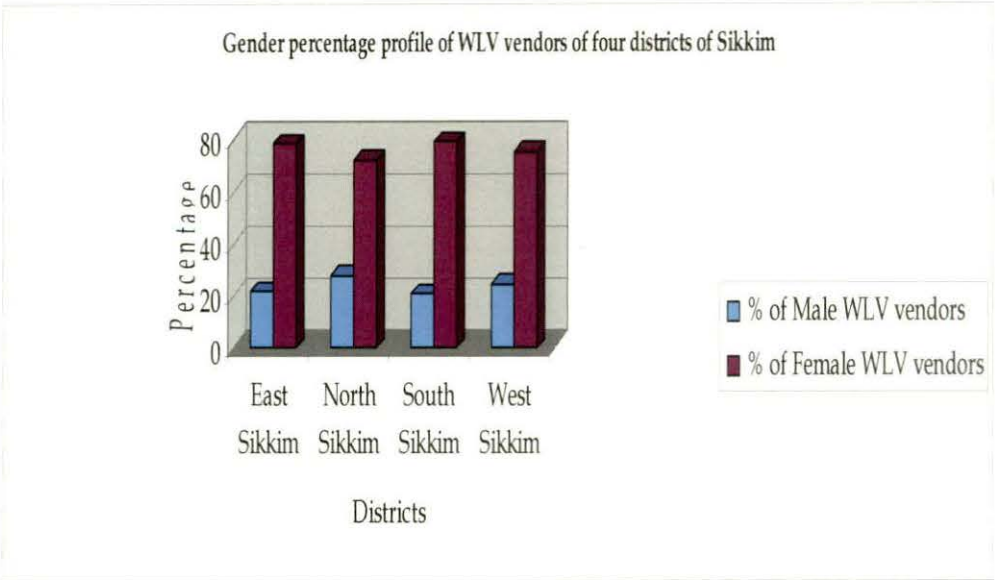

Fig 4e. Graphical representation of gender percentage profile of WLV vendors in the four districts of Sikkim

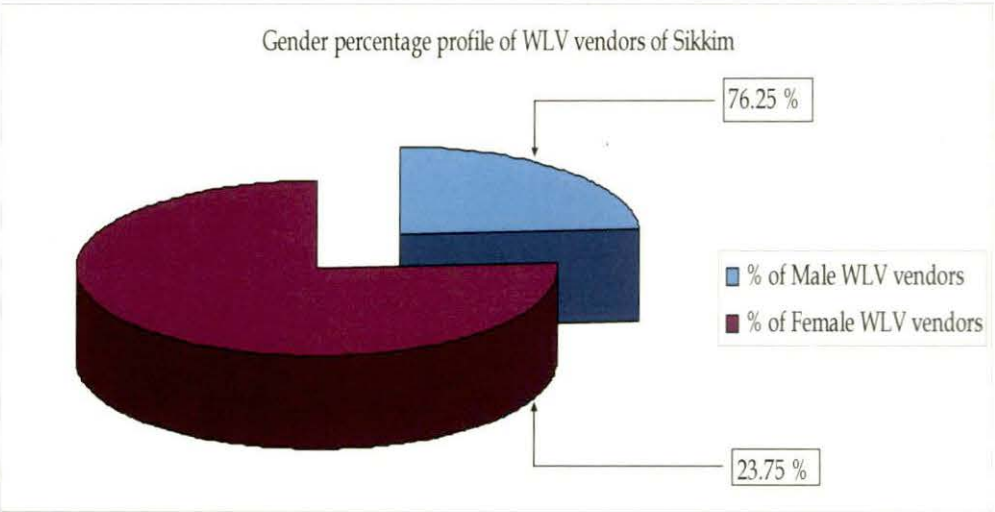

Fig 4e. Graphic representation of gender percentage profile of WLV vendors of Sikkim

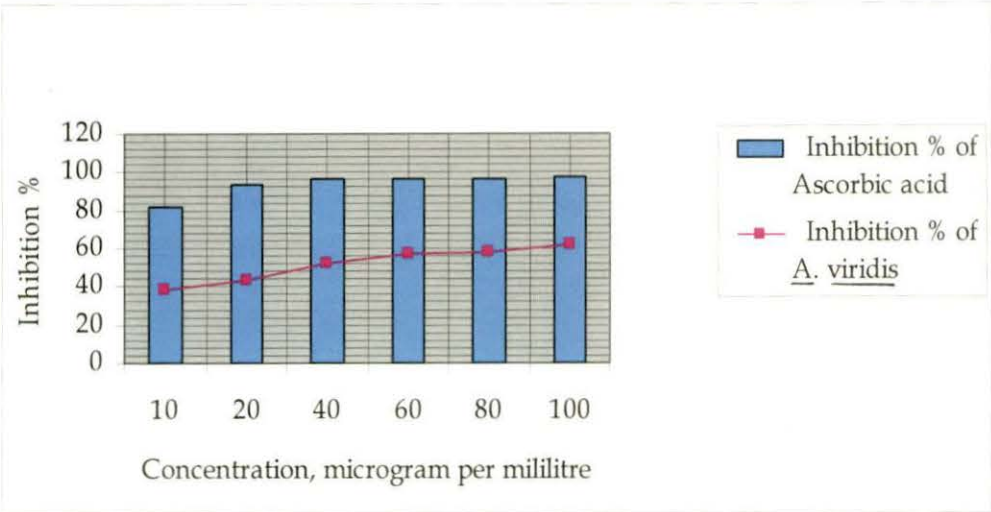

Fig 5a. Graphic representation of DPPH free radical scavenging activity of *Amaranthus viridis*

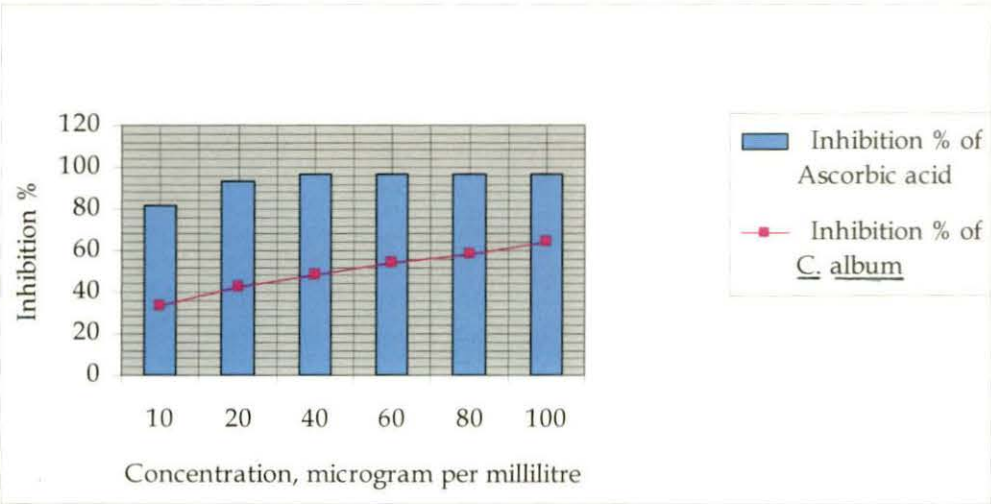

Fig 5b. Graphic representation of DPPH free radical scavenging activity of *Chenopodium album*

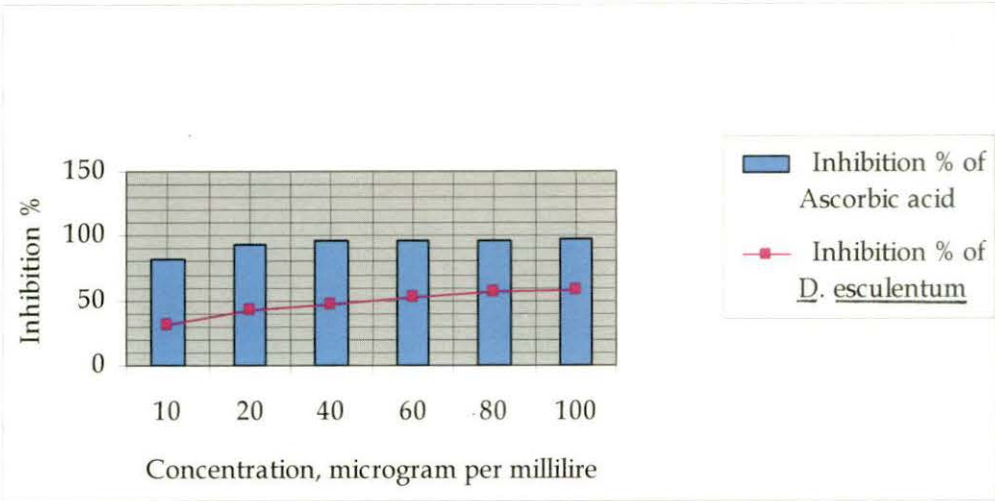

Fig 5c. Graphic representation of DPPH free radical scavenging activity of *Diplazium esculentum*

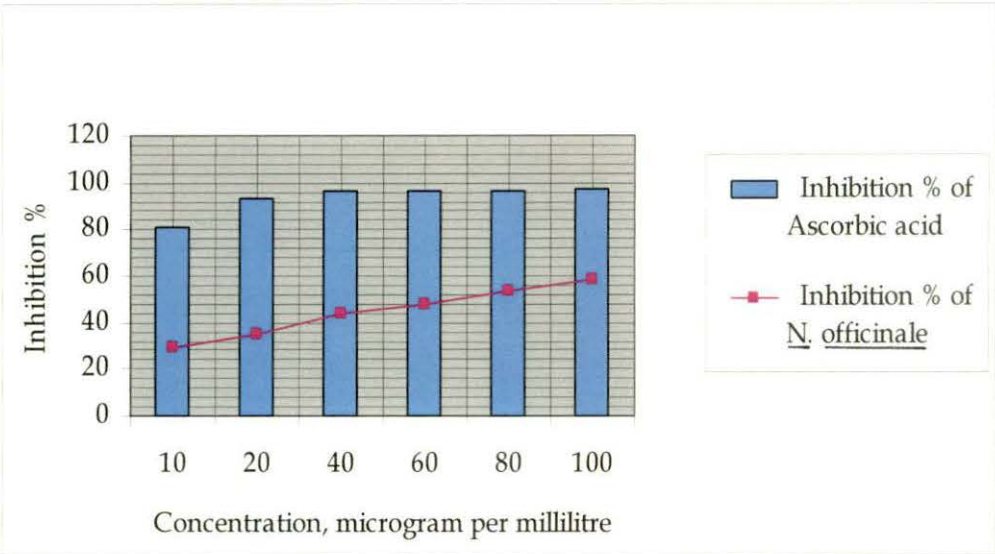

Fig 5d. Graphic representation of DPPH free radical scavenging activity of *Nasturtium officinale*

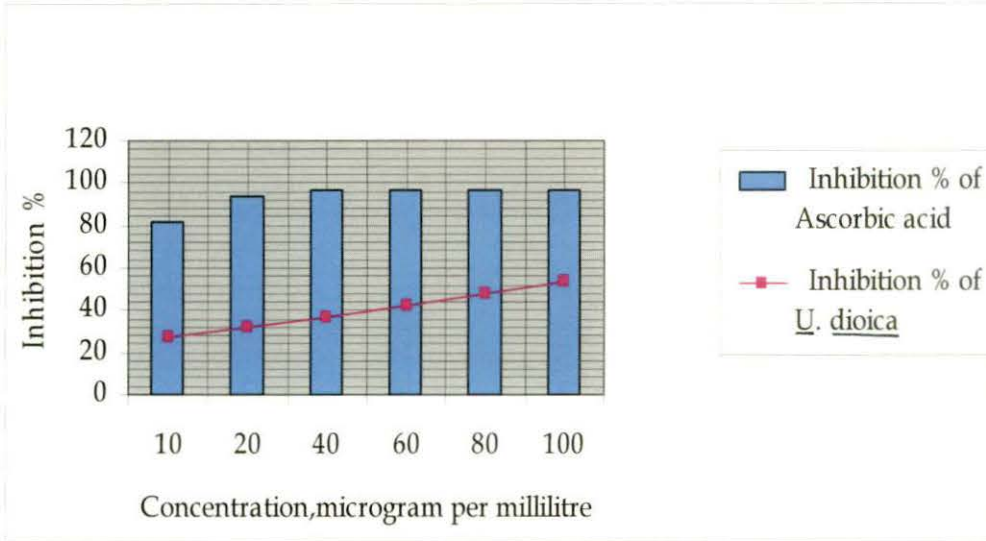

Fig 5e. Graphic representation of DPPH free radical scavenging activity of *Urtica dioica*

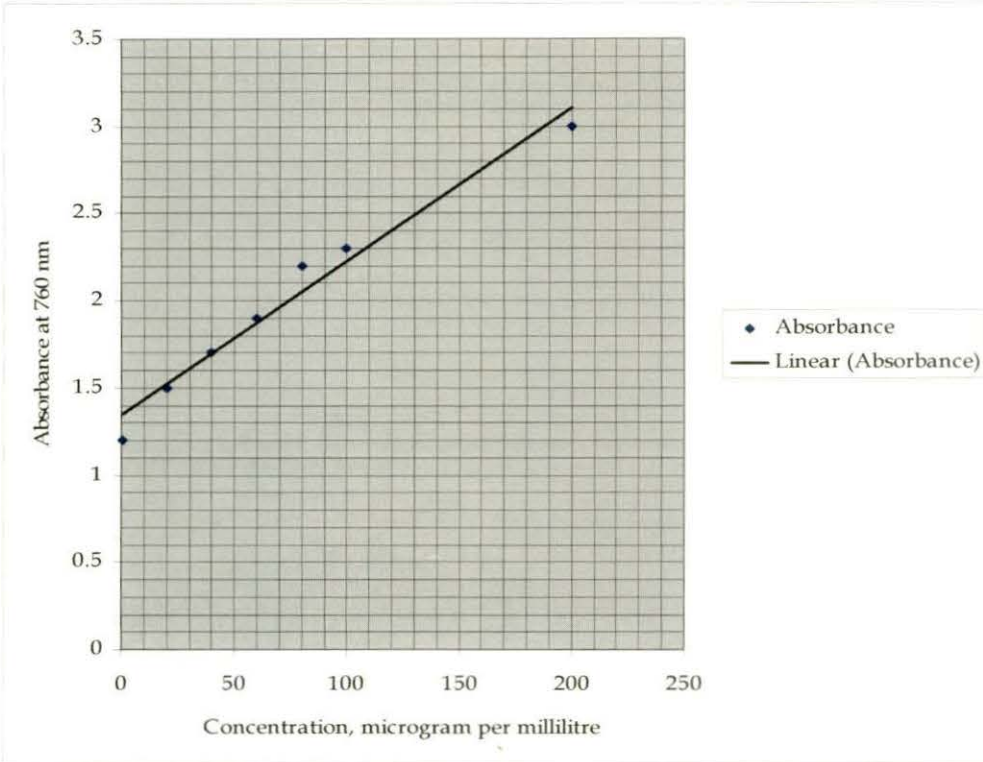

Fig 6a. Graphic representation of Gallic Acid standard calibration curve

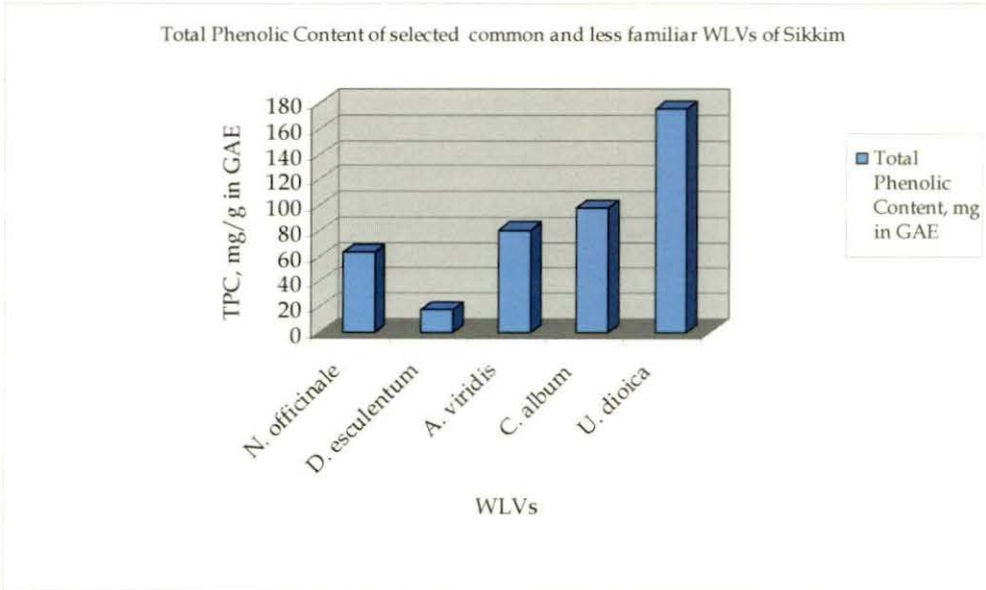

Fig 6b. Graphic representation of Total Phenolic Content of selected common and less familiar WLVs of Sikkim

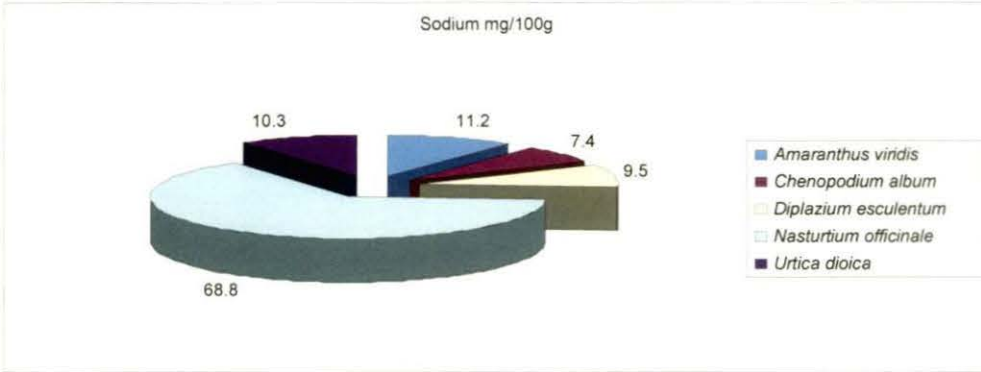

Fig 13a. Graphic representation of elemental sodium content of selected common and less familiar WLVs of Sikkim

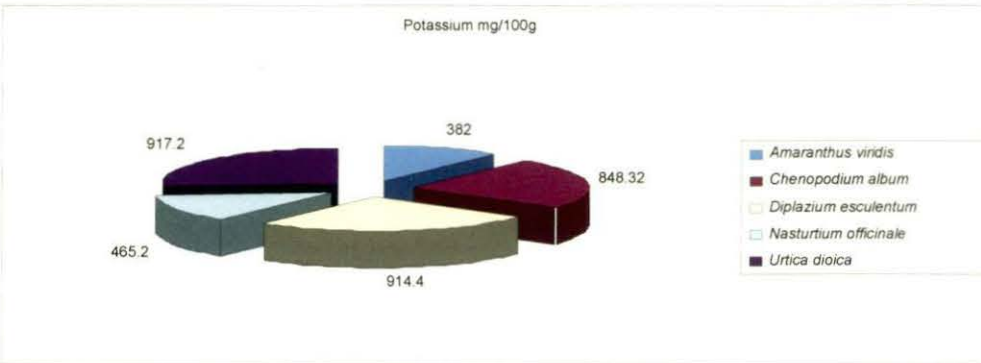

Fig 13b. Graphic representation of elemental potassium content of selected common and less familiar WLVs of Sikkim

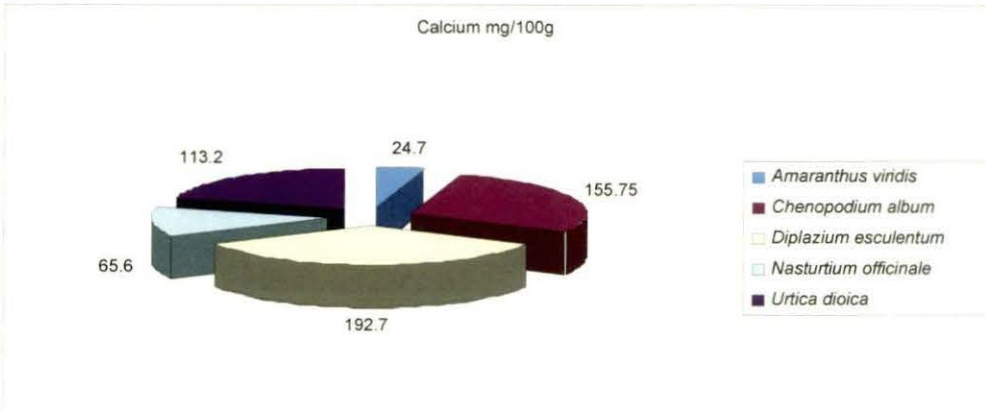

Fig 13c. Graphic representation of elemental calcium content of selected common and less familiar WLVs of Sikkim

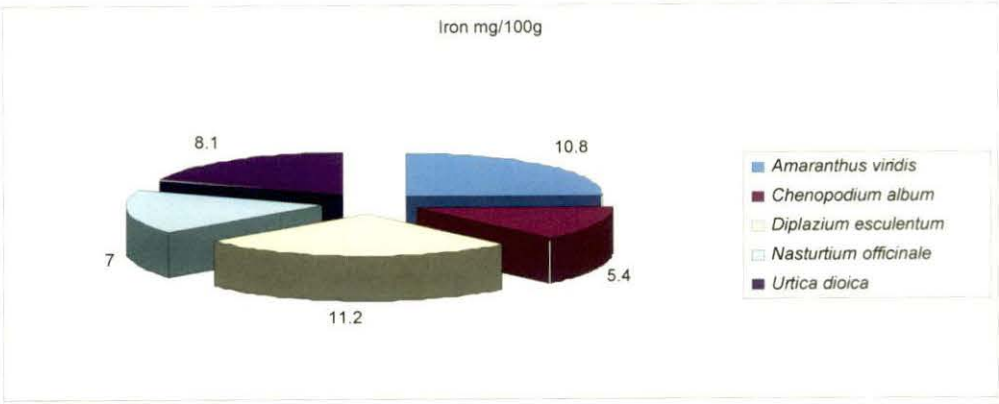

Fig 13d. Graphic representation of elemental iron content of selected common and less familiar WLVs of Sikkim

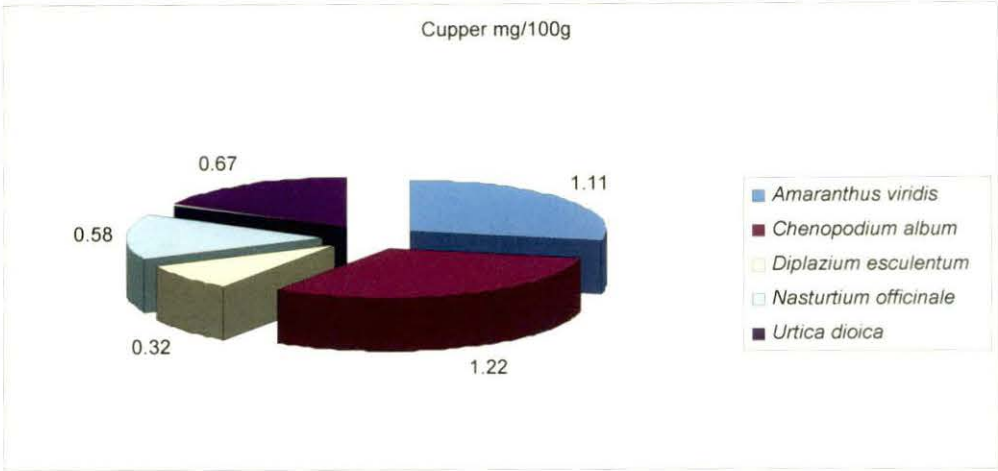

Fig 13e. Graphic representation of elemental copper content of selected common and less familiar WLVs of Sikkim

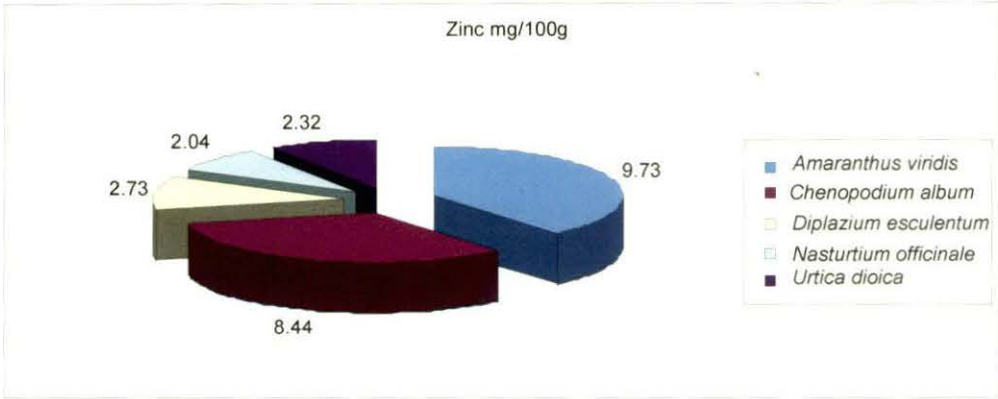

Fig 13f. Graphic representation of elemental zinc content of selected common and less familiar WLVs of Sikkim

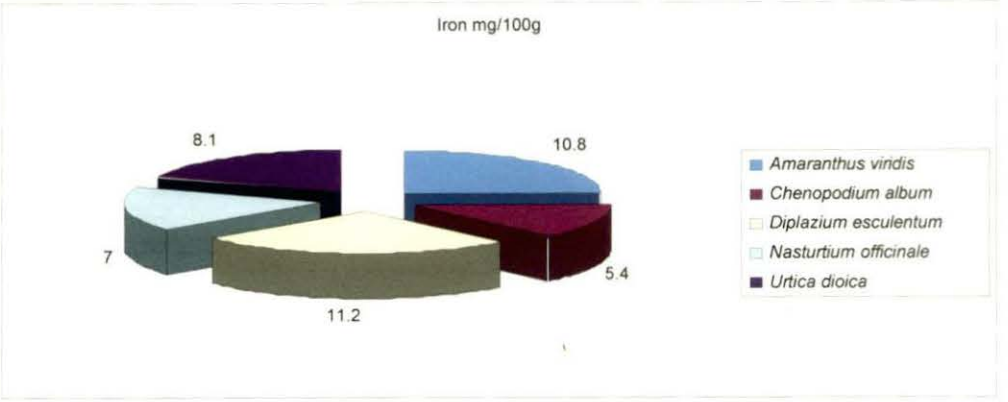

Fig 13d. Graphic representation of elemental iron content of selected common and less familiar WLVs of Sikkim

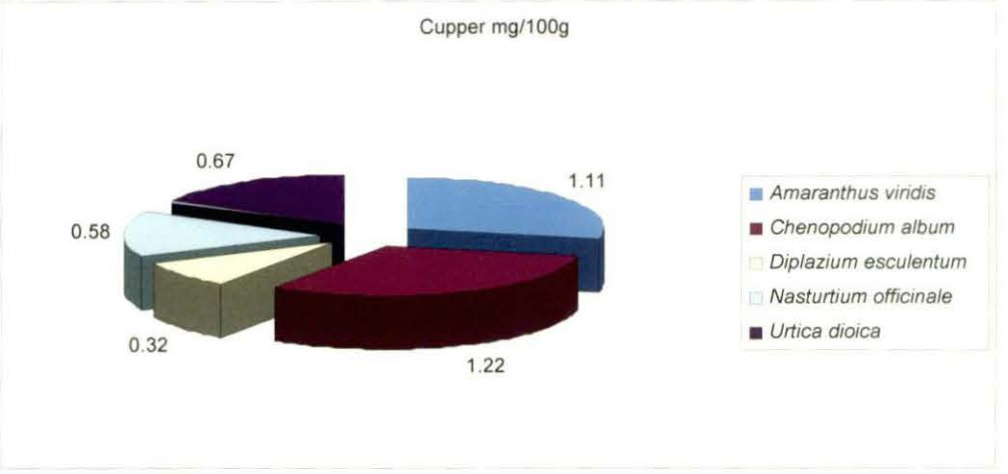

Fig 13e. Graphic representation of elemental copper content of selected common and less familiar WLVs of Sikkim

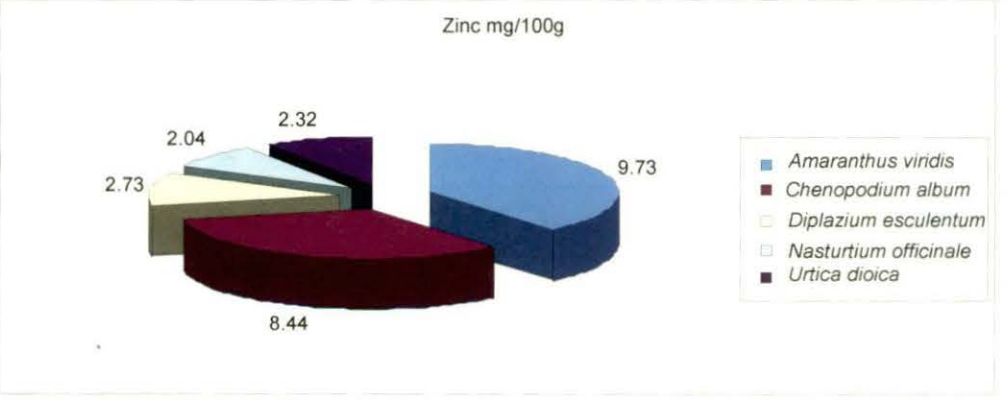

Fig 13f. Graphic representation of elemental zinc content of selected common and less familiar WLVs of Sikkim

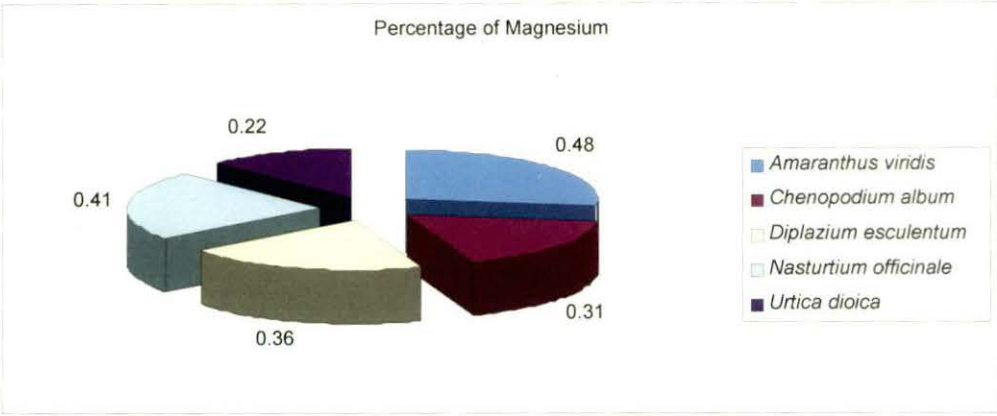

Fig 13g. Graphic representation of elemental magnesium content of selected common and less familiar WLVs of Sikkim.

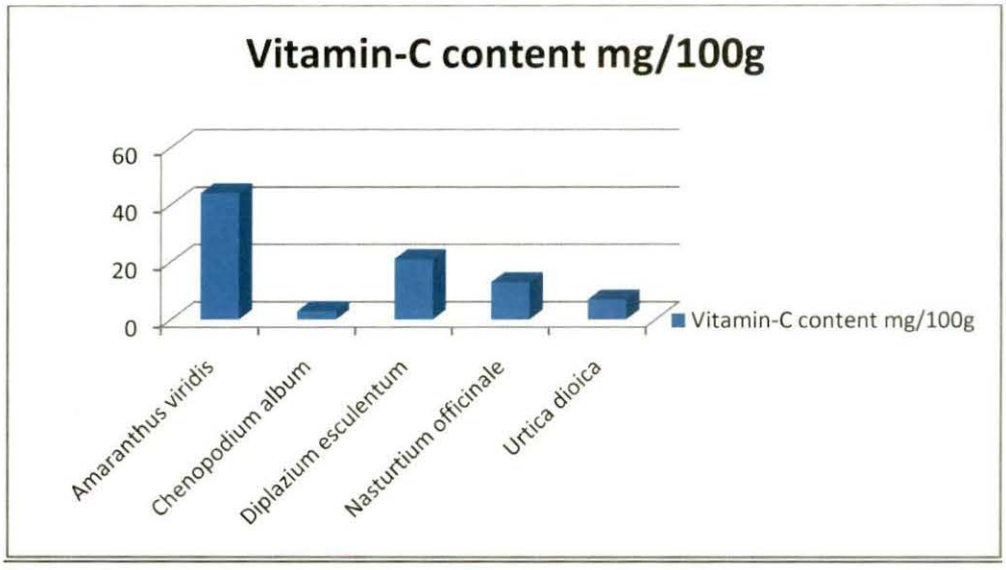

Fig 14a. Graphic representation of Vitamin-C content of selected common and less familiar WLVs of Sikkim

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.

SUMMARY

The major objective of this thesis were twofold: (a) the ecological distribution and socio economy of the common and less familiar wild leafy vegetables consumed by the ethnic people of the Sikkim Himalayas, and (b) the nutritional value of some common and less familiar wild leafy vegetables consumed by the ethnic people of the Sikkim. Out of 26 WLVs documented, 05 species were prioritized for detailed assessment. During the first phase a substantial documentation has been made on the ecological distribution and socio-economy of WLVs consumed by the ethnic people of Sikkim. Traditional knowledge of the ethnic people on the ethnic value, foraging, mode of consumption, culinary, trade and prospects of the selected common and less familiar WLVs were well documented. All these WLVs were recorded to have important bearing in the food habit and food security of ethnic people of the Sub-Himalayan region.

A major emphasis in this thesis has been the analysis of nutritional value of the selected common and less familiar WLVs. The investigations included the analysis of proximate composition, food value, mineral estimation, estimation of vitamin-C content, estimation of antioxidant activity, estimation of total phenolic content and examination on the microbial safety of five selected common and less familiar WLVs.

For the selected WLVs *Amaranthus viridis, Chenopodium album, Diplazium esculentum, Nasturtium officinale* and *Urtica dioica,* a wide range of adaptability with their specific ecological habitat from a cultivated field to a wasteland, home garden to a reserve forest, ditches to a stream and a furrow to the vertical margins of the field were recorded. In terms of altitudinal distribution, these WLVs were found luxuriantly growing from an elevation of 1000 ft to 12000 ft and were found to have distribution efficiency across the low hills to upper hills of the Himalaya. All the selected WLVs were recorded to have their specific ethnic value, socio-economic importance and were detected to be the vegetables generally available during the time of scarcity and emergency. All the selected species appeared to be multi-prospective plants and were found to be consumed by all the ethnic communities in large quantity. The market demand of *Amaranthus viridis* and *Chenopodium album* were found to be moderate while *Diplazium esculentum, Nasturtium officinale* and *Urtica dioica* were of high demand. Continuous rise in the market price, high demand and high supply equation with moderate or high edibility acceptance by the ethnic younger generation were observed to be the indicators of growing popularity and commercial viability of the selected five WLVs in the Himalayan region. Foraging and

trade of such WLVs in the hills were mostly done by the female members of the family.

With an aim towards ascertaining the nutritive value, different parameters were considered for investigation. All the five WLVs studied were found to have high protein content, high crude fiber content and high calorific value with comparatively low fat content. The findings indicated that the WLVs studied, could be identified as good quality greens for nutrient supplement and human health management. With an objective to examine the variability in mineral content the WLVs were subjected to different test parameters. The findings indicated that the WLVs studied could make significant contribution to the recommended dietary allowances for the nutrients.

Similarly with the objective to find out the phytonutrient content, the selected WLVs were investigated for antioxidant activity, total phenolic content and vitamin-c content. All the five WLVs were found to exhibit moderate antioxidant activity with variability in total phenolic content and vitamin-c content. Further, with an aim to ascertain the microbiological safety for human consumption, these wild leafy vegetables in raw state were examined for the occurrence of pathogenic bacteria *such as Listeria* sp., *Salmonella* sp., *Shigella* sp. *Staphylococcus aureus* and *Bacillus cereus*. The

results indicated that they were microbiologically safe for human consumption. Altogether it firmly establishes rich nutritional efficiency of all the five selected WLVs which can be recommended for human dietary supplement, nutritional management and medicinal alternatives.

Having established the benefit exponents of the selected WLVs, their traditional method of foraging from wild habitat however, has been observed to have some serious adverse effects on the environment and its biodiversity. It was well felt that, it is very difficult to answer how could the indiscriminative foraging level of WLVs be reduced, food security and income of local residents is increased and biodiversity conservation is ensured for such wild leafy vegetables.

Thus, with the benchmark of twofold objectives and observation on the adverse effects of foraging, an Ethnic Food, Health and Environment (EFHE) domestication model of WLV species, have been proposed in this thesis.

BIBLIOGRAPHY

Abajo, C., Boffill, M.A., Campo, J.D., Mendez, M.A., Gonzalez, Y., Mitjans, M. and Vinardell, M.P. (2004). *In vitro* study of the antioxidant and immunomodulatory activity of aqueous infusion of *Bidens pilosa*. *Journal of Ethnopharmacology* 93: 319-323.

Aberoumand, A. and Deokule, S.S. (2009). Studies on Nutritional Values of Some Wild Edible Plants from Iran and India. *Pakistan Journal of Nutrition* 8 (1): 26-31.

Abosi, A.O., and Raseroka, B.H. (2003). *In vivo* antimalarial activity of *Vernonia amygdalina*. *British Journal of Biomedical Science 60* (20): 89-91.

Abuye, C., Urga, K., Knapp, H., Selmar, D., Omwega, A.M., Imungi J.K., and Winterhalter, P. (2003). A compositional study of *Moringa stenopetala* leaves. *East African Medical Journal* 80: 247-252.

Acharya, E. and Pokhrel, B. (2006). Ethno-medicinal plants used by Bantar of Bhaudaha. *Morang Nepal Our Nature.* 4: 96-103.

Acharya, R., and Acharya, K.P. (2009). Ethnobotanical Study of Medicinal Plants Used by Tharu Community of Parroha VDC, Rupandehi District, Nepal Scientific *World.* 9: 81-85.

Addis, G. (2006). Depth and breadth of collecting and documenting plant-use data through herbarium specimen labels and Ethiopian Flora volumes: the case of five Angiosperm families. Addis Ababa University.

Addis, G. (2009). Wild and Semi-wild edible plants of Hamar and Xonso (South Ethiopia) with emphasis on their ethnobotany and nutritional composition of selected species. *Ph.D Thesis,* Addis Ababa University.

Addis, G., Urga, K. and Dikasso, D. (2005). Ethnobotanical study of edible wild plants in some selected districts of Ethiopia. *Human Ecology.* 33 (1): 83-118.

Addy, E.O. and Eteshola, E. (1984). Nutritive value of a mixture of tigernut tubers (*Cyperus esculentus* L.) and baobab seeds (*Adansonia digitata* L.). *Journal of the Science of Food and Agriculture* 35: 437-440.

Adebooye, O.C., and Opabode, J.T., (2004). Status of conservation of the indigenous leaf vegetables and fruits of Africa. *African Journal of Biotechnology* 3: 700–705.

Adedapo A., Jimoh F. and Anthony A. (2011). Comparison of the Nutritive Value and Biological Activities of the Acetone, Methanol and Water extracts of the leaves of *Bidens pilosa* and *Chenopodium album. Acta Poloniae Pharmaceutica n Drug Research,* 68 (1): 83-92.

Adefolaju, G.A., Ajao, M.S., Olatunji, L.A., Enaibe, B.U. and Musa M.G. (2009). Hepatoprotective Effect of Aqueous Extract of Water Leaf (*Talinum Triangulare*) on Carbon tetrachloride (CCL4) Induced Liver Damage in Wistar Rats.*The Internet Journal of Pathology* 8: 1.

Adewunmi, A.O. and E.A. Sofowora, (1980). Preliminary Igwe, D., (2004). Phytochemical Analysis of *Tetrapleura* screening of some plant extracts for molluscidalactivity. *Planta Medica* 39: 57-82.

Adewunmi, O. I. (2008). Economics of poultry production in Egba division of Ogun State. *Medwell online Agricultural Journal* 3 (1): 9-12.

Adeyeye, E.I. and Otokiti, M.K.O. (1999). Proximate composition and some nutritionally valuable minerals of two varieties of *Capsicum annum* (Bell and Cherry peppers). *Discovery and Innovation* II: 75-81.

Aduku, A.O and Olukosi, J.O. (1990). Rabbit Management in the Tropics. *Living Books Series,* G.U. Publications, Abuja, FCT. pp. 1 - 2.

Afolayan, A .J. and Meyer, J. J. M. (1997). The antimicrobial activity of 3, 5, 7-trihydroxiflavone isolated from the shoots of *Helichrysumaureonitens. Journal of Ethnopharmacoly* 57: 177-181.

Afolayan, A.J. and Jimoh, F.O. (2008). Nutritional quality of some wild leafy vegetables in South Africa. *International Journal of Food Science and Nutrition 26*: 1-8.

Afolayan, A. and Jimoh, F. (2009). Nutritional quality of some wild leafy vegetables in South Africa. *International Journal of Food Science and Nutrition* 60 (5): 424-431.

Afroz, S. and Alamgir, M. (2006). Antidiarrhoeal activity of the ethanol extract of *Paederia foetida* Linn. (Rubiaceae); *Journal of Ethnopharmacology* (1-2): 125- 130.

Agra, M.F., Baracho G.S., Nurit, K., Basilio, I.J.L.D. and Coelho, V.P.M. (2007). Effect of methanolic extr act of *Amaranthus viridis* (MEAV) on hot plate test in mice. *Brazil Journal of Ethnopharmacolgy* 111 (2): 283-395.

Ahmad, M., Khan, M .A., Manzoor, S., Zafar, M. and Sultana, S. (2006). Check list of medicinal flora of Tehsil Isakhel, District Mianwali Pakistan. *Ethnobotanical Leaflets* 10: 41-48.

Aja, P.M., A.N.C. Okaka., P.N. Onu., U. Ibiam and A.J. Urako, (2010). Phytochemical composition of *Talinum triangulare* (water leaf) leaves. *Pakistan Journal of Nutrition* 9: 527-530.

Ajayi. I.A., Oderinde, R.A., Kalogbola, D.O and Ukponi, J.U. (2006). Oil of Underutilized Legumes from Nigeria. Food Chem. 99 (1): 115-120.

Akachuku, C. O and Fawusi M.A.O. (1995). Growth Characteristics, Yield and Nutritional Value of Waterleaf, Talinum triangulare (Jacq) Wild in a Semi-Wild Environment. *Discovery and Innovation* 7: 163-172.

Akah, P.A. and Okafor, C.I. (1992). Hypoglycemic effect of *Vernonia amygdalina* (Del) in experimental rabbits. *Plant Medicinal Research* 1: 6-10.

AKEPIC, database. (2010). Alaska Exotic Plant Information Clearinghouse Database. Available: http: // *akweeds . uaa . Alaska . edu.*

Akhtar, F. (2001). Uncultivated food in the context of poor people's livelihood: A Nayakrishi experience. Pp. 8-17 in *the Proceedings of the Regional Workshop on Uncultivated Foods and Biodiversity.* Edited by M.M. Johnston. September 24 to 26, Kathmandu, Nepal. USC Canada- Nepal, Kathmandu.

Akpanyung, E. O. (2005). Proximate and mineral composition of bouillon cubes produced in Nigeria. *Pakistan Journal of Nutrition* 4 (5): 327-329.

Akubugwo, I. E., Obasi, N.A., Chinyere, G.C and Ugbogu A. E., (2008). Mineral and phytochemical contents in leaves of *Amaranthus hybridus L* and *Solanum nigrum L.* subjected to different processing methods. *African Journal of Biochemistry Research* 2 (2): 040-044.

Alcorn, J.B. (1981a). Huastec non crop resource management. *Human Ecology 9*: 395-417.

Alcorn, J.B. (1984b). Some factors influencing botanical resource perceprion among the Huastec: suggestion for ethnobotanical inquiry *Journal of Ethnobiology* 1: 221-230.

Ali, A., Ghosh, P.P., Dastidar, S.C., Pakrashi, L. J., Durham, A .M. and Duffield (1972). Sesqiterpene lactones of *Enhydra fluctuans*. Stuctures of enhydrin, fluctuanin and fluctuadin. *Tetrahedron*. 28: 2285-2292.

Ali B., Chaudhry, Z., Jan, G., Danish, M., Rehman, A. ur., Ahmad, R., Khan, A., Shah, K., Ullah, I., Shah, Z., Ali, F., Mushtaq T. and Jan F. G. (2011). Nutritional and elemental analyses of some selected fodder species used in traditional medicine. *African Journal of Pharmacy and Pharmacology* 5 (8): 1157-1161.

Ali. M. and Tsou, C. S. (1997). "Combating micronutrient deficiencies through vegetables- a neglected food frontier in Asia." *Food Policy* 22: 17-39.

Aliero, A.A. and Wara, S.H. (2009). Validating the medicinal potential of *Leptadenia hastata. African Journal of Pharmacy and Pharmacology* 3: 335-338.

Aliero, B.L., Umar, M.A., Suberu, H.A. and Abubakar, A. (2001). *A Hand Book of Common Plant in North western Nigeria.* Usmanu Danfodiyo University, Sokoto, *Nigeria Press* pp. 78.

Alpinar, K., Ozyurek, M., Kolak, U., Guclu, K., Aras, C., Altun, M., Celik, S.E., Berker, K.I., Bektasoglu, B. and Apak, R. (2009). Antioxidant Capacities of Some Food Plants Wildly Grown in Ayvalik of Turkey. *Food Science and Technology Research* 15: 59-64.

Alvarez, L. (1996). "Bioactive polyacetylenes from *Bidens pilosa.*" *Planta Medica* 62 (4): 355-57.

Ambasta, S.P. (1986). The useful plants of India. *Publication and Information Directorate, CSIR,* New Delhi, 698-699.

Anandkumar, B. H. and Sachidanand, Y .N. (2001).Treatment of acne vulgaris with new polyherbal formulation clarina cream, *Indian Journal Dermatology* 46: 1-3.

Andrade-Neto, V.F., Brandao, M.G.L., Oliveira, F.Q., Casali, V.W.D., Njaine, B., Zalis, M.G., Oliveira, L.A. and Krettli, A.U. (2004). Antimalaria activity of *Bidens pilosa* L. (Asteraceae) ethanol extracts from wild plants collected in various localities or plants cultivated in humus soil. *Phytotherapy Reseasrch* 18: 634-639.

Anitha, R. and Kanimozhi, S. (2012). Pharmacognostic Evaluation of *Alternanthera Sessilis* (L.) R.Br.ex.DC, *Pharmacognosy Journal* Vol. 4, Issue 28. DOI: 10.5530/pj.2012.28.6. ISSN: 0975-3575.

Anjorin, T.S., Ikokoh, P. and Okolona, S. (2010). Mineral Composition of *Moringa Oleifera* leaves, Pods, and seed from two regions in Abuja, Nigeria. *International Journal of Agriculture and Boilogy* 12: 43–434.

Anyoola, P.B., Adeyeye, A. and Onawumi O.O. (2010). Trace Element and Major Evaluation of *Spondias mombin, Vernonia Anygdalina* and *Momordica Charantia* Leaves, *Pakistan Journal of Nutrition* 9(8): 755-758.

AOAC (1990). Official Methods of Analysis of the Association of Official Analytical Chemists (15th edition), Washington DC, 992–995.

Apicius, (1958). The Roman Cookery Book.A critical Translation of the Art of Cooking, for use in the study and the Kitchen [B Flower and E Resenbaun, translator], George G.Harrap. London.

Arano, L. C. (1976). The Medival Health handbook: *Tacuinum sanitatis.* New York: George Brazillier.

Aregheore, E.M. (1998). Chemical composition, nutritive value and preference of goats for bitter leaf (*Vernonia amygdalina*) as a browse plant. *Scientia Agriculturae Bohemica* 29: 213-221.

Arhoghro, E.M., Ekpo, K.E., Anosike, E.O. and Ibeh, G.O. (2009). Effect of aqueous extract of bitter leaf (*Vernonia amygdalina* Del) on carbon tetrachloride (CCl4) induced liver damage in albino wistar rats. *European Journal of Scientific Research* 26: 115-123.

Arnold, T.H., Wells M.J. and Wehmeyer A.S. (1985). Khoisan food plants. Taxa with potential for future economic exploitation. Pp. 69-86 *in Plant for Arid Lands* (G.E.Wickens, J.R. Goodin and D.V. Field, eds.). George Allen & Unwin, London.

Arollado, E.C. and Osi M. O. (2010). Hematinic activity of *Alternanthera sessilis* (L.) R. BR. (Amarantheceae) in mice and rats *E-International Scientific Research Journal Volume:* 2 Issue: 2.

Arora, R.K and Pandey, A. (1996). Wild Edible Plants of India: Diversity, Conservation and Use. *National Bureau of Plant Genetic Resources,* New Delhi.

Arruda S.F., Siqueira, E.M., Souza, E.M (2004). Malanga (*Xanthosoma sagittifolium*) and purslane (*Portulaca oleracea*) leaves reduceoxidative stress in vitamin A-deficient rats. *Annals of Nutrition and Metabolism* 48: 288-295.

Artemis P. Simpoulos (2004). Omega-3 Fatty Acids and Antioxidants in Edible Wild Plants. The Center for Genetics, Nutrition and Health, Washington, DC, USA. *Biological Research 37:* 263-277.

Asaolu, S.S. and Asaolu, M. F. (2010). Trace metal distribution in Nigerian leafy vegetables. *Pakistan Journal of Nutrition, 9* (1): 91-92.

Asaolu, S.S., Adefemi, O. S., Oyakilome, I. G., Ajibulu, K. E., and Asaolu, M. F. (2012). Proximate and Mineral Composition of Nigerian Leafy Vegetables. *Journal of Food Research* Vol. 1, No. 3.

Ashok, K.B.S., Lakshman, K., Jayaveea, K.N., Sheshadri, S.D., Saleemulla, K., Thippeswamy, B.S. and Veerapur, V.P. (2010). Antidiabetic, antihyperlipidemic and antioxidant activities of methanolic extract of *Amaranthus viridis* Linn in alloxan induced diabetic rats. *Experimental and Toxicological Pathology* Available online 18 July, 2010.

Athenaeus, (1927). The Deipnosophists [Cb Gulick, translator], G.P. Putnams Sons. Babalola, O.O., J.I. Anetor and F.A. Adeniyi, 2001. Amelioration of carbon tetrachloride-induced hepatotoxicity by terpenoid extract from leaves of *Vernonia amydgalina. African Journal of Medcine and Medical Sciences* 30: 91-93.

Atta, A.H., El-Sooud, K.A. (2004). The antinociceptive effect of some Egyptian medicinal plant extracts. *Journal of Ethnopharmacology* 95: 235–238.

Atta, A.H., Nasr, S.M. and Mouneir, S.M. (2005). Antiulcerogenic effect of some plants extracts. *Natural Product Radiance* 4: 258–263.

Babu, T.D., Kuttan, G. and Padikkala, J. (1995). Cytotoxic and antitumour properties of certain taxa of Umbelliferae with special reference to *Centella asiatica* (L.) Urban. *Journal of Ethnopharmacology* 48: 53–7.

Bajpai, M., Pande, A., Tewari, S.K. and Prakash, D. (2005). Phenolic contents and antioxidant activity of some food and medicinal plants. *International Journal of Food Sciences and Nutrition,* 56 (4): 287-291.

Bakshi, D.N.G., Sensarma, P. and Pal, D.C. (1999). A lexicon of medicinal plants in India, Naya Prakash, Calcutta, pp.424-425.

Bala, A., Kar B., Haldar, P.K., Mazumder, U.K. and Bera S. (2010). Evaluation of anticancer activity of *Cleome gynandra* on Ehrlich`s

ascites carcinoma treated mice. *Journal of Ethnopharmacology 129*: 131-134.

Bala, S.A. (2006). Common ethnomedicinal plants of the semi-arid regions of West Africa, their description and phytochemicals, (Trium publishing company. Kano Nig.), Volume 1.

Bala, V. and Manyam, M.D. (1999). Dementia in ayurveda. *The Journal of Alternative and Complementary Medicine* 5: 81–88.

Balemie, K. and Kebebew, F. (2006). Ethnobotanical study of wild edibleplants in Derashe and Kucha Districts, South Etiopia. *Journal of Ethnobiology and Ethnomedicine* 2: 53.

Balian, S., Ahmad, S. and Zafar, R. (2006). Anti-inflammatory activity of leaf and leaf callus of *Silybum marianum* (L.) Gaertn. in albino rats. *Indian Journal of Pharmacology* 38 (3): 213-14.

Ballard, R. (1986). *Bidens pilosa* Complex (Asteraceae) in North and Central America. *American Journal of Botany* 73: 1452-1465.

Baquer, S.R. (1989). Medicinal and Poisonous Plants of Pakistan. Printas Karachi: Karachi. 278:368, 103.

Baruah, P. and Sharma G.C. (1984). On the medicinal uses of plants by the Boro tribals of Assam India. *Journal of Economic and Taxonomic Bototany* 5 (3): 599-604.

Beck, L.Y. [transl.]. (2005). Pedanius Dioscorides of Anazarbus: *De materia medica.* Olms-Weidmann, Hildesheim.

Becker, B. (1983). The contribution of wild plants to human nutrition in the Ferlo (Northern Senegal). *Agroforestry Systems* 1: 257-267.

Bell, J. (1995). The hidden harvest in seeding. The Quarterly Newsletter of genetic resources. *Action International* 1-8.

Bello, A., Aliero, A.A., Saidu, Y., Muhammad, S. (2011). Phytochemical Screening, Polyphenolic Content and Alpha-Glucosidase Inhibitory Potential of *Leptadenia hastata* (Pers.) Decne. *Nigerian Journal of Basic and Applied Science* 19: 181-186.

Bender, A.E. (1966). Biological value of proteins, a new aspect. British *Journal of Nutrition* 11: 140-140.

Bennett, B.C. (1992). Plants and people of the Amazonian rain forests: The role of ethnobotany in sustainable development. *Bioscience* 42 (8): 599-607.

Bennet, S.S.R. (1987). Name Changes in Flowering Plants. *Triseas Publications,* Dehradun, India, pp.772.

Benz, B., Cevallos, J., Santana, F., Rosales, J. and Graf, S. (2000). Loosing knowledge about plant use in the Sierra de Manantlan Biosphere Reserve, Mexico." *Economic Botany* 54: 183-191.

Berry, B.J.L. (1967). Geography of Market Centers and Retail Distribution, Englewood Cliffs, N.J. : Prentice-Hall.

Bhat, R.B. and Rubuluza, T. (2001). The biodiversity of traditional vegetables of the Transkei region in the Eastern Cape of South Africa. *South African Journal of Botany* 68: 94-99.

Blatter, E. and Caius, J.F. (1981). Indian Medicinal Plants. II: 1297-1299.

Blois, M.S. (1958). Antioxidant determinations by the use of stable free radical. *Nature* 181: 1199 -1200.

Blumenthal, M. (1998). The complete German Commission E monographs: therapeutic guide to herbal medicines. Austin: *American Botanical Council.*

Bokhary, H.A. and Parvez, S. (1993). Chemical composition of desert truffles Terfezia claveryi. *Journal of Food Composition and Analysis* 6: 285-293.

Bokhary, H.A., Suleiman, A.A., Basalah, M.O. and Parvez, S. (1987). Chemical composition of desert truffles from Saudi Arabia. *Canadian Institute of Food Technology Journal* 20: 336–341.

Bonet, M.A. and Vallès, J. (2002). Use of non-crop food vascular plants in Montseny biosphere reserve (Catalonia, Iberian Peninsula). *International Journal of Food Sciences andNutrition* 53: 225–248.

Bonsi, M.L.K., Osuji, P.O., Tuah, A.K. and Umunna, N.N. (1995). *Vernonia amygdalina* as a supplement to teff straw (*Eragrostis tef*) fed to ethiopian menz sheep. *Agrofoestry Systems* 31: 229-241.

Borah, A., Yadav, R.N.S. and Unni, B.G. (2011). In Vitro Antioxidant and Free Radical Scavenging Activity of *Alternanthera Sessilis. International Journal of Pharmaceutical Sciences and Research* 2: 1502-6.

Bosch, C.H., Borus, D.J. and Siemonsma J.S. (2005). Vegetables of Tropical Africa. Conclusions and Recommendations Based on *PROTA 2: 'Vegetables'*. PROTA Foundation, Wageningen, Netherlands. 10 modules, 68pp.

Boulos, L. and El-Hadidi, M. N. (1984). The weed flora of Egypt. The American Univerity in Cairo Press. ISBN No. 977-424-038-3.

Bown, D., (1995): Encyclopaedia of Herbs and their Uses. Dorling Kindersley, London. ISBN 0-7513-020-31.

Bradn, W. W., Cuvlier, M. E. and Barset, C. (1995). New parameter for evaluation of free radical scavenging capacity of polyphenols lebensm-wiss Technol, 28: 25-30.

Broin, M. (2006). The nutrient value of *Moringa oleifera* Lam. leaves: What can we learn from figure? 2006 Moringa news work shop. http://www.moringanews.org/doc/GB? Posters? Broin_poster. pdf. accessed 18/05/2010.

Burkill, H.M. (1985). Useful Plants of West Tropical Africa. 2nd Edn., Vol. 1, Families A-D, Royal Botanic Gardens, Kew, England, Pages: 960.

Burlingam, B. (2000). " Wild Nutrition." *Journal of Food Composition and Analysis* 13: 99-100.

Bussman, R.W. and Sharon, D. (2006). Traditional medicinal plant use in Northern Peru: tracking two thousand years of healing culture. *Journal of Ethnobotany and Ethnomedicine* 2: 47.

Bussmann, R.W., Gilbreath, G.G., Solio, J., Lutura, M., Lutuluo, R., Kunguru, K., Wood, N. and Mathenge, S.G. (2006). Plant use of the Maasai of Sekenani Valley, Maasai Mara, Kenya. *Journal of Ethnobotany and Ethnomedicine* 2: 22.

Bye, R.A. (1979). Incipient domestication of mustards in north-west Mexico. *Kiva,* 44: 237-256.

Byg, A., and Balslav, H. (2001). "Traditional knowledge of Dypsis fibrosa (Araceae) in Eastern Madagascar. " *Economic Botany* 55: 263-275.

Byrne, R. and McAndrews, J. H. (1975). "Pre-Columbian puslane (*Portulaca oleracea* L.) in the New World". *Nature* 253 (5494): 726-727.

Campos, A.M. and Lissi, E.A. (1995). Evaluation of the antioxidant capacity of herbal teas by a procedure based on the bleaching of ABTS radical cations. *Boletin de la Sociedad Chilena de Quimica* 40: 375-381.

Cavender, A. (2006). Folk medicinal uses of plant foods in southern Appalchia, United States. *Journal of Ethnopharmacology* 108: 74-84.

Census of India, (2011). Provisional Population Totals- India, Our Census , Our Future, Ministry of Home Affairs, New Delhi.

Chadare, F.J., Linnemann, A.R., Hounhouigan, J.D., Nout, M.J.R. and Van Boekel M.A.J.S. (2009). Baobab Food Products: A Review on their Composition and Nutritional Value. Critic. Rev. *Food Science and Nutrition* 49: 254-274

Chandrika, U.G., Svanberg, U. and Jansz, E.R. (2006). *In vitro* accessibility of ß-carotene from cooked Sri Lankan green leafy vegetables and their estimated contribution to vitamin A requirement. *Journal of the Science of Food and Agriculture* 86: 54-61.

Chang, J.S., Chiang, L.C., Chen, C.C., Lui, L.T., Wang, K.C., and Lin. C.C. (2001). Antileukemic activity of *Bidens pilosa* L. var. minor (Blume) Sherff and *Houttuynia cordata* Thunb. *The American Journal of Chinese Medicine* 29: 303 - 312.

Chang, S.L., Chiang, Y.M., Chang, C.L., Yeh, H.H., Shyur, L.F., Kuo, Y.H., Wu, T.K. and Yang, W.C. (2007). Flavonoids, centaurein and centaureidin, from *Bidens pilosa*, stimulate IFN-gamma expression. *Journal of Ethnopharmacology* 112 (2): 232-6.

Chanishvili, S., Badridze, G. and Janukashvili, N. (2007). "Effect of altitude on the contents of antioxidants in leaves of some herbaceous plants", *Russian Journal of Ecology* 38: 367-373.

Chan, K., Islam, M.W., Kamil, M., Radhakrishnan, R., Zakaria, M.N., Habibullah. M. and Attas, A. (2000). The analgesic and anti-inflammatory effects of *Portulaca oleracea* L. subsp. Sativa (Haw.) Celak. *Journal of Ethnopharmacology* 73: 445-451.

Chapman and Hall, (1997). World Vegetables, Second Edition, Appendix, C.

Charaka, (1981). Charaka Samhita. Agnivesa's Treatise Refined and Annonated by Charaka and Redected by Dridhabala, vol.1 Sitrasthana to Indryasthana. [P Sharma editor], Chaukambha Orientalis, Delhi.

Chen, J.C.C., Chiu, M.H., Nie, R.L., Cordell, G.A. and Qiu, S.X. (2005). Cucurbitacins and cucurbitane glycosides: structures and biological activities. *Natural Product Report* 22: 386–399.

Chen, Y.J., Huang, L.W. and Shih, T.S. (2003). Diognosis of oxide films by cavitation micro-jet impact. *Materials transactions*, 44, 327 -335.

Chiang, L.C., Chiang, W., Chang, M.Y. and Lin, C.C. (2003) In vitro cytotoxic, antiviral and immunomodulatory effects of *Plantago major* and *Plantago asiatica. American Journal of Chinese medicine* 31: 225–234.

Chiang, L.C., Chiang, W., Chang, M.Y., Ng, L.T. and Lin C.C. (2002. Antiviral activity of *Plantago major* extracts and related compounds in vitro. *Antiviral Research* 55: 53–62.

Chiang, Y.M., Chuang, D.Y., Wang, S.Y., Kuo, Y.H., Tsai, P.W. and Shyur, L.F. (2004). Metabolite profiling and chemopreventive bioactivity of plant extracts from *Bidens pilosa. Journal of Ethnopharmacology* 95: 409-419.

Chih, H.W., Lin, C.C. and Tang, K.S. (1996). The hepatoprotective effects of Taiwan folk medicine Ham-hong-chho in rats. *American Journal of Chinese Medicine* 24: 231–240.

Chin, H.W., Lin, C.C. and Tang, K.S. (1996). The hepatoprotective effects of Taiwan folk medicine *ham-hong-chho* in rats, *American Journal of Chinese Medecine* 24: 231–240.

Chopra, R.N., Chopra, S.L. and Chopra, I.C. (2000). *In*: Glossary of Indian Medicinal Plants. New Delhi, NISC (CSIR), 107.

Chopra, R.N., Nayar, S.L. and Chopra, I.C. 1986. Glossary of Indian Medicinal Plants (Including the Supplement). 3rd Edn., *Council of Scientific and Industrial Research,* New Delhi, India.

Chowdhury, A. and Das, A. P. (2011). Comparative analysis of Herbaceous plants in some Natural andPlantation forests of Terai and Duars in Paschimbanga. *Recent Studies in Biodiversity and Traditional Knowledge* 161-171.

Chu, Y.F., Sun, J., Wu, X. and Liu, R.H. (2002). Antioxidant and antiproliferative activities of common vegetables. *Journal of Agriculture and Food Chemistry* 50: 6910-6916.

Chweya, J. A. and Mnzava, N.A (1997). Cats's Wishkers - *Cloeme gynandra* L., Promoting the conservation and use of underutilized and neglected crop – 11, Institute of Plant Genetics and Crop Plant Research, Gatersleben/ International Plant genetic resources Institute,Rome, Italy.

Chweya, J.A. and Eyjagui, P.B. (eds), (1999). The Biodiversity of Traditional leafy vegetables. International Plant Genetic resources Institute, Rome, Italy.

Chweya, J. A. (1985). Identification and nutritional importance of indigenous green leafy vegetables in Kenya. *Acta Hortculturae* 153: 99-108.

Chweya, J.A. (1990). Nutrient evaluation and production of *Gynandropsis gynandra* (L.) Briq: An indigenous leaf vegetable in Kenya. Final Scientific Project Report submitted to the National Council for Research Science and Technology, Government of Kenya.

Chweya, J.A. (1995). Genetic enhancement of indigenous vegetables in Kenya. Paper presented at the workshop 'Genetic Resources of Traditional Vegetables in Africa: Options for Conservation and Use', Nairobi, Kenya, 29-31 August 1995.

Chweya, J.A. (1992). The potential of Kenyan leafy vegetables. Paper presented at the International conference on development of new crops. Jerusalem March 8-12, 1992.

Chweya, J. A. and Eyzaguirre, P. (1999). The biodiversity of traditional leafy vegetables. IPGRI Rome (Italy), 182 p.

Costa, J.F., Kiperstok, A.C., David, J.P., David, J.M., Giulietti, A.M., de Queiroz, L.P., dos Santos, R.R. and Soares, M.B. (2007). Anti-leishmanial andimmunomodulatory activities of extracts from *Portulaca hirsutissima* and *Portulaca werdermannii*. *Fitoterapia*, 78: 510-514

Coulibaly, B. (1993). *Politique Forestière Cynégétique Halieutique du Burkina Faso*. Projet TCP/BKF/2357, appui à la préparation de la réunion sectorielle sur l'environnement. *Food and Agriculture Organization of the United Nations*, Rome.

Dansi, A., Adjatin A., Adoukonou-Sagbadja, H., Faladé, V., Yedomonhan, H., Odou, D. and Dossou, B. (2008a). Traditional leafy vegetables and their use in the Benin Republic. Genetic Resources and Crop Evolution, *Springer-Verlag* (onlinefirst).

Daodu, M.O. and Babayemi, O.J. (2009). Utilization of some edge-row plants as forage in Nigeria. *Pakistan Journal of Nutrition* 8: 1269-1274.

Darby, W.J., Ghalioungui, P. and Grivetti, L.E. (1977). Food: The Gift of Osiris. *Academic Press*, London.

Darmon, N., and Khlat, M. (2001). An overview of the health status of migrants in France, in relation to their dietary practices. *Public Health Nutrition* 4: 163-172.

Das, T. K. (2001). Overview weed dynamics in crop field. *Pesticide Information* 27 (3) : 35-46.

Davidson, S., Passmore, R., Brock, J.F. and Truswell, A.S. (1975). Human Nutrition and Dietetics. 6th Edn., Churchill Livingstone, Edinburgh, ISBN: 0443012466, Pages: 756.

Deba, F., Xuan, T,D., Yasuda, M. and Tawata, S. (2008). Chemical composition and antioxidant, antibacterial and antifungal activities of the essential oils from *Bidens pilosa* Linn. Var. *Radiata. Food Control* 19: 346-352.

De Caluwé., E. Halamová, K. and Van Damme, P. (2010). *Adansonia digitata* L. -A review of traditional uses, phytochemistry and pharmacology *Afrika focus* 23: 11-51.

De La Puerta, R. (1996). Effect of silymarin on different acute inflammation models and in leukocyte migration *Journal of Pharmcy and Pharmacology* 48: 968-970.

Demeulenaere, E. (2001). *Moringa stenopetala,* a subsistence resource in the Konso district. Proceedings of the International Workshop Development Potential for Moringa Products, October 29-November 2, 2001, Dar-Es-Salaam, Tanzania, pp: 2-29.

de Padua, L.S., Bunyapraphatsara, N. and Lemmens, R.H.M.J. editors (1999). *Centella asiatica.* In: *Plant Resources of South East Asia No.12 (1) Medicinal and Poisonous Plants 1,* 192 p. Bogor: Prosea Foundation Publication.

De Silva, H.A., Saparamadu, P.A., Thabrew, M.I., Pathmeswaran, A., Fonseka, M.M. and de Silva H.J., (2003). Liv-52 in alcoholic liver disease: a prospective, controlled trial *Journal of Ethnopharmacology* 84: 47-50.

De Silva, W. (2010). *Moringa oleifera*: A magical vegetable tree. Health and Fitness, October 26, 2010. http://ezinearticles.com/?Moringa-Oleifera,-A-Magical-Vegetable-Tree and id=5247485.

Dewanji, A., Matai, S., Si, S.L., Barik, S. and Nag, A. (1993). Chemical composition of two semi aquatic planta for food use. *Plants Foods for Human Nutrition* 44: 11-15.

Dhellot, J.R., Matouba1, E., Maloumbi, M. G., Nzikou, J.M., Dzondo, M.G., Linder, M., Parmentier, M. and Desobry, S. (2006). Extraction and nutritional properties of *Solanu nigrum* L seed oil. *African Journal of Biotechnology* 5 (10): 987-991.

Dhyani, P.P. and Khali, M.P. (1993). Fruit yield and economic of Jelly and Jam production from fruits of some promising *Ficus* (Figs) tree crops. *Ecology of Food and Nutrition* 30: 169-178.

Dhyani, D., Maikhuri, R.K., Rao, K.S., Kumar, L., Purohit, V.K., Sundriyal, M. and Saxena, K.G. (2007). Basic nutritional attributes of Hippophae rhamnoides (sea buckthorn) populations from Uttarakhand Himalaya, India. *Current Science* 92:1148-1152.

Diamond, J. (2002). Evolution, consequences and future of plant and animal domestication *Nature* 418:700-707.

Dimo, T., Azay, J., Paul, V., Tan, P.V., Pellecuer, J., Cros, G., Bopelet, M. and Serrano J.J. (2001). Effects of the aqueous and methylene chloride extracts of *Bidens pilosa* leaf on fructose- hypertensive rat *Journal of Ethnopharmacology* 76: 215-221.

Dimo, T., Rakotonirina, S., Kamgang, R., Tan, P.V., Kamanyi, A. and Bopelet, M. (1998). Effects of leaf aqueous extract of *Bidens pilosa* (Asteraceae) on KCl- and norepinephrine-induced contractions of rat aorta *Journal of Ethnopharmacology* 60: 179–182.

Dimo, T., Rakotonirina, S.V., Tan, P.V., Azay, J., Dongo, E. and Cros, G. (2002). Leaf methanol extract of *Bidens pilosa* prevents and attenuates the hypertension induced by high-fructose diet in Wistar rats. *Journal of Ethnopharmacology* 83: 183–191.

Diop, A.G., Sakh, M., Dornier, M., Cissé, M. and Reynes, M. (2005). Le baobab africain (*Adansonia digitata* L.): principales caractéristiques et utilisations. Fruits, 61: 55-69.

Dioxon, B. M. and Harris, E. M. (2004). Nigeria food consumption and nutrition survey, 2001-2003.

Di Tomaso, J. and Healy, E. (2007). Weeds of California and Other Western States. Vol. 1. *University of California Agriculture and Natural Resources Communication Services*, Oakland, CA. 834 p.

Dixon, R.A. and Paiva, N.L. (1995). "Stress-induced phenylpropanoid metabolism," *Plant Cell* 7:1085–1097.

Dragsted, L.O., Strube, M. and Leth, T. (1997). Dietary levels of plant phenolsand other non-nutritive components: could they prevent cancer? *European Journal of Cancer Prevention* 6: 522-528.

D'Souza, J. and Kulkarni, A.R. (1993). Comparative studies on nutritive values of tender foliage of seedlings and mature plants of

Moringa oleifera Lam. *Journal of Economic and Taxonomy Botany* 17: 479-485.

Duke, J.A. and Ayensu, E.S. (1985). Medicinal Plants of China Reference Publications, Inc., 20-24.

Edmonds, J.M. and Chweya, J.A. (1997). Promoting the conservation and use of under-utilized and neglected crops: Black nightshades (*Solanum nigrum* L.) and related species. *International Plant Genetic Resources Institute*, Rome, Italy, pp: 1-90.

Edwards, P. (1980). Food Potential of Aquatic Macrophytes. 1st Edn., International Centre for Living Aquatic Resources Management, Metro Manila, Philippines.

Edwards, S., Tadesse, M., Demissew, S. and Hedberg, I. (2000). Flora of Ethiopia and Eritrea, Volume 2, Part 1: Magnoliaceae to Flacourtiaceae. Addis Ababa University, Ethiopia, Uppsal, Sweden, pp: 660.

Egedigwe, C.A. (2010). Effect of dietary incorporation of *Vernonia amygdalina* and *Vernonia colorata* on blood lipid profile and relative organ weights in albino rats. *MSc. Dissertation, Departmen of. Biochemistry*. MOUAU, Nigeria.

Ejoh, A. R., Tanya, A.N., Djuikwo, N.A. and Mbofung C.M. (2005). Effect of processing and preservation methods on vitamin C and total carotenoid levels of some *Vernonia* (bitter leaf) species. *African Journal of Food Agriculture Nutrition and Development* 5: 105-117.

Ejoh, A. R., Djuikwo, V.N. and Tanya, A.N. (2003). Effect of food preparation techniques on the nutritional profile of four species of *Vernonia*. Food, Nutrition and Health Proceedings Papers. http://foodAfrica.nri.org/nutrition/ nutritionpapers.html.

Ejoh, A. R., Nkonga, D.V., Inocent, G. and Moses M.C. (2007). Nutritional components of some non-conventional leafy vegetables consumed in Cameroon. *Pakistan Journal of Nutrion* 6: 712-717.

Ekpenyong, T.E. (1986). Nutrient Composition of Tropical Foodstuffs available to rabbit feeding. *Journal of Applied Rabbit Research* 9: 14-20.

El- Bakry, A.A., Mostafa, H.A.M. and Eman, A. A. (2012). Antioxidant Activity of *Rumex Vesicarius* L. at the vegetative stage of growth. *Asian Journal of pharmaceutical and Clinical Research* Vol 5, Issue 4. 2012.

Eleyinmi, A.F., Sporns, P. and Bressler, D.C. (2008). Nutritional composition of *Gongronema latifolium* and *Vernonia amygdalina*. *Nutrition and Food Science* 38: 99-109.

Elizabeth, K. (1994). Immense Help from Nature's Workshop. 1st Ed. Elikaf Health Services Ltd., pp: 207-209.

El-Zalabani, S.M., Mahmoud, II., Ahmed, F.I. and Shehab, N.G. (1999) Protein carbohydrate, mineral and vitamin contents of *Sonchus oleraceus* L. growing in Egypt. *Journal of Pharmaceutical Sciences* 23: 46–54.

Emmy, De C., Halamová, K. and Damme, P. V. *Adansonia digitata* L.–A review of traditional uses, phytochemistry and pharmacology, *AFRIKA FOCUS*. 23 :11-51.

Ermias, L. M. U., Zemede, A., Ensermu, K. and Damme ,P. V. G. (2011) Wild edible plants in Ethiopia: a review on their potential to combat food insecurity. *AFRIKA FOCUS*. 24 (2): 71-121

Etkin, N.L. and Rose P.J. (1994). Pharmacological implications of "wild" plants in Hausa diet. In eating on the wild side: Pharmacologic, ecologic, social implkications of using noncultigens. *Nina L Etkin, ed.* Tuscon, University of Arizona Press.

Ezeagu, I. E. (2005). Baobab (*Adansonia digitata* L.). Seed Protein Utilization in Young albino Rats I: Biochemical ingredients and performance Characteristics. *Animal Research International* 2 (1): 240 -245.

Ezekwe, M.O., Besong, S.A. and Igbokwe, P.E. (2001). Beneficial influence of purslane and waterleaf supplement to Human, *Federation of American Societies for Experimental Biology Journal* 16: A639.

Ezekwe, M.O., Omara, A., Thomas R. and Membrahtu, T. (1999). Nutritive characterization of purslane accessions as influenced by planting date. *Plant Foods for Human Nutrition* (Dordrecht), 54(3): 183-191.

Faber, M., Phungula, M.A.S., Venter, S.L., Dhansay, M.A. and Benadé, A.J.S. (2002 b). Home gardens focusing on the production of yellow and dark-green leafy vegetables increase the serum retinol concentrations of 2-5 years old children in South Africa. *American journal of clinical nutrition* 76: 1048–54.

Faber, M., Van Jaarsveld, P.J. and Laubscher, R. (2007). The contribution of dark-green leafy vegetables to total micronutrient intake of

two- to five-year-old children in a rural setting. *Water SA* 33 (3): (special issue):407–12.

Fahey, J.W. (2005). *Moringa oleifera*: A review of the medical evidence for its nutritional, therapeutic and prophylactic properties. Part 1. *Trees Life Journal* Vol. 1.

Fallah, H.S.M., Alavian, H.R., Heydari, M.R. and Abolmaali, K. (2005). The efficacy of Liv-52 on liver cirrhotic patients: a randomized, double blind, placebo-controlled first approach. *Phytomedicine* 12(9): 619-624.

FAO (2006 a). Corporate Document Repository. Calculation of the Energy Content of Foods-Energy Conversion Factors. [http: /www .fao . org/ag].

FAO (2006 b). Corporate Document Repository. Proximate Composition of Foods. [http:/www.fao.org/ag].

FAO (1997). Corporate Document Repository. Use and potential of wild plants in farm households

FAO (2006). FAO statistical data base for food crops.

FAO (1968). Food composition Table for Use in Africa. Energy factor. pp: 226.

FAO (1995). Non-wood forest products in nutrition. In: Snedecor, W. and W. Cochran, 1980. Statistical Non-Wood Forest Products for Sustainable Forestry, Yogyakarta, Indonesia, 17-27 January, 1995. *Non-Wood Forest Products*, vol. 3. FAO, Food and Nutrition Division, Rome.

FAO (1992). Nutrition and development: A global assessment. Proceedings of the International Conference on Nutrition, December, 1-2, 1992, Rome, Italy.

FAO/WHO (2002). Report of a Joint FAO/WHO Expert Consultation Bankok, Thailand Expert consultation on human vitamin and mineral requirements. pp. 223-229.

FAO (1990). Roots, Tubers, Plantains and Bananas in Human Nutrition. Food and Agriculture Organization of the United Nations, Rome.

FAO (1993). The Sixth WorldFood Survey, FAO, United Nations, Rome.

FAO (2010). The state of food insecurity in the world: addressing food insecurity in protracted crises. FAO, Rome.

FAO. (1988c). Traditional food plants - a resource book for promoting the exploitation and consumption of food plants in arid, semi-arid and sub-humid lands of eastern Africa. FAO Food and Nutrition Paper No. 42. Rome.

FAO (1988). Tropical Food Plants. *Food and Nutrition* Paper 42. Food and Agriculture Organization, Rome.

Farooque, M. (2002). Management Plan of Ayubia National Park 2002-2007. Natural resource conservation project, Galiat, Abbotabad. 11-12.

Ferreira, P.M.P., Farias, D.F., de Oliveira, J.T.A. and de Carvalho, A.F.U. (2008). *Moringa oleifera*: Bioactive compounds and nutritional potential. *Review of Nutrition* 21: 431-437.

Flora, K., Hahn, M., Rosen, H. and Benner, K. (1998). Milk thistle (*Silybum marianum)* for the therapy of liver disease. *American Journal of Gastroenterology* 93:139-43.

Florence, O. J., Adeolu, A. A. and Anthony J. A. (2011). Comparison of the Nutritive Value, Antioxidant and Antibacterial Activities of *Sonchus asper* and *Sonchus oleraceus, Records of Natural Products* 5 (1): 29-42

Font Quer, P. (1990). Plantas medicinales. El Diosco´rides Renovado. 12th Edition. Labor, Barcelona.

Fox, F.W and Norwood, Y.M.E. (1982). Food from the veld: Edible Wild Plants of Southern Africa. Delta Books, Johannesburg, South Africa. 399 pp.

Fugile, L.J. (2005). The Moringa Tree: A local solution to malnutrition? Church World Service in Senegal.

Galitskii, L.A., Barnaulov, O.D., Zaretskii, B.V., Malkov, M.I., Konenkov, S.I., Gol'm, N.P., Tomakov, V.S., Ogarkov, P.I. and Batskov, S.S. (1997). Effect of phytotherapy on the prevention and elimination of hepatotoxic responses in patients with pulmonary tuberculosis, carriers of hepatitis B virus markers, Probl. Tuberk. 4: 35–38.

Ganguly, S.N., Ganguly, T. and Sircar, S.M. (1972). Gibberelins of *Enhydra fluctuans. Phytochemistry* 11: 3433-3434.

García-Herrera, P., Sánchez-Mata, M.C., Cámara, M., Tardío, J and Olmedilla-Alonso, B. (2012). Carotenoid content of wild edible young shoots traditionally consumed in Spain (*Asparagus*

acutifolius L., *Humulus lupulus* L., *Bryonia dioica* Jacq. and *Tamus communis* L.). *Journal of the Science of Food and Agriculture.* doi: 10.1002/jsfa.5952. [Epub ahead of print]

Gari, J.A. (2002). Agrobiodiversity, Food Security and HIV/ AIDS Mitigation in Sub-Saharan Africa. Strategic issues for agricultural policy and programme responses. www. fao.org /sd/ 2002/ PE0104a _ en. htm Accessed 23 April 2007.

Gazak, R., Svobodova, A. and Psotova, A. (2004). Oxidized derivatives of silybin and their antiradical and antioxidant activity. *Bioorganic and Medical Chemistry.* 12: 5677.

Gebauer, J., El-Siddig, K. and Ebert, G. (2002). Baobab (*Adansonia digitata* L.): A review on a multipurpose tree with promising future in the Sudan. Gartenbauwissenschaft, 67: 155-160.

Geissberger, P. and Sequin, U. (1991). Constituents of *Bidens pilosa* L.: do the components found so far explain the use of this plant in traditional medicine? *Acta Tropica* 48 (4): 251 - 261.

George, P.M. (2003). Encyclopedia of foods. Humane Press, Washington D.C, 1: 526.

Ghani, A. (1998). Monographs : *Elaeocarpus serratus* Linn. *In*: Medicinal plants of Bangladesh: Chemical constituents and Uses. *Asiatic. Society Bangladesh Publication* 253-254.

Ghorbani, A., Langenberger, G. and Sauerborn, J. (2012). A comparison of the wild food plant use knowledge of ethnic minorities in Naban River Watershed National Nature Reserve, Yunnan, SW China. *Journal of Ethnobiology and Ethnomedicine* 8: 17.

Ghosh, T., Maity, T. K., Swain, P.K. and Bose, A. (2007). Anthelmintic and antimicrobial activity of *Enhydra fluctuans* Lour. Aerial parts. *Pharmacognosy Magagine* 11: 204-208.

Giday, M., Asfaw, Z. and Woldu, Z. (2009). Medicinal plants of the Meinit ethnic group of Ethiopia: An ethnobotanical study. *Journal of Ethnopharmacology* 124 (3): 513-521.

Gill, L.S. (1992). Ethnomedical Uses of Plants in Nigeria. Uniben Press, Benin City, Nigeria. p. 243.

Giner, R.M., Ubeda, A., Just, M.J., Serrano, A., Manez, S. and Rios, J.L (1993). A chemotaxonomic survey of *Sonchus* subgenus *Sonchus. Biochemical Systematics and Ecology* 21: 617.

Glew, R.H., VanderJagt, D.J., Lockett, C., Grivetti, L.E., Smith, G.C., Pastuszyn, A. and Millson, M. (1997). Amino acid, fatty acid and mineral composition of 24 indigenous plants of Burkina Faso. *Journal of Food Composition and Analysis* 10: 205-217.

Gomez, M.I. (1981). Carotene content of some green leafy vegetables of Kenya and effects of dehydration and storage on carotene retention. *Journal of Plant Foods* 3: 231-244.

Gong, F., Li, F., Zhang, L., Li, J., Zhang, Z. and Wang, G. (2009). Hypoglycemiceffects of crude polysaccharide from purslane. *International Journal of Molecular Sciences* 10: 880-888.

Gopalan, C., Rama, B. V. and Sastri, B.V.R. (1971). Nutritive value of Inidan food (Reprinted Edition1885) National Iinstitute of Nutrition. Indian Council of Medical Research Hydrabad.

Gopalan, C., Sastri, B.V.R. and Balasubramanian, S.C. (2004). Nutritive Value of Indian Foods. National Institute of Nutrition, Indian Council of Medical Research, Hyderabad, India, pp: 2-58.

Gopalan, C., Sastri, B. V. R., Balasubramaniam, S. C., Narasinga Rao, B. S., Deosthale, Y. G. and Pant, K. C. (1996). Nutritive value of Indian foods. Hyderabad, India: National Institute of Nutrition, Indian Council for Medical Research.

Grivetti, L.E. and Ogle, B.M. (2000). Value of traditional foods in meeting macro-and micronutrients needs: The wild plant connection. *Nutrition Research Reviews* 13: 31-46.

Grieve, M. (1998). A Modern Herbal – the medicinal, culinary, cosmetic and economic properties, cultivation and folklore of herbs, grasses, fungi, shrubs and trees with all their modern scientific uses. *Tiger Books International*, London. ISBN No.1-85501-249-9.

Grubben, G.J.H. (2004). *Amaranthus cruentus* L. In: Grubben GJH and Denton OA (eds.) *PROTA 2: Vegetables/Légumes* [CD-Rom]. PROTA, Wageningen, The Netherlands. 71-72

Grubben, G.J.H. and Denton, O.A. (2004). Plant Resources of Tropical Africa 2 vegetables, p: 668. PROTA Foundation, Wageningen, Netherlands Backhuys Publishers, Leiden, Netherlands/CTA, Wageningen Netherlands

Grubben, G.J.H., Siemonsma, J. S. and Kasem, P. (1994). Introduction in Plant resources of South east Asia 8: Vegetables, Siemonsma, J.S. and P. Kasem (Eds.) PROSAE, Bogor, Indoasia.

Guarino, L. (1997). Traditional African vegetables. Promoting the conservation and use of underutilized and neglected crops 16. Proceedings of the IPGRI International Workshop on Genetic Resources of Traditional Vegetables in Africa: conservation and Use, 29-31 August 1995. ICRAF-HQ, Nairobi, Kenya. Institute of Plant Genetics and Crop Plant Research, Gatersleben /International Plant Genetic Resources Institute, Rome, Italy. 171.

Guil-Guerrero, J.L., Gimenez-Gimenez, A., Rodrguez-Garc, I. and Torija-Isasa M.E. (1998). Nutritional composition of *Sonchus* species (*S. asper* L., *S. oleraceus* L., and *S. tenerrimus* L.). *Journal of the Science of Food and Agriculture* 76: 628- 632.

Guil-Guerrero, J L., Rodríguez-García, I., Torija E., (1997). Nutritional and toxic factors in selected wild edible plants. *Plant Foods for Human Nutrition* 51 (2): 99-107.

Gupta, A.K. (2004). Indian medicinal plants, ICMR, New Delhi, 151-157.

Gupta, M., Mazumdar, U.K. and Gomathi P. (2007). In vitro antioxidant and free radical scavenging activities of *Galenga purpurea* root, PHCOG MAG 3: -225.

Gupta, M. P. (1996). "Screening of Panamanian medicinal plants for brine shrimp toxicity, crown gall tumor inhibition, cytotoxicity and DNA intercalation." *International Journal of Pharmacognosy* 34(1): 19–27.

Gupta, S.A., Jyothi, M.N., Lakshmi, M.N. and Prakash, J. (2005). Analysis of nutrient and anti-nutrient content of underutilized green leafy vegetables. *Journal of Food Science and Technology* 38(4): 339-345.

Gurung, B. (2002). The Medicinal Plants of Sikkim Himalaya. Maples Chakung. West Sikkim pp.772

Hadad Chi, G.R. and Moradi, Z. (2005). The amounts and distribution of diosgenin and saponin and their carbohydrate moiety of *Tamus communis* L. *Journal of Agricultural Science and Technology* 12: 55-66.

Halimutal, S.A.S. (2003). Sayur–Sayuran Semenanjung, Malaysia 1st Edn. Dewan Bhahsa dan Pustaka, Kaula Lumpur.

Hamowia, A.M. and Saffaf, A.M. (1994). Pharmacological studies on *Vernonia amygdalina* (Del) and *Tithonia diversifolia* (Gray). *Journal of Veterinary Medicine,* Giza 2: 91-97.

Handique, A. K. (1993). Free amino acid content in non-conventional leafy vegetables. *Crop Research* 6: 189-193.

Hao, H., Nancai, Y., Lei, F., Wen, S., Guofu, H., Yanxia, W., Hanju, H. and Qian, L. (2009). Retracted: Antiaging effect of purslane herb aqueous extractsand its mechanism of Action. *Phytotherapy Research* 23: i-vii

Hara, H. (1966). The flora of Eastern Himalaya.University of Tokyo, Japan pp.744.

Harris, M.A. and Mohammed, S. (2003). Relying on nature: wild foods in Northern Nigeria. *Ambio.* 32(1): 24–29.

Hart, T.G.B. and Vorster, H.J. (2006). Indigenous Knowledge on the South African Landscape–Potentials for Agricultural Development. Urban, Rural and Economic Development Programme. Occasional paper No 1. HSRC Press, Cape Town, South Africa. 52 pp.

Haskell, M.J., Pandey, P., Graham, J.M., Peerson, J.M., Shrestha, R.K., and Brown, K.H. (2005). Recovery from impaired dark adaptation in nightblind pregnant Nepali women who receive small daily doses of vitamin A as amaranth leaves, carrots, goat liver, vitamin A-fortified rice, or retinyl palmitate. *American Journal of Clinical Nutrition* 81: 461–71.

Hassan, L.G. and Umar, K.J. (2006). Nutritional value of Momordica balsamina L. leaves. *Pakistan Journal of Nutrition* 5(6): 522-529.

Hassan, L.G. and Umar, K.J. (2008). Nutritional value of *Solanum americanum* L. leaves. *Electronic Journal of Food and Plants Chemistry* 3(1): 14-17.

Hassan, M. El-Mallah., Safinaz, M. El-Shami and Minar, M. Hassanein. (2003). Detailed studies on some lipids of *Silybum marianum* (L.) *seed oil Grasas y Aceites* (54)4: 397-402

Haywood, V.H. (1979). Flowering Plants of the World. *Oxford University Press,* ISBN0-19-217674-9.

Heinrich, M., Leonti, M., Nebel, S. and Peschel, W. (2005). 'Local food-nutraceuticals': an example of a multidisciplinary research project on local knowledge. *Journal of Physiology and Pharmacology* 56: 5–22.

Helal, A.M., Nakamura, N., El-Askary, H. and Hattori, M. (2000). Sesquiterpene lactone glucosides from *Sonchus asper*. *Journal of Phytochemistry* 53(4): 473-7.

Heyne, K. (1987). Tumbuhan Berguna Indonesia. Sarana Wana Jaya, Jakarta, Indonesia.International Conference on Development of new crops. Jerusalem March 8-12, 1992. *Phytochemistry*, 53: 473-477.

Hill, M.G. (1987). Encyclopedia of Food Agricultural Nutrition. 5th Edn., Mc-Graw Hill Book Company, New York, pp: 117-120.

Hoddinott, J. and Yohannes, Y. (2002). Dietary diversity as a household food security indicator. Washington, DC: Food and Nutrition Technical Assistance Project, Academy for Educational Development.

Holetz, F.B., Pessini, G.I., Sanches, N.R., Cortez, D.A., Nakamura, C.V. and Filho, B.P. (2002). Screening of some plants used in the Brazilian folk medicine for the treatment of infectious diseases. *Memorias do Instituto Oswaldo Cruz*. 97: 1027–1031.

Holm, L., Pancho, J.V., Herberger, J.P. and Plucknett, D.L. (1979). A geographical atlas of world weeds. New York:John Wiley & Sons. 391 p.

Hsu, Y.J., Tsung-Han Lee, T.H., Chang, C.L., Huang, Y.T. and Yang, W.C. (2009). Anti-hyperglycemic effects and mechanism of *Bidens pilosa* water extract. *Journal of Ethnopharmacology* 122: 379-383.

Humphrey, C.M., Clegg, M.S., Keen, C.L and Grivetti, L.E. (1993). Food diversity and drought survival; The Hausa example. *International Journal of Food Science and Nutrition* 44: 1–16.

Hussain, K., Shahazad, A. and Zia-ul-Hussnain, U. (2008). An ethnobotanical survey of important wild medicinal plants of Hattar, District Haripur Pakistan. *Ethnobotanical Leaflets* 12: 29-35.

Hutchinson, I., Colosi, J. and Lewin, R. (1984). The Biology of Canadian Weeds. 63. *Sonchus asper* (L.) Hill and *S. oleraceus* L. *Canadian Journal of Plant Science*. 64(3): 731-744.

Hwang, B.Y., Kim, H.S., Lee, J.H., Hong, Y.S., Ro, J.S. and Lee K.S. (2001). Antioxidant benzoylated flavan 3–ol glycoside from *Celastrus orbiculatus*. *Journal of Natural Product* 64: 82 -84.

Hynniewta, S.R. and Kumar, Y. (2008). Herbal remedies among the Khasi traditional healers and village folks in Meghalaya. *Indian Journal of Traditional Knowledge* 7: 581-586.

Idowu, T.O., Iwalewa, E.O., Aderogba, M.A., Akinpelu B.A. and Ogundaini A.O., (2006). Antinociceptive, Anti-inflammatory and antioxidant activities of eleagnine: An alkaloid isolated from *Chrysophyllum albidum* seed cotyledons. *Journal of Biological Sciences* 6: 1029-1034.

Ifon, E. T. and Bassir, O. (1980). The nutritive value of some Nigerian leafy green vegetables Part 2. The distribution of protein, carbohydrates (including ethanolsoluble simple sugars), crude fat, fibre and ash. *Food Chemistry* 5: 231-235.

Igboeli, L.C., Addy, E.O.H. and Salami, L.I. (1997). Effects of some processing techniques on the antinutrient contents of baobab seeds (*Adansonia digitata*). *Bioresource Technology* 59: 29-31.

Igile, G.O., Oleszyek, W., Burda, S. and Jurzysta, N. (1995). Nutritional assessment of *Vernonia amygdalina* leaves in growing mice. *Journal of Agriculture and Food Chemistry* 43: 2126-2166.

Igile, A.O., Oleszek, W., Jurzysta, M., Burda, S., Fafunso, M. and Fasamade, A.A. (1994). Flavonoids from *Vernoina amygdalina* and their antioxidant activity. *Journal of Agriculture and Food Chemistry* 42: 2445-2448.

Iheanacho, K. and Udebuani, A.C. (2009). Nutritional composition of some leafy vegetables consumed in Imo state, Nigeria. *Journal of Applied Sciences and Environmental Management* 13(3): 35-38

Ihekoronye, A. I. and Ngoddy, P. O. (1985). Tropical Fruits and Vegetables. In Integrated Food Science and Technology for theTropics. *Macmillian Publishers*, London. 293-304.

Ijeh, I.I. and Adedokun, A.T. (2006). Effects of administration of ethanolic extract of *Vernonia amygdalina* Del. on kidney function of experimental rabbit model. *Research Journal of Biotechnology* 1: 34-35.

Ijeh, I.I. and Akomas, S.C. (2005). Effect of oral administration of ethanolic extract of *Vernonia amygdalina* on the exocrine functions in weanling rabbits. *Proceedings of 30th Confererence of Nigerian Society for Animal Production* 30: 109-112.

Ijeh, I.I., Nwugo, V.O. and Obidoa, O. (1996). Comparative studies on the nutritive, phytochemical and antimicrobial properties of two

varieties of *Vernonia amygdalina. Plant Product Research Communication* 1: 71-75.

IKEDA, T. (2000). Anti-herpes virus activity of *Solanum* steroidal glycosides, *Biological and pharmaceutical bulletin* vol. 23, (Tokyo, JAPON: Pharmaceutical Society of Japan,

Iltis, H.H. (1960). Studies in the Capparidaceae. VII. Old World Cleomes adventive in the New World. *Brittonia* 12: 279-294.

Iltis, H.H. (1967). Studies in the Capparidaceae. XI. *Cleome afrospina,* A tropical African endemic with neotropical affinities. *American Journal of Botany* 54: 953-962.

Indian Materia Medica (2002). (Nandkoni KM ed). Bombay Popular Prakashan, Mumbai. 892.

Indrayan, A.K., Sharma S., Durgapal D., Kumar, N. and Kumar, M. (2005). Determination of nutritive value and analysis of mineral elements for some medicinally valued plants from Uttaranchal. *Current Science* 89: 1252-1255.

Indu B. J. and Ng, T.L. (2000). *Centella asiatica.* In: Herbs–The green pharmacy of Malaysia, p. 21–25. Kuala Lumpur: Vimpress Sdn. Bhd. Publications.

Irawan, D., Wiyaya, C.H., Limin, S.H., Hashidoko, Y., Osaki,M.and Kulu,I.P. (2006). Ethnobotanical study and nutrient potency of local traditional vegetables in Central Kalimantan TROPICS 15: 4.

Isaev, M.I. (2000). *Bryonia* isoprenes. II. Cucurbitacin L and bryoamaride from *Bryonia melanocarpa. Chemistry of Natural Compounds* 36: 292–294.

Isong, E. and Idiong, U. (1997). Nutrient content of the edible leaves of seven wild plants from Nigeria. *Plant Foods for Human Nutrition* 51: 79-84.

Izevbigie, E.B., Bryant, J.L. and Walker, A. (2004). A novel natural inhibitor of extracellular signal related kinases and human breast cancer cell growth. *Experimental Biology and Medicine (Maywood).* 229: 163-169.

Izevbigie, E.B. (2003). Discovery of water-soluble anticancer agents (edotides) from a Vegetable found in Benin City, Nigeria. *Experimental Biology and Medicine* 228: 293-298

Jadhav, D. (2006). Commercial Non-Timber Forest Products collected by the Bhil tribe in Shivgarh town of Ratlam District, Madhya Pradesh. Journal of Non - Timber Forest Products, 13 (4): 295 - 296.

Jager, A, K., Hutchings, A. and van Staden, J. (1996). Screening of Zulu medicinal plants for prostaglandin-synthesis inhibitors. *Journal of Ethnopharmacology* 52: 95-100.

Jain, A.K. and Tiwari, P. (2012). Nutritional value of some traditional edible plants used by tribal communities during emergency with reference to Central India. *Indian Journal of Traditional knowledge* 11(1): 51-57.

Jainu, M., Chennam, S. and Shyamala, D. (2006). "Anti - ulcerogenic and Ulcer Healing Effects of *Solanum Nigrum* (L.) on Experimental Ulcer Models: Possible Mechanism for the Inhibition of Acid Formation." *Journal of Ethnopharmacology* 104: 156–163.

James, W.P., Duthie, G.G. and Wahle, K.W. (1989). The Mediterranean diet: protective or simply non-toxic? *European Journal of Clinical Nutrition 43:* S31- S41.

Jan, G., Khan, M.A. and Gul, F. (2009). Ethnomedicinal Plants Used against Jaundice in Dir Kohistan Valleys (NWFP) Pakistan. *Ethnobotanica Leaflets,* 13: 1029-1041.

Janaki, Ammal, E.K. (1955) *An Introduction to Subsistence Economy of India, Man's Role in Changing the Face of the Earth,* edited by William Jr LT (Wenner -Green Foundation, University of Chicago Press, Chicago, 1955-56, 324–325.

Jana, M.M. (1997). Markets and behavioural pattern of buyers and sellers in Sikkim. *Journal of Hill Research* 10(2): 151-157.

Jansen van Rensburg, W.S., Venter, S.L., Netschluvhi, T.R., van den Heever, E., Vorster, H.J. and de Ronde, J.A. (2004). Role of indigenous leafy vegetables in combating hunger and malnutrition. *South African Journal of Botany* 70:52-59.

Jansen Van Rennsburg, W.S., Van Averbeke, W., Slabbert, R., Faber, M., Van Jaarsvelf, P., Van Heerden, I., Wenhold, F. and Oelofse, A. (2007). African leafy vegetables in South Africa. *Water* South Africa 33: 3

Jayarajan, P., Reddy, V and Mohanram, M. (1980). Effect of dietary fat on absorption of β-carotene from green leafy vegetables in children. *Indian Journal of Medical Research* 71: 53-66.

Jefferey, E.H., Brown, A.F., Kwilich, A.C. and Keu, A.S. (2002). Variation in content of bioactive components in broccoli. *Journal of Food Composition and Analysis* 16: 323–330.

Jiru, D., Sonder, K., Alemayehu, L., Mekonen, Y. and Anjulo, A. (2006). Leaf yield and Nutritive value of *Moringa stenopetala* and *Moringa oleifera* accessions: Its potential role in food security in constrained dry farming agro forestry system. Proceedings of Moringa and other Highly Nutritious Plant Resources: *Strategies, Standards and Markets for a Better Impact on Nutrition in Africa,* Nov. 16-18, Accra, Ghana, pp: 1-14.

Jisaka, M., Ohigashi, H., Takagaki, T., Nozaki, H. and Tada, T. (1992). Bitter steroid glucosides, vernoniosides A1, A2, A3 and related B1 from a possible medicinal plant: *Vernonia amygdalina* used by wild chimpanzees. *Tetrahedron,* 48: 625-632.

JI, Y., Wang, H. and Gao S (2005). (Postdoctoral Program, Institute of Materia Medica,Harbin University of Commerce, Harbin 150076, China); Study on effect of solanine on activities of ATPase in tumor cell membrance; *Journal of Harbin University of Commerce*(Sciences Edition); 2005 -02 , 625-632.

Johns, T. and Kokwaro ,J. O. (1991). Food Plants of the Luo of Siaya District, Kenya. *Economic Botany,* 45 (1): 103–113.

Johns, T. (2003). Plant biodiversity and malnutrition: simple solutions to complex problems. *African Journal of Food, Agriculture, Nutrition and Development 3:* 45-52.

Jong, T.T and Jean, M.Y. (1993). Alkaloids from *Houttuynia cordata. Journal of the Chinese Chemical Society* 40: 301–303.

Jonsson, S. (1983). Blomsterbroken. Markens Urter, Lyng og Traer. Teknologisk Forlag. Oslo.

Joshi, B.S and Kamat, V.N (1972). Structure of enhydrin, a germacronolide from *Enhydra fluctuans. Indian Journal of Chemistry* 10: 771-776.

Joshi, N., Kehlenbeck, K., and Maas, B.L. (2007). Traditional, neglected vegetables of Nepal: Their sustainable utilization for meeting human needs. Conference on International Agricultural Research for Development, University of Kassel- Witzenhausen and University of Gottingen, Tropentag 2007.

Justesen, U. and Knuthsen, P. (2001). Composition of flavonoids in fresh herbs and calculation of flavonoid intake by use of herbs in traditional Danish dishes. *Food Chemistry* 73(2): 245-250.

Kabuye, C.S. and Ngugi, G.W. (2001). Nutritional and medicinal importance of indigenous food plants. In *The Potential of Indigenous Wild Foods.* Workshop Proceedings.

Kalab, M. and Krechler, T. (1997). The effect of the heptoprotective agent Liv- 52 on liver damage, *Cas. Lek. Cesk.* 136: 758–760.

Kala, C.P. (2007). Prioritization of cultivated and wild edibles by local people in the Uttaranchal hills of Indian Himalaya. *Indian Journal of Traditional Knowledge* 6: 239-243.

Kalogo, Y., F. Rosillon., F. Hammes and W. Verstraete. (2000). Effect of a water extract of *Moringa oleifera* seeds on the hydrolytic microbial species diversity of a UASB reactor treating domestic wastewater. *Letters in Applied Microbiology* 31: 259-264.

Kareru, P.G., Kenji, G.M., Gachanja, A.N., Keriko, J.M. and Mungai, G. (2007). Traditional medicine among the Embu and Mbeere peoples of Kenya. *African Journal of Traditional Complementary and Alternative Medicine* 4: 75-86.

Karim, S.M.R., Amzi, B.M. and Ismail, B.S. (2004). Weed problems and their management in rice fields of Malaysia: An overview.Weed Biology and Management 4: 177–186.

Katiyar, S.K. (2005). Silymarin and skin cancer prevention: anti-inflammatory, antioxidant and immunomodulatory effects. *International Journal of Oncology* 26: 169-176.

Kaur, N., Dhuna, V., Kamboj, S.S., Agrewala J.N. and Singh, J. (2006). A novel antiproliferative and antifungal lectin from *Amaranthus viridis* Linn seeds. *Protein and Peptide Letters* 13: 897-905.

Kawashty, S.A., Gamal-El-Din, E., Abdalla, M.F. and Saleh, N.A.M. (1994). Flavonoids of *Plantago* species in Egypt. *Biochemical Systematic and Ecology* 22: 729– 733.

Kennedy, G., Nantel, G., and Shetty, P. (2003). The scourge of "hidden hunger": global dimensions of micronutrient deficiencies. *Food, Nutrition and Agriculture* 32: 8-16.

Kerharo, J. and Adam, J. G. (1974). La pharmacopée Sénégalaise Traditionnelle: plantes médicinales et toxiques. *Editions Vigot freres,* 1011p.

Khan, M., Musharaf, S., Ibrar, M. and Hussain, F. (2011).Pharmacognostic evaluation of the *Amaranthus viridis* L. *Research In Pharmaceutical Biotechnology* 3(1): 11-16.

Khan, M.H. and Yadava, P.S. (2010). Antidiabetic plants used in Thoubal district of Manipur, Northeast India. *Indian journal of Traditional Knowledge* 9(3): 510-514.

Khan, M.R., Kihara, M. and Omoloso, A.D. (2001). Anti-microbial activity of *Bidens pilosa, Bischofia javanica, Elmerillia papuana* and *Sigesbekia orientalis. Fitoterapia* 72: 662-665.

Khan, R.A., Khan, M.R., Sahreen, S. and Ahmed, M. (2012). Evaluation of phenolic contents and antioxidant activity of various solvent extracts of *Sonchus asper* (L.) Hill. Chemistry Central Journal 6: 12.

Khan, R.A., Khan, M.R., Sahreen, S. and Bokhari, J. (2010). Antimicrobial and phytotoxic screening of various fractions of *Sonchus asper African Journal of Biotechnology* 9 (25): 3883-3887.

Khan, R.A., Khan, M.R., Sahreen, S. and Bokhari, J. (2010). Prevention of CCl4-induced nephrotoxicity with *Sonchus asper* in rat. *Food Chem Toxicol,* 23:1304-1321.

Khanzadi, F. K. (2011). Nutrient composition, phenolic content and free radical scavenging activity of some uncommon vegetables of Pakistan. *Pakistan Journal of Pharm Sciences* 24(3): 277-283

Khare, C.P, (2007). CCRAS. Indian medicinal plants, pp : 459. Germany: Springer Link.

Khoshoo, T.N. (1992). Plant diversity in the Himalayas:Conservation and Utilization. G.B. Pant Memorial Lecture II G.B. Pant Institute of Himalayan Environment and Develop ment, Kosi, Almora-263443, India.

Kim, S.K., Ryu, S.Y., No, J., Choi, S.U. and Kim, Y.S. (2001). Cytotoxic alkaloid fro *Houttuynina cordata. Archives of pharmaceutical research* 24: 518 - 521.

Koche, D.K., Shirsat, R.P., Imran, S., Nafees, M., Zingare, A.K. and Donode, K.A. (2008). Ethnomedicinal Survey of Nageria Wild Life Sanctuary, District Gondia (M.S.). India- Part II. *Ethnobotanical Leaflets* 12: 532-537.

Kokwaro, J.O. (1976). Medicinal Plants of East Africa. East African Literature Bureau, Nairobi, Kampala, Dar-es-Salaam.

Koleva, I.I., van Beek, T.A., Linssen, J.P.H., de Groot A. and Evstatieva, L.N. (2002). Screening of plant extracts for antioxidant activity:

A comparative study on three testing methods. *Phytochemical Analysis* 13: 8-17.

Kosinova A (1975). Weed communities of winter crops in Egypt. Preslia, 47: 58-74.

Krauze-Baranowska, M. and Cisowski, W. (1995). Flavone Cglycosides from *Bryonia alba* and *B. dioica*. *Phytochemistry* 39: 727–729.

Krishnaswamy, N.R and Prasanna, S. (1975). Cholesterol from *Enhydra fluctuans*. *Phytochemistry* 14: 1663-1668

Krishnaswami, N.R., Seshadri, T.R. and Sharma, B. (1968). Chemical components of *Enhydra fluctuans*. *R. Current Science* 37: 94-98.

Krishnaswamy, N.R and Ramji, N. (1995). Sesqiterpene lactones of *Enhydra fluctuans*. *Phytochemistry* 38: 433 - 435.

Kirtikar, K. and Basu, B.D. (1987). "Indian Medicinal Plants" 2nd ed. vol.1 International Book Dis-tributors, Rajpur Road, Dehradun India p.153.

Kritikar, K.R. and Basu, B.D. (2001). (eds.) Indian medicinal plants. Dehradun, India: Oriental Enterprices.

Kuhnlein, H.V. and Receveur, O. (1996). Dietary change and traditional food systems of Indigenous Peoples. *Annual Reviews in Nutrition, 16*: 417-442.

Kuhn, U. (1988). Capparaceae. Pp. 109-120 in Dicot Weed (T.J. Hafliger and M. Wolf, eds.). CIBA Geigy LTD, Basle, Switzerland.

Kumar, S. and Kumar, D. (2009). Antioxidant and free radical scavenging activities of edible weeds, *American Journal of Food Agriculture And Development* 9: 5.

Kumar, S., Biswas, S., Banerjee, S., Mandal, D., Roy, H.N., Chakraborty, S., Kabir, S.N., Banerje and, S., Mondal, N.B. (2007). *Chenopodium album* seed extract: a potent sperm-immobilizing agent both *in vitro* and *in vivo*. *Contraception*. 75(1): 71-78.

Kunwar, R.M., Nepal, B.K., Kshhetri, H.B., Rai, S.K., and Bussmann, R.W. (2006). Ethnomedicine in Himalaya: a case study from Dolpa, Humla, Jumla and Mustang districts of Nepal. *Journal of Ethnobotany Ethnomedicine* 2: 27.

Kviecinski, M.R., Felipe, K.B., Schoenfelder, T., Wiese, L.P.L., Rossi, M.H., Goncalez. E., Felicio, J.D., Filho, D.W. and Pedrosa, R.C. (2008). Study of the antitumor potential of *Bidens pilosa*

(Asteraceae) used in Brazilian folk medicine. *Journal of Ethnopharmacology* 117: 69-75.

Ladio, A.H., and Lozada, M. (2003). " Comparision of Wild Edible Plant Diversity and Foraging Strategies in Two Aboriginal Communities of Northwestern Patagonia." *Diversity and Conservation.* 12: 937-951.

Lanska, D. (1992). The Illustrated Guide to Edible Plants. Chancellor Press.. ISBN No. 1-85152-117-8.

Lavender, S. and Franklin, A. (1996). Herb Craft - A guide to the shamanic and ritual use of herbs. Capall Bann Publishing, Chievely, Berks. ISBN No. 1-898307-57-9.

Leakey, R. R. B., and Newton, A.C. [eds.] (1994). Domestication of Tropical trees for Timber and Non Timber Product, MAB Digest 17. Paris: UNESCO.

Leakey, R.R.B. and Newton, A.C. (Eds). (1994) Tropical trees: the potential for domestication and the rebuilding of forest resources. Proceedings of a Conference organized by the Edinburgh Centre for Tropical Forests, held at Heriot-Watt University, Edinburgh, on 23-28 August 1992. HMSO, London.

Lee, T.C. and Chichester, C.O. (1974). The influence of harvest time on nutritional value. In: Nutritional qualities of fresh fruits and vegetables, (Philip, L.W. and Nancy, S.R.D., eds.), p. 111. New York: Futura Publishing Company

Leonti, M., Nebel, S., Rivera,D. and Heinrich, M. (2006). Wild gathered food plants in the European Mediterranean: A comparative analysis.*Economic Botany* 60(2): 130-142.

Leung, A.Y. and Foster, S. (1996). Encyclopedia of Common Natural Ingredients used in food, drugs and cosmetics. 2nd. edition. John Wiley ISBN No. 0-471-50826-8.

Lewin, R. (1948). The Biological Flora of the British Isles *Sonchus* L. *Journal of Ecology.* 36(1). 203-223.

Leyel, C.F. (1987). Herbal Delights. Faber and Faber. ISBN 0-571-14850-6.

Liang, D., Zhou, Q., Gong, W., Wang, Y., Nie, Z., He, H., Li, J., Wu, J., Wu, C., and Zhang, J. (2011). Studies on the antioxidant and hepatoprotective activities of polysaccharides from Talinum triangulare. *Journal of Ethnopharmacology* 136(2): 316-321.

Lid, J. and Lid, D. T. (1998). Flora of Norway. Det Norske Samlaget, Oslo. Pp. 1014.

Lindsay, R.C. (1996). Flavours. In: Fennema RO, Karel M, Sanderson GW, Tannenbaum SR, Walstra P and Witaker JR (eds). *Food Chemistry, Marcel Dekker Incorporation*. New York. pp. 611-612.

Lindsay, W.L., and Norvell, W.A. (1978). Development of a DTPA soil test for zinc, iron, manganese and copper. *Soil Science Society of America Journal* 42: 421-428.

Lin, J.T., Liu, S.C., Chen, S.L., Chen, H.Y., and Yang, D.J (2006). Effects of domestic processing on steroidal saponins in taiwanese yam cultivar (*Dioscorea pseudojaponica* Yamamoto). *Journal of Agricultural Food Chemistry* 54: 9948–9954.

Liphadzi, M. and Kirkham, M. (2006). Heavy metal displacement in EDTA-assisted phytoremediation of biosolids soil. *Water Science and Technology* 54: 147-153.

Lockett, C.T., Calvert, C.C. and Grivetti, L.E. (2000). Energy and micronutrient composition of dietary and medicinal wild plants consumed during drought. Study of rural Fulani, Northeastern Nigeria. *International Journal of Food Science and Nutrition* 51: 195-208.

Loeffler, J. H. and Ponting, J.D (1942). Industrial and Engineering Chemistry, Analytical Education 14: 846.

Lulekal, E., Kelbessa, E., Bekele, T., Yineger, H. (2008). An ethnobotanical study of medicinal plants in Mana Angetu district, southeastern Ethiopia. *Journal of Ethnobiology and Ethnomedicine* 4(1): 10.

Luper, S. (1998). "A Review of Plants Used in the Treatment of Liver Disease." Part 1. *Alternative Medicine Review* 3(6): 410-421.

Macwan C. P. and Patel, M. A. (2010). Antioxidant potential of dried root of *Capparis Zeylanica* Linn. *International Journal of Pharmacy and Pharmaceutical Sciences* ISSN- 0975-1491 Vol 2, Issue 3, 2010.

Madhavashetty, K., Shivaji, K. and Tulasirao, K. (2008). Flowering plants of chittor district, Andhra pradesh, India ,Students offset printers,2 nd edition, pp 298.

Maghrani, M., Zeggwagh, N.A., Lemhadri, A. E.I., Amraoui, M., Michael, J.B. and Eddouks, M. (2004). Study of the hypoglycaemic activity of fraxinus excelsior and Silybum marianum in an animal model

of type 1 diabetes mellitus. *Journal of Ethnopharmacology* 91: 309-316.

Maikhuri, R.K. (1993). Evaluation of some multipurpose trees in traditional agroecosystems of Garhwal Himalaya, India. *Nitrogen Fixing Tree Association Journal* (NFTA) 11: 11-13.

Maikhuri, R.K. (1991). Nutritional value of some lesser known wild food plants and their role in tribal nutrition: A case study in North-East India. *Journal Tropical Science* 31: 397-405.

Maikhuri, R. K. and Rao, K. S (2006). Promoting Eco-tourism in Nanda Devi Biosphere Reserve : Strategies and Action Plan. G. B. Pant Institute of Himalayan Environment and Development.

Maikhuri, R.K., Rao, K.S. and Saxena, K.G. (2004). Bioprospecting of wild edibles for rural development in central Himalaya. *Mountain Research and Development* 24: 110-113.

Maikhuri, R.K., Misra, S. and Saxena, K.G. (2008). Wild leafy vegetables: A study of their subsistence dietetic support to the inhabitants of Nanda Devi Biosphere Reserve, India Journal of Ethnobiology and Ethnomedicine 4: 15.

Maikhuri, R.K., Nautiyal, S. and Rao, K.S. (2001). Medicinal plant cultivation practices of Bhotiyas in Nanda Devi Biosphere Reserve villages of Garhwal Himalaya. In *Himalayan Medicinal Plants: Potential and Prospects* (eds. Samant, S.S., U. Dhar and L.M.S. Palni), Gyanodaya Prakashan, Nainital, pp. 217-328.

Maikhuri, R. K., Nautiyal, S., Rao K.S. and Saxena, K.G. (1998). Medicinal plants cultivation and Biosphere Reserve management: A case study from Nanda Devi Biosphere Reserve. *Current Science,* 73 (9): 777-782.

Maikhuri R.K., Nautiyal, S. Rao, K.S. and Saxena, K.G. (1998). Role of medicinal plants in the traditional health care system: A case study from Nanda Devi Biosphere Reserve. *Current Science,* 75 (2): 152-157.

Maikhuri, R.K., Nautiyal, S., Rao, K.S. and Semwal, R.L. (2000). Indigenous knowledge of medicinal plants and wild edibles among three tribal sub communities of the central Himalayas, India. *Indigenous Knowledge and Development Monitor* 8: 7-13.

Maikhuri, R.K., Rao, K.S., Chauhan, K., Kandari, L.S., Prasad, P. and Rajasekharan, C. (2003). Development of marketing of medicinal plants and other forest products-can it be a pathway for

effective management and conservation? *Indian Forester* 129: 169-178.

Maikhuri, R.K., Semwal R.L., Singh A. and Nautiyal M.C. (1994). Wild fruit as a contribution to sustainable rural development: A case study from the Garhwal Himalaya. *International Journal of Sustainable Development and World Ecology* 1: 56-68.

Maisuthisakul, P., Pasuk, S. and Rithiruang, P., (2008). Retionship between antioxidant proerties and chemical composition of some Thai plants. *Journal of Food Composition and Analysis* 21: 229–240.

Makkar, H.P.S. and Becker, K. (1997). Nutrients and antiquality factors in different morphological parts of *Moringa oleifera* tree. *Journal of Agricultural Science* 128: 311-322.

Malla, S.B., Rajbhandari, S.B., Shrestha, T.B., Adhikari, P.M. and Adhikari, S.R. (1982). Wild edible plants of Nepal, Kathmandu. Department of medicinal Plants, HMG/ Nepal.

Malonza, M.M., Dipeolu, O.O., Amoo, A.O. and Hassan, S.M. (1992). Laboratory and field observations on anti-tick properties of the plant *Gynandropsis gynandra* (L.) *Briq. Veterinary Parasitology*.

Manandhar, N.P. (1995). Ethnobotanical notes on unexploited wild food plants of Nepal. *Ethnobotany* 7:95-101. 42 (1-2): 123-136.

Manandhar, N.P. (2002). *Plants and People of Nepal.* Portland, Oregon: Timber Press, Inc. p. 6.

Manandhar, N.P. (1989). *Useful wild edible plants of Nepal.* Nepal research centre publications No.14. Franz Steiner Verlag Weisbaden GMBH, Stuttgart.

Manandhar, N.P. (1982). Wild edible plants of Nepal. Bull. Dept. Med. Pl., No. 11. Thapathali, Kathmandu, Nepal

Manez, S., Recio, M.C., Giner, R.M., Sanz, M.J., Terencio, M.C., Peris, J.B., Stubing, G. and Rios, J.L. (1994). A chemotaxonomic review of the subtribe Crepidinae based on its phenolic constituents.. *Biochemical Systematics and Ecology* 22: 297.

Marimuthu, S., Samuel, S., Muthuswamy, A. D. and Chinnakkannu, P. (2005). Emerging role of *Centella asiatica* in improving age-relatedneurological antioxidant status. Experimental Gerontology 40: 707–715.

Martin, G.J. (1995). Ethnobotany: A methods manual. London, UK: Chapman and Hall.

Mashoor, M. (1988). Aquatic weeds in rice waterways, Proceeding of the National Seminar and Workshop on Rice Weed Management, Jun.7-9, Penang, Malaysia, pp: 69 -78.

Mathenge, L. (1995). Nutritional value and utilization of indigenous vegetable in Kenya. Paper presented at the Workshop on Genetic Resources of Traditional Vegetables in Africa. Options for Conservation and Use, 29-31 August 1995, Nairobi, Kenya.

Mathooko, F.M. and Imungi, J.K. (1994). Ascorbic acid changes in three indigenous Kenyan leafy vegetables during traditional cooking. *Ecology of Food and Nutrition* 32:239-245.

Matkowski, A. (2008). Plant *in vitro* culture for the production of antioxidants–A review. *Biotechnology Advances* 26: 548- 560.

Mayhew, S. and Penny, A. (1988). Macmillan Tropical and Sub-Tropical Foods. Macmillan Publishers Ltd, London.

Mbhenyane X.G., Venter, C.S., Vorster,H.H. and Steyn, H.S (2005). Nutrient intake and consumption of indigenous foods among college students in Limpopo Province. *South Africal Journal of Clinical Nutritiom.* 18 (1): 32-38.

Medical Economics Company, (2000). Milk Thistle (*Silybum marianum*) in PDR for Herbal Medicines. *Medical Economics Company* Montvale, NJ, pp. 516–520.

Mekonnen, Y. (1999). Effects of ethanol extract of *Moringa stenopetala* leaves on guinea pig and mouse smooth muscle. *Phytotherapy Research,* 13: 442-444.

Melnyk, M. (1994). Biodiversity's contribution to rural livelihoods - a component of environmental impact assessment. *In* A.F. Krattiger, J.A. McNeely, W.H. Lesser, K.R. Miller, Y. St Hill & R. Senanayake, eds. *Widening perspectives on biodiversity,* p. 347-351. Gland, Switzerland, IUCN.

Meng, J., Leung, K.S., Jiang, Z., Dong, X. and Zhao, Z. (2005a). Eastablishment of GC-MS fingerprint of Fresh *Houttuynia cordata. Chemical and Pharmaceutical Bulletin* 53: 1484 -1489.

Meng, J., Leung, K.S., Jiang, Z., Dong, X., Zhao, Z and Xu, Lj. (2005b). Eastablishment of HPLC – DAD - MS fingerprint of Fresh *Houttuynia cordata. Chemical and Pharmaceutical Bulletin, 53, 1604 – 1609.*

Mepha, H.D, Eboh, L., Banigbo, D.E.B. (2007). Effects of processing treatments on the Nutritive Composition and consumer acceptance of some Nigerian edible leafy vegetables. *African Journal of Food Agriculture, Nutrition and Development* 7(1): 1-18.

Middleton, E., Kandaswami, C. and Theoharides T.C. (2000). The effects of plant flavonoids on mammalian cells: Implications for inflammation, heart disease and cancer. *Pharmacol Reviews* 52: 673–751.

Mnkeni, A.P., Masika, P. and Maphaha, M. (2007). Nutritional quality of vegetable and seed from different accessions of *Amaranthus* in South Africa. *Water South Africa* 33 (3): 377–380.

Mnzava, N. A. (1997). Comparing nutritional values of exotic and indigenous vegetables. *In* R. Schippers and L. Budd, editors. *African Indigenous vegetables*, ODA, UK, 70-75.

Mnzava, N.A. (1990). Studies on tropical vegetables. 2. Amino and fatty acid composition in seed of cleome (*Gynandropsis gynandra* (L.) Briq) selections from Zambia. *Food Chemistry* 35(4): 287-293.

Modarresi, A. C., Ibrahim, D. and Sulaiman, S. F. (2010). Antioxidant, Antimicrobial Activity and Toxicity Test of *Pilea microphylla, International Journal of Microbiology* Article ID 826830, 6 pages doi:10.1155/2010/826830.

Modi, M., Modi, A and Hendriks, S. (2006) Potential role for wild vegetables in household food security: a preliminary case study in Kwa Zulu-Natal, South Africa. *African Journal of Food Agriculture, Nutrition and Development Vol.6(1),2006.*. (Accessed on 04/09/2006).

Moerman, D.E. (1994). North American food and drug plants. Pages 166-181 in Nina L. Etkin, ed., Eating on the Wild Side. University of Arizona Press, Tucson.

Mohammed, A. A. (2006). Chemical composition of hummayd (*Rumex vesicarius*) grown in Saudi Arabia. *Journal of Food Composition and Analysis* 19: 552–555.

Mohammed, A. D., Ahmed, E. A. M., Saleh, A, Q. and Reda, A. S. (2011). Antioxidant effect of purslane (*Portulaca oleracea*) and its mechanism of action , *Journal of Medicinal Plants Research* 5(9): 1589-1563.

Mohammed, A.I. and Hussein, A.S. (1994). Chemical composition of purslane(*Portulaca oleracea*). *Plant Foods for Human Nutrition* 45: 1-9.

Mohammed, M. I. and Sharif, N. (2011). Mineral composition of some leafy vegetables consumed in Kano, Nigeria. *Nigerian Journal of Basic and Applied Science* *19*(2): 208-211.

Morazzoni P. and Bombardelli, E. (1995): Silybum marianum (*Carduus marianus*). *Fitoterapia* 66: 3–42.

Morton, J. (1962). Spanish Needles (*Bidens pilosa* L.) as a Wild Food Resource. *Economic Botany* 16: 173-179.

Mosquin, D. (2008). *Moringa oleifera* Lam. http://www.Botanical garden.ubc.ca/potd/2008/05/moringa_oleifera.php.

Mostafa, H.A.M., El-Bakry, A.A. and Eman, A. A (2011). Evaluation of antibacterial and antioxidant activities of different plant parts of Rumex Vesicarius L. (Polygonaceae). *International Journal of Pharmacy and Pharmaceutical Sciences* 3(2):109-118.

Muchuweti, M., Mupure, C., Ndhlala, C., Murenje, T. and Benhura, M.A.N. (2007). Screening of antioxidant and radical scavenging activity of *Vigna ungiculata, Bidens pilosa* and *Cleome gynandra. American Journal of Food Technology* 10: 161–168.

Murage, E. N. (1990). The effect of nitrogen rate on the growth, leaf yield and nutritive quality of the Black nightshade (*Solanum nigrum* L.). MSc. thesis. University of Nairobi, Kenya.

Murai, M., Takenaka, T. and Nishibe, S. (1996). Iridoid from *plantago major. Natural Medicines* 50: 306.

Murphy, J.M., Caban, M. and Kemper, K.J. (2000). Milk Thistle. Longwood Herbal Task Force. 1-25.

Muta, H, Z., Japar, S. B., Raesah, A., Maini, C. and Suzalina, A. (2005). Aquatic Macrophytes in Natural and man made water bodies. *Bio-Science Research Bulletin* 21: 27–36.

Mwajumwa, L.B.S., Kahangi, E.M. and Imungi, J.K. (1991). The prevalence and nutritional value of some Kenyan indigenous leafy vegetables from three locations of Machakos District. *Ecology of Food and Nutrition* 26: 275-280.

Nakama, S. (2011). "Anti-adult T-cell leukemia effects of *Bidens pilosa.*" *International Journal of Oncology* 38(4): 1163-73.

Nakama, S., Tamaki, K., Ishikawa, C., Tadano, M. and Mori, N. (2012). Efficacy of Bidens pilosa Extract against Herpes Simplex Virus Infection In Vitro and In Vivo. Evid Based Complement Alternat Med. 2012; 2012:413453. Epub 2012 Feb 28.

Nardkarnis, K.M. (2002). Indian materia medica, Popular prakashan pvt.ltd, vol:1, 1080- 1081.

Narendhirakannan, R.T., M. Kandaswamy and S. Subramanian, (2005). Anti-inflammatory activity of *Cleome gynandra* L. on hematological and cellular constituents in adjuvant-induced arthritic rats. *Journal of Medicinal Food* 8: 93-99.

Narendhirakannan, R.T., Subramanian, S. and Kandaswamy, M. (2007). Antiinflammatory and lysosomal stability actions of Cleome gynandra L. studied in adjuvant induced arthritic rats. *Food and Chemical Toxicology* 45 : 1001–1012.

Nasiruddin., Tariq, M., Muhammad, A., Syed, S.S., Noreen, A. and Saifullah (2012). Nutritional content of some medicinal herbs of Peshawar district, Pakistan. *Sarhad Journal of Agriculture* 28: 4.

Nayak, P., Nayak, S., Kar, D.M. and Das, P. (2010). Pharmacological evaluation of ethanolic extracts of the *plant Alternanthera sessilis* against temperature regulation. *Int. J. Food Sci. Nutr.* 47, 455–468.. *Journal of Pharmacy Research* 3: 1381-3.

Nesamvuni, C., N. Steyn and M. Potgieter. (2001). Nutrients analysis of selected western African foods. *South African Journal of Science* 97: 51-54.

Nielson, F.H. (1996). Other Trace Elements in Present Knowledge of Nutrition. 7th edition, International life Science Institute Press, Washington D.C.; 353-377.

Nishibe, S., Tamayama, Y., Sasahara, M., Andary, C. (1995). A phenylethanoidglycoside from *Plantago asiatica. Phytochemistry* 38: 741–743.

Nishida, H. and Ozawa, T. (1997). Effect of polyphenol oxidase on deodorization. *Bioscience Biotechnology Biochemistry,* 61, 2080 - 2084.

Nkafamiya, I.I., Osemeahon, S.A., Dahiru, D. and Umaru, H.A. (2007). Studies on the chemical composition and physicochemical properties of the seeds of baobab (*Adansonia digitata*). *African Journal of Biotechnology* 6: 756-759.

Nnamani, C.V., Oselebe, H.O. and Agbatutu, A. (2009). Assessment of nutritional values of three underutilized indigenous leafy vegetables of Ebonyi State, Nigeria, *African Journal of Biotechnology* 8(9): 2321-2324.

Nnamani, C.V., Oselebe, H.O., Okporie, E.O (2007). Ethnobotany of indigenous leaf vegetables of Izzi Clan in Ebonyi State, Nigeria. In: Proceeding of 20th Annual National conference of Biotechnology of Nigeria. Abakaliki, pp. 111-114.

Noonan, S.C. and Savage, G.P. (1999). Oxalate content of foods and its effect on humans, *Asia Pacific Journal of Clinical Nutrition* 67: 64-74.

Nordeide, M.B., Hatloy, A., Folling M., Lied. E. and Oshaug A. (1996). Nutrient composition and nutritional importance of green leaves and wild food resources in an agricultural district, Koutiala, in Southern Mali. *International Journal of Food Science and Nutrition* 47: 455-468.

Nutrition news, (1996). National Institute of Nutrition, Hyderabad, 17:2.

Nwachukwu, C.U., Umeh, C.N., Kalu, I.G., Okere, S. and Nwoko, M. (2010). Identification and traditional uses of some common medicinal plants in Ezinihitte Mbaise L.G.A., of Imo State, Nigeria. *Report and Opinion*, pp: 1-8

Nwanjo, H.U. (2005). Efficacy of aqueous leaf extract of Vernonia amygdalina on the plasma lipoprotein and oxidative status of diabetic rat models. *Nigerian Journal of Physiological Sciences.* 20: 39-42.

Nya E.J., Okorie N.U. and Eka, M.J. (2010). An Economic Analysis of *Talinum triangulare* (Jacq.) Production/Farming in Southern Nigeria. *Trends in Agricultural Economics* 3: 79-93.

Nyunt T.M., Lwin K.K., Aye T.T., Than M.A., Chit K., Kyaw T., Hlaing O.M.T., Wun, M. and Win, N.N. (2007). Antihypertensive effect of *Plantago major* Linn. whole plant (Ahkyawpaung-tahtaung) on mild to moderate hypertensive patients. *Myanmar Health Sciences Research Journal* 19: 97–102.

Oboh, F. O. J. and Enobhayisobo, E. I. (2009). Effect of aqueous extract of *Vernonia amygdalina* leaves on plasma lipids of hyperlipidaemic adult male albino New Zealand rabbits. *African Scientists* 10: 4.

Odhav, B., Beekrum, S., Akula, U.S. and Baijnath, H. (2007). Preliminary assessment of nutritional value of traditional leafy vegetables in

Kwazulu-Natal, South Africa. *Journal of Food Composition and Analysis* 20: 430-435.

Oduro, I., Ellis, W. O. and Owusu, D. (2008). Nutritional potential of two leafy vegetables: *Moringa oleifera* and *Ipomoea batatas* leaves. *Scientific Research and Essay* 3 (2): 057-060.

Ogle, B.M., Tuyet, H.T., Duyet, H.N. and Nguyen, N. X. D. (2003). Food, feed or medicine: The multiple functions of edible wild plants in Vietnam. *Economic Botany* 57: 103-117.

Ogle, B.M. (2001). Wild vegetables and micronutrient nutrition. Studies on the significance of wild vegetables in women diet in Vietnam. *Turkish Journal of Botany* 25: 367-371.

Ohigashi, H., Jisaka, M., Takagaki, T., Nozaki, H. and Tada, T. (1991). Bitter principle and a related steroid glucoside from Vernonia amygdalina, a possible medicinal plant for chimpanzees. *Agricultural amd Biological Chemistry* 55: 1201-1203.

Oh, K.B., Chang, I.M., Hwang, K.J. and Mar, W. (2000). Detection of antifungalactivity in Portulaca oleracea by a single-cell bioassay system. *Phytotherapy Research* 14: 329-332.

Olaiya, C. and Adebisi, J. (2010). Phytoevaluation of the nutritional values of ten green leafy vegetables in South -Western Nigeria. *The Internet Journal of Nutrition and Wellness* 9: 2. DOI: 10.5580/1150.

Olivier-Bover, B.E.P. (1986). Medicinal Plants in Tropical West Africa. 1stEd. 375 pages

Ononogbu, I.C. (2002). Lipids in Human Existence. 1st edition. AP Express Publishing Company, Nsukka 1-15.

Onyango, M.A. (1993). Effect of plant density and harvesting frequency on the yield and vegetable quality of four variants of black nightshade *(Solanum nigrum* L.). M.Sc. Thesis, University of Nairobi.

Opole, M., Chweya, J.A. and Imungi, J.K. (1995). Indigenous Vegetables of Kenya: Indigenous knowledge, Agronomy and Nutitive value. Field and Laboratory Experience Report.

O. Potterat (1997). Antioxidants and Free Radical Scavengers of Natural Origin. *Current Organic Chemistry 1: 415–440.*

Orech, F.O., Aagaard-Hansen, J. and Friis, H. (2007). Ethnoecology of traditional leafy vegetables of the Luo people of Bondo district,

western Kenya. *International Journal of Food Science and Nutrition* 58(7): 522-530.

Ouedoraogo, I., Hilou, A., Sombie, P. A. E. D., Compaore, M., Millogo, J. and Nacoulma O. G. (2011). Nutraceutical assessment of four *Amaranthus* species from Burkina Faso. *Current Research Journal of Biological Science* 3(5): 451-458.

Owoeye, O. (2010). Anticancer Activity of *Vernonia amygdalina* Del. Leaf Extract, its Antioxidant and Radioprotective Properties in the Brain of Rats. Ph. D Thesis; Department of Veterinary Medicine, University of Ibadan: Ibadan, Nigeria.

Ozkan, A., Yumrutas, O., Saygideger, S.D. and Kulak, M. (2011). Evaluation of Antioxidant Activities and Phenolic Contents of Some Edible and Medicinal Plants from Turkey's Flora. *Advances in Environmental Biology* **5** (2): 231-236.

Padulosi, S., Giuliani, A. and Noun, J. (2003). Underutilized species: what are they? International workshop on underutilized species, Leipzig, Germany, 6-8 May 2003. International Plant Genetic Resources Institute, CWANA Regional Office, Aleppo, Syria.

Padulosi, S., Hodgkin, T., Williams, J.T. and Haq, N. (1999). Underutilized Crops. Trends, Challenges and Opportunities in the 21st Century. IPGRI, Rome.

Palmer, E. and Pitman, N. (1972). *Trees of Southern Africa Vol. 2.* A.A. Bal Kema Cape Town.

Panduraju, T., Rao, P.R.S., Kumar, V.S (2009). A study on antimicrobial activity of *Rumex vesicarius* Linn. *International Journal of Pharmacy and Technology 1*(1): 21-25.

Pankaj, S. and Dibakar, C. D. (2013). Mineral content of some wild green leafy vegetables of North-East India. *Journal of Chemical and Pharmaceutical Research 5*(3): 117-121.

Pardo, de-Santayana M., Blanco, E. and Morales, R. (2005). Plants known as 'té' (tea) in Spain. An ethno-pharmaco-botanical review. *Journal of Ethnopharmacology* 98: 1–19.

Pardo, de Santayana, M., J. Tardio and R. Morales.(2005). The gathering and consumption of wild edible plants in the Campoo (Cantabria, Spain) *International Journal of Food Sciences and Nutrition* 56 (7): 529-542.

Paris, A., Gonnet, N., Chaussard, C., Belon, P., Rocourt, F., Saragaglia, D. and Cracowski, J.L. (2008). Effect of homeopathy on analgesic intake following knee ligament reconstruction: a phase III monocentre randomized placebo controlled study. *British Journal of Clinical Pharmacology* 65: 180-184.

Parry, O., Marks, J.A., Okwuasaba, F.K. (1993). The skeletal muscle relaxant action of Portulaca oleracea : Role of potassium ions. *Journal of Ethnopharmacology* 40: 187-194.

Parsons, N. (1993). *A New History of Southern Africa* (2nd edn.) Mac-Millan, London. 349 pp

Patil S.M., Kadam, V.J and Ghosh, R. (2009). In vitro antioxidant activity of methanol extract of stem bark of Gmelina arborea Roxb. (verbenaceae). *International. Journal of Pharm Tech Research,* Vol.1, No.4,pp1480 -1484.

Patra, A., Rai, B., Rout, G.R. and Das, P. (1998). Successful plant regeneration from callus cultures of *Centella asiatica* (Linn.) Urban. *Plant Growth Regulation* 24: 13-16. 187.

Pearson, D. (1976). *Chemical analysis of foods.* 7th edn.. Churchill, Livingstone, London 1976.

Peiris, K.H.S. and Kays, S.J. (1996). Asiatic pennywort, *Centella asiatica* (L.) Urb., a little known vegetable crop.Horticulture technology 613-18.

Perez, R.M., Perez, J.A., Garcia, L.M.D. and Sossa, H.M. (1998). Neuropharmacological activity of *Solanum nigrum* fruit, *Journal of Ethnopharmacology* 62 (1): 43-48.

Phillips, R. and Rix. M. (1991). *Perennials Volumes 1 and 2.* Pan Books ISBN 0- 330-30936-9

Picchi, G. and Pieroni, A. (2005). - *Le Erbe (Atlante dei prodotti tipici),* Roma, INSOR e AGRA/RAI ERI, 2005.

Pieroni, A. (2001). Evaluation of the cultural significance of wild food botanicals traditionally consumed in Northwestern Tuscany, Italy. *Journal of Ethnobiology* 21: 89–104.

Pieroni, A. (1999). Gathered wild food plants in the upper valley of the Serchio River (Garfagnana), Central Italy. *Economic Botany* 53(3): 327–341.

Pieroni, A., Houlihan, L., Ansari, N., Hussain, B. and Aslam, S. (2007). Medicinal perceptions of vegetables traditionally consumed by

south-Asian migrants living in Bradford, Northern England. *Journal of Ethnopharmacology* 113: 100-110.

Pieroni, A. (2000). Medicinal plants and food medicines in the folk traditions of the upper Lucca Province, Italy. *Journal of Ethnopharmacology* 70: 235–273.Pieroni, A., Nebel, S., Quave, C., Münz, H. and Heinrich, M. (2002). Ethnopharmacology of liakra: traditional weedy vegetables of the Arbëreshë of the Vulture area in southern Italy. *Journal of Ethnopharmacology* 81(2): 165–185.

Pilger, R. (1937). Plantaginaceae. In: Das Pflanzenreich (Engler A., Ed.). H. R. Engelmann Verlag, Berlin, 1–466.

Pipithsangchan, S. (1993). Insecticidal activity of selected Thai plants on diamondback moth, *Plutella xylostella* (L.) (Lepidoptera: Ypnomeutidea). Univ. Philippines, Los Banos, College, Laguna, Phillipines. Monograph.

Potterat, O. (1997). Antioxidant and free radical scavengers of natural origin. Current Organic Chemistry. 1: 415-440.

Pourmorad, F., Hosseinimehr, S.J. and Shahabimajd, N. (2006). Antioxidant Activity, Phenol and Flavonoid Contens of Some Selected Iranian Medicinal Plants. *African Journal of Biotechnology* 5 (11): 1142-1145.

Pourreza, J. and Bahrani, A. (2012). Estimating Cardinal Temperatures of Milk Thistle (*Silybum marianum*) Seed Germination. American-Eurasian *Journal of Agricultural and Environmental Science.* 12 (8): 1030-1034.

Prasad, K. and Bisht, G. (2011). Evaluation of Nutritive, Antioxidant and Mineral Composition of *Pavetta indica* Linn. Leaves. *Research Journal of Phytochemistry, 5: 54-59.*

Prasad, P. and Rajasekharan, C. (2003). Development of marketing of medicinal plants and other forest products– can it be a pathway for effective management and conservation? *Indian Forester* 129: 169-178.

Prasad, P. and Ramakrishnan, N. (2012.a). Chromatographic finger print analysis of *Rumex vesicarius* L. by HPTLC Technique. *Asian Pacific Journal of Tropical Biomedicine;* 1 (2): 1-7.

Prasad, P. and Ramakrishnan, N. (2012.b). Antioxidant assay of *Rumex vesicarius* L. *International Journal of Current Research* 3(11): 074-076.

Prasad, P. and Ramakrishnan, N. (2012.c). *In vitro* lipid peroxidation assay of *Rumex vesicarius* L. *International Journal of Pharmacy and Pharrmaceutical Sciences* 4 (suppl. 1): 368-370.

Prescott-Allen, O.C. and Prescott-Allen, R. (1990). How many plants feed the world? *Conservation Biology* 4: 365-374.

Price, L. L. (2003). Farm women's rights and roles in wild plant gathering and management in North-east Thailand. In:P. Howard (ed.), Women and Plants. Gender relations in biodiversity management and conservation. Zed Press & Palgrave-Macmillan, London and New York, 101-114.

Price, M.L. (1985). *The Moringa Tree,* ECHO Technical Note (revised 2000 by Kristin Davis).

Proceedings of International Symposium on the Nutritional Value and Water Use of Indigenous Crops for Improved Livelihoods. 19-20 September 2006.

Puff, C. (1991a). The genus *Paederia* L. (Rubiaceae-Paederieae): taxonomic history, revised generic description, and subgeneric division. *In* Puff, C. (ed.) The genus *Paederia* L. (Rubiaceae- Paederieae): A multidisciplinary study. *Opera Botanica Belgica* 3: 195-204.

Puff, C. (1991b). Revision of the genus *Paederia* in Asia. *In* Puff, C. (ed.) The genus *Paederia* L. (Rubiaceae- Paederieae): A multidisciplinary study. *Opera Botanica Belgica* 3: 207-289.

Pullaiah, T. and Ali, M, D. (1997). Flora of Andhra Pradesh (India), *Scientific Publishers,* 2: 817.

Purseglove, J.W. (1943). Some Ugandan vegetables. *East African Agricultural Journal* 9: 98.

Quisumbing, E. (1951). *Medicinal Plants of the Philippines,* Department of Agriculture and Natural Resources. Manila: Bureau ofprinting, p. 269.

Qureshi, R., Waheed, A., Arshad, M. and Umbreen, T. (2009). Medicoethanobotanical inventory of tehsil Chakwal, Pakistan. *Pakistan Journal of Botany* 41: 529-538.

Ragasa, C. Y., Tremor, N and Rideout, J.A. (2002). Ionone derivatives from *Alternanthera sessilis. Journal of Asian Natural Products Research* 4 (2) : 109-115.

Raghuvanshi, R.S., Singh, R. and Singh, R. (2001). Nutritional Composition of uncommon foods and their role in meeting

micronutrient needs. *International Journal of Food Science and Nutrition* 52: 331-335.

Rahman, M.T., Begum, M., Alimuzzaman, M. and Khan, M.O.F. (2002). Analgesic activity of Enhydra fluctuans. *Fitoterapia* 73: 77-79.

Rai, A.K., Sharma, R.M. and Tamang, J.P. (2005). Food value of common edible plants of Sikkim. *Journal of Hill Research* 18 (2): 99-103.

Rai, P.C., Sarkar, A., Bhujel, R.B. and Das, A.P. (1998). Ethnobotanical studies in some Fringe Areas of Sikkim and Darjeeling Himalayas. *Journal of Hill Research* 11(1): 12-21.

Rainone, F. (2005): Milk Thistle. American Family Physician, 72,1285-1288.

Ranganna, S. (1986). *Handbook of Analysis and Quality Control for Fruit and Vegetable Products, 2nd Edition,* Tata McGraw-Hill Publishing Company Limited, New Delhi pp. 127-130.

Rao, B.N. (2003). Bioactive phytochemicals in Indian foods and their potential in health promotion and disease prevention. *Asia Pacific Journal of Clinical Nutrition* 12 (1): 9-22.

Rao, K.N.V., Sunitha C., David B., Sandhya, S, and Saikumar P. (2011). Pharmacognostic Studies on *Rumex vesicarius. Asian Journal of Plant Science and Research,* 2011, 1 (1): 102-115.

Rao, K.V.R., Rao, K.R.S.S., Nelson, R. and Nagaiah, K. (2011). Hypoglycemic and antidiabetic effect of *Alternanthera sessilis* in normal and streptozotocin (STZ)-induced rat. *Journal of Global Trends in Pharmaceutical Science* 2: 325-35.

Rasheed, A.N., Afifi, F.U. and Disi, A.M. (2003). Simple evaluation of the woundhealing activity of a crude extract ofPortulaca oleracea L. (growing inJordan) in Mus musculus JVI-1. *Journal of Ethnopharmacology* 88: 131-136.

Rasheed, A.N. and Disiam, A. (2010). Simple evaluation of the wound healing activity of a crude extract of *P. oleracea* (L) growing in Jordan in Mus musculus JVI-1, *Journal of Ethnopharmacology* 88: 131-136.

Rastogi, R.P. (1993). Compendium of Indian medicinal plant, 2nd edn, CDRI, Lucknow, 1970-9.

Ravn, H. and Brimer L. (1988). Structure and antibacterial activity of plantamajoside, a caffeic acid sugar ester from *Plantago major* subsp. *major. Phytochemistry* 27: 3433-3437.

Redzic, S.J. (2006). Wild Edible plants their traditional use in the human nutrition in Bosnia-Herzegovina. *Ecol. Food Nutr.*, 45(3): 189–232.

Regmi, B.R., Aryal, K.P., Tamang, B.B. and Shrestha, P.K.. (2006). Homegardens: An Opportunity to minimize pressure on slash and burn system and options for improving dietary diversity of Chepang households. Pp. 35-47 in *Enhancing the Contribution of Home Gardens to On-Farm Management of Plant Genetic Resources and to Improve the Livelihoods of Nepalese Farmers: Lessons learned and policy implications*. Proceedings of home garden workshop, 6-7 August 2004, Pokhara, Nepal. Edited by R. Gautam, B.R. Sthapit and P.K. Shrestha. LI-BIRD, Bioversity International and SDC, Kathmandu.

Rehman, E.U, (2006). Indigenous knowledge on medicinal plants, village Barali Kass and its allied areas, District Kotli Azad Jammu and Kashmir, Pakistan. *Ethnobotanical Leaflets* 10: 254-264.

Reviews on Indian Medicinal Plants (2004). Vol. II. New Delhi, India: Indian Council of Medical Research; 2004, p. 150.

Rice, R. P., Rice, L. W. and Tindau, H. D. (1986). Fronts and Vegetables in the Tropics. Macmillan Educational Books Ltd., London.

Rivera, N.D. and Oben, D.C.C. (1993). Ethnopharmacology of Murcia (SE Spain). *Conference Internationale Ethnomedecine*. Heidelb2e.4rg-2,7.

Roberts, M. S., Nakamura, L. K. and Cohan, F. M. (1996). *Bacillus vallismortis sp. nov.*, a close relative of *Bacillus subtilis*, isolated from soil in Death Valley, California. *International Journal of Systematic Bacteriology* 46: 470–475.

Rohani, M. Y., Rosalizan, M. S., Samsiah, J., Nor Ismawaty, N. and Zainal Abidin, H. (2008). Effect of organic and inorganic fertilizers on the quality and terpene contents of pegaga (Centella asiatica). Paper presented at National Conference on Organic Agriculture 2008, 4-6 Nov. 2008, Sheraton Subang Hotel and Towers, Kuala Lumpur.

Rojas, J.J., Ochoa, V.J., Ocampo, S.A. and Munoz, J.F. (2006). Screening for antimicrobial activity of ten medicinal plants used in Colombian folkloric medicine: A possible alternative in the treatment of nonnosocomial infections. *BMC Complementary and Alternative Medicine* 6:2. Doi: 10.1186/1472-6882-6-2

Rosalizan, M. S., Rohani, M. Y., Khatijah, I. and Shukri, M. A. (2008). Physical characteristics, nutrient contents and triterpene

compounds of ratoon crops of *Centella asiatica* at three different stages of maturity. *Journal of Tropical Agriculture and Food Science* 36 (1): 43-51.

Roy, S.K., Mazumder, U. K. and Islam, A. (2011). Pharmacological evaluation of *Enhydra fluctuans* Arial parts for central nervous system depressant activity. *Pharmacology online* 1: 632-643.

Sabeen, M. and Ahmad, A.A. (2009). Exploring the Folk Medicinal Flora of Abbotabad City, Pakistan. *Ethnobotanical Leaflets* 13: 810-833.

Sadhu, M.K. (1990). In: Fruits: Tropical and Subtropical (Kose T.K. and Mitra S.K., eds). Naya Prokash, Calcutta, India. Fig. Pp. 650-663.

Sagar, G.R. and Harper, J.L. (1960). Factors affecting the germination and early establishment of plantains (*Plantago lanceolata. P. media and P. major*). The biology of weeds. J.L. Harper (ed.), *British Ecological Society Symposium* 1, Blackwell, Oxford, 236–245.

Saha, J., Sarkar P.K. and Chattopadhyay, S. (2011). A survey of ethnomedicinal plants of Darjeeling hills for their antimicrobial and antioxidant activities, *Indian Journal of Natural Products and Resources* 2(4): 479-492

Sahu, N.P., Roy, S.K. and Mahato, S.B. (1989). Spectroscopic determination of structures of triterpenoid trisaccharides from *Centella asiatica*. *Phytochemistry* 28, 2852–2854.

Saldanha, L.G. (1995). Fibre in the diet of U. S. Children: results of national surveys. *Pediatrics*. (96): 994-996.

Semih, O. and Buket, Y. (2012). Phenolic Compounds Analysis of Root, Stalk and Leaves of Nettle. *The Scientific World Journal*. Article ID564367 1-12.

Sammon, A.M. (1998). Protease Inhibitors and Carcinoma of the Esophagus. Cancer, 83: 405-408.

Samuelsen, A.B. (2000). The traditional uses, chemical constituents and biological activities of *Plantago major* L. A review. *Journal of Ethnopharmacology* 71: 1–21.

Samy, J., Sugumaran, M. and Kate, L.L. W. (2005). Herbs of Malaysia: An Introduction to the medicinal, Culinary, Aromatic and Cosmetic use of Herbs. 1st Edn., Shah Alam, Selangor.

Sánchez-Mata, M.C., Cabrera-Loera, R.D., Morales, P., Fernández-Ruiz, V., Cámara, M., Díez-Marqués, C., Pardo-de-Santayana, M. and

Tardío, J. (2012). Genetic Resources and Crop Evolution, 59 (3): 431-443

Sannigrahi, S., Majumder, U. K., Pal, D. K., Mishra, S. L. and Maity, S. (2011). Flavonoids of *Enhydra Fluctans* Exhibits analgesic and anti-inflammatory activity in different animal models. *Pakistan Journal of Pharmaceutical Sciences* 24 (3): 369-375.

Sannigrahi, S., Mazumder, U.K., Pal, D.K., Mondal, A and Roy, S (2009). Hepatoprotective potential of flavonoid rich fraction of *Enhydra fluctuans* against CCl4-induced oxidative damage in rats. *Pharmacologyonline* 2: 575- 586.

Sannigrahi, S., Mazumder, U.K., Pal, D.K., Parida, S. and Jain, S . (2010a). Antioxidant potential of crude extract and different fractions of *Enhydra fluctuans* Lour. *Iranian Journal of Pharmaceutical Research* 9: 75-82.

Sannigrahi, S., Mazumder, U.K., Mondal, A., Pal, D.K., Mishra, S.L and Roy, S (2010b). Flavonoids of *Enhydra fluctuans* exhibits anticancer activity against Ehrlich's Ascites Carcinoma in mice. *Natural Product Communications* 5: 1239-1242.

Saupi, N., Zakaria, M.H. and Bujang J.S. (2009). Analytic Chemical Composition and Mineral Content of Yellow Velvetleaf (*Limnocharis flava* L. Buchenau)'s Edible Parts. *Journal of Applied sciences* 9 (16): 2969–2974.

Scherrer, A.M., Motti, R. and Weckerle, C.S. (2005). Traditional plant use in the areas of Monte Vesole and Ascea, Cilento National Park (Campania, Southern Italy). *Journal of Ethnopharmacology* 97: 129-143.

Schippers, R.R. (2000). African Indigenous Vegetable-an Overview of the *Cultivated* Species. National Resources Institute (NRI), University of Greenwich, United Kingdom, London, pp: 214.

Schröder, H. (2007). Protective mechanisms of the Mediterranean diet in obesity and type 2 diabetes. *Journal of Nutritional Biochemistry 18:* 149-160.

Schulz, V., Hansel, R. and Tyler, V.E. (1997). Rational Phytotherapy: A Physicians' Guide to Herbal Medicine. Berlin: *Springer,* 1997:306.

Sekeroglu, N., Ozkutlu, F., Deveci, M., Dede, O. and Yilmaz, N. (2006). Evaluation of some wild plants aspect of their nutritional values used as vegetable in eastern black sea region of Turkey. *Asian Journal of Plant Sciences* 5: 185-189.

Sena, L.P., Vanderjagt, D.J., Rivera, C., Tsin, A.T. and Muhamadu, I. (1998). Analysis of nutritional components of eight famine foods of the republic of Niger. *Plant Foods for Human Nutrition* 52: 17-30.

Shackleton, C.M. (2003). The prevalence of use and value of wild edible herbs in South Africa. *South African Journal Science* 99: 23-25.

Shankar, U., Murali, K.S., Umashankar, R., Ganeshaiah, K.N. and Bawa, K.S. (1998). Extraction of non-timber forest products of Biligiri Rangan Hills, India, 4. Impact on floristic diversity and population structure in a thorn scrub forest. *Economic Botany* 53 (3): 302-315.

Sharma, J. and Sharma, R. (2002). Radioprotection of Swiss albino mouse by *Centella asiatica* extract. *Phytotherapy Research*. 16: 785–786.

Sharma, J.R. (2000). Agrotechnology for mandookparni or gotukola (*Centella asiatica*). Retrieved in 2004 from http://www.bisnetindia.com/app/wsnsa.dll/bisnet/technopro file 2.

Sharma, N., Gupta, P.C. and Rao, C.V. (2012). Nutrient Content, Mineral Content and Antioxidant Activity of *Amaranthus viridis* and *Moringa oleifera* Leaves. *Research Journal of Medicinal Plant, 6: 253-259.*

Sheela, K., Nath, K.G., Vijayalakshmi, D., Yankanchi, G.M. and Patil, R.P. (2004). Proximate composition of underutilized green leafy vegetables in Southern Karnataka. *Journal of Human Ecology* 15: 227-229.

Sheikh, S. A. and Sumaira, J. (2007). Exploring the economic value of underutilized plant in Ayubia National park. *Pakistan Journal of Botany* 39(5): 1435–1442.

Shepeleva, V.V. and Nezhinskaya, G.I. (2008). Immunoprotective activity of medicinal plants preparations infusion in immunodepression caused by cytostatics. Rastitel'nye Resursy 44: 129–135.

Shimizu, S., Miyase, T., Ueno, A. and Usmanghani, K. (1989). Sesquiterpene lactone glycosides and ionone derivative glycosides from *Sonchus asper*. *Phytochemistry* 28: 3399.

Shirwaikar, A., Malini, S. and Kumari, S.C. (2003). Protective effect of Pongamia pinnata flowers against cisplatin and gentamicin inducednephrotoxicity in rats. *Indian Journal Experimental Biology* 41: 58-62.

Shiundu, K. M. (2002). Role of African leafy vegetables (ALVs) in alleviating food and nutrition insecurity in Africa. *African Journal of Food Nutrition Science* 2 (2): 97-99.

Shizuo, T. (2005). Journal of Medicinal Food. Antioxidative Effects of Polyphenols in Leaves of *Houttuynia cordata* on Protein Fragmentation by Copper-Hydrogen Peroxide *In Vitro,* 8 (2): 266-268.

Shrestha, P.M. and Dhillion, S.S. (2006). Diversity and traditional knowledge concerning wild food species in a locally managed forest in Nepal. *Agroforestry Systems* 66: 55-63.

Shrestha, S.R. (2001). The state of Uncultivated Foods in Nepal Biodiversity and Uncultivated food plants. Pp. 33- 39 in *The Proceedings of the Regional Workshop on Uncultivated Foods and Biodiversity.* Edited by M.M. Johnston. September 24 to 26, Kathmandu, Nepal. USC Canada- Nepal, Kathmandu.

Shreya, M., Sahithi, B., Rajani, G.P. and Deepthi, R.K.N. (2011). Evaluation of memory enhancing and anti-inflammatory activities of ethanolic and aqueous extracts of aerial parts of Alternanthera sessilis L. *Indian Journal Pharmacology* 43: 159.

Sidibe, M. and Williams, J.T. (2002). Baobab - *Adansonia digitata.* Fruits for the future. Int. Centre Underutil. Crops, Southampton, UK, 96 p.

Siegal, C.B., Gawlak, S.L., Chace, D., Wolff, E.A., Mixan, B. and Marquardt, H. (1994). Characterization of ribosome-inactivating proteins isolated from *Bryonia dioica* and their utility as carcinoma-reactive immunoconjugates. *Bioconjugate Chem* 5: 423–429.

Siemonsma, J.S. and Piluek, K. (1994). PROSEA: Plant Resources of South East Asia, 8. *Prosea Foundation,* Bogor, Indonesia.

Sikdar, M. and Dutta, U. (2008). Traditional phytotherapy among the Nath people of Assam. *Ethno-Med* 2: 39-45.

Simopoulos, A.P. (1991). Omega-3 fatty acids in health and disease and in growth and development. *Amercan Journal Of Clinical Nutrition* 54: 438-463.

Simopoulos, A.P. (2001). Evolutionary aspects of diet and essential fatty acids. In: Hamazaki T, Okuyama H (eds). Fatty Acids and Lipids - New Findings. *World Review of Nutrition and Dietetics* 88: 18-27.

Simopoulos, A.P. (2001). The Mediterranean Diets: What is so special about the diet of Greece? The Scientific Evidence. *Journal of Nutrition* 131: S3065-S3073.

Simopoulos, A.P (2004). Omega-3 Fatty Acids and Antioxidants in Edible Wild Plants. *Biological Research* 37: 263-277.

Simopoulos, A.P., Norman, H.A. and Gillaspy, J.E. (1995). Purslane in human nutrition and its potential for world agriculture. *World Review of Nutrition and Dietetics* 77: 47-74.

Simopoulos, A.P and Salem, N. Jr. (1986). Purslane: a terrestrial source of omega-3 fatty acids. *New England Journal of Medicine* 315: 833.

Simopoulos, A.P., Tan, D.X., Manchester, L.C. and Reiter, R. J (2005). Purslane: a plant source of omega-3 fatty acids and melatonin. *Journal of Pineal Research* 39: 331-332.

Simoons, F.J. (1991). Food in China.A Cultural and Historical Inquiry. , CRC Press, Boca Raton. Arano, L.C. (1976). Tacuinum Sanitatis. The Medieval Health Handbook.New York. N Y George Braziller.

Singha, S.C. (1966). Medicinal plants in Nigeria. National press Ltd. Apapa. Nigeria, p. 46.

Singh, A. (1983a). Efficiency of certain plant extracts against brinjal aphid (*Aphis gossypii* Glover). *Indian Journal of Entomolology* 45: 313-314.

Singh, A., Kandasamy, T. and Odhav, B. (2009). *In vitro propagation of Alternanthera sessilis* (sessile joyweed), a famine food plant. *African Journal of Biotechnology* 8 (21): 5691-5695.

Singh, A. V. (2011). A study on the ethnobotanical, phytochemical and the socio- economical relevance of *Houttuynia cordata* Thunb. In Manipur. *Life sciences leaflets*. 20: 908-922.

Singh, C., Jamwal, U., Gupta, G.K., Sharma, A.K. and Singh, P. (1999). Comparative growth, herbage yield, asiaticoside and madecassoside composition in Brahama manduluki (*Centella asiatica*). *Journal of Medicinal and Aromatic Plant Science 21(4)*: 21-24

Singh, G., Asha, K. and Sehgal, S. (2001). Nutritional composition of selected green leafy vegetables, herbs and carrots. *Plant Foods for Human Nutrition* 56: 369-364.

Singh, H.B. and Arora, R.K. (1978). Wild edible plants of India (1sted.). ICAR Publication, New Delhi.

Sinha, R. and Lakra V. (2005). Wild tribal foods plants of Orissa. *Indian Journal of traditional knowledge* 4 (3): 246-252.

Sinha, P., Arora, V.K. and Wahi, S.P. (1984). Chemical investigation on *Alternanthera sessilis,* Indian Drug, 1: 139-4.

Slinkard, K. and Singleton, V.L. (1977). Total phenol analyses: automation and comparison with manual methods. *American Journal of Enology and Viticulture* 28: 49-55.

Snedecor, G. W. and Cochran, W. G. (1989). *Statistical Methods,* Eighth Edition, Iowa State University Press.

Sobukola, O. P., Dairo, O. U., Odunewu, A. V. and Fafiolu, B. O. (2007). Thin-layer drying process of some leafy vegetables under open sun. *Food Science and Technology 13*(1): 35-40.

Soerjani, M., Kostermans, A.J.G.H. and Tjitrosoepomo, G. (1987) *Weeds of Rice in Indonesia.* (Balai Pustaka: Jakarta).

Song-Chow, L., Yun-Ho, L., Shyh-Jong, S., Chung-Ching, L., (2006). Hepatoprotective effects of Taiwan folk medicine: *Alternanthera sessilis* on liver damage induced. 2006. *Phytotherapy Research* 8(7): 391–398.

Son, Y.O., Kim, J., Lim, J.C., Chung, Y., Chung, G.H and Lee, J.C, (2003). Ripe fruits of Solanum nigrum L. inhibits cell growth and induces apoptosis in MCF-7 cells, *Food and Chemical Toxicology* 41 (10): 1421-1428.

Sreedevi, I., Chaturvedi, A. (1993). Effect of vegetable fibre on post prandial glycemia. *Plant Foods for Human Nutrition* 44: 71-78.

Sreeramulu, N., Ndosi, G.D. and Mtotomwema, R. (1983). Effect of cooking on the nutritive value of common food plants of Tanzania. Part 1. Vitamin C in some of the wild-green leafy vegetables. *Food Chemistry* 10: 205-210.

Srianta, I., Arisasmita, J.H., Patria, H.D. and Epriliati, I. (2012) Ethnobotany, nutritional composition and DPPH radical scavenging of leafy vegetables of wild *Paederia foetida* and *Erechtites hieracifolia International Food Research Journal 19(1): 245-250*

Standal, B. R. (1963) Nutritional value of proteins of oriental soybean foods. *Journal of Nutrition* 81: 279-285.

Steenkamp, V. and Gouws, M.C (2006). Cytotoxicity of six South African plants extracts used in the treatment of cancer. *South African Journal of Botany* 72: 630-633.

Steyn, N.P., Oliver, J., Winter, P., Burger, S., Nesamvuni, C. (2001 b). A survey of wild, leafy vegetables and their potential in combating micronutrient deficiencies in rural populations. *South African Journal of Science* 97: 276-278.

Strack, D., (1997). "Phenolic metabolism," in Plant Biochemistry, P.M. Dev. and J.B. Harborne (Eds.), London, UK, Academic Press, 1997, 387-416.

Sturm, S. and Stuppner, H. (2000). Analysis of cucurbitacins in medicinal plants by high-pressure liquid chromatography mass spectrometry. *Phytochemical Analysis* 11: 121-127.

Subba, J.R. (200). Biodiversity of Sikkim Himalayas, (SYMS publication, Gangtok).

Sudhakar, D., Krishna, K. R. and Parthasarathy, P.R. (2010). *Portulaca oleracea* L. extract ameliorates the cisplatin-induced toxicity in chickembryonic liver. *Indian Journal of Biochemistry and Biophysics* 47: 185-189.

Suguna, L., Sivakumar, P. and Chandrakasan, G. (1996). Effects of *Centella asiatica* extract on dermal wound healing in rats. *Indian Journal of Experimental Biology* 34 (12): 1208-11.

Sultana, S., Asaduzzaman, Md. and Sohail, A. (2012). Allelopathic Potential of *Amaranthus viridis* l. on Canola and Annual Ryegrass. *Bangladesh Research Publications Journal* 7(1): 29-35.

Sundararajan, P., Dey, A., Smith, A., Doss, A.G., Rajappan, M. and Natarajan, S. (2006). Studies of anticancer and antipyretic activity of *Bidens pilosa* whole plant. *African Health Science* 6: 27-30.

Sundriyal, M. (1999). Distribution, Propagation and Nutritive value of some wild Edible Plants in the Sikkim Himalaya. PhD Thesis, High Altitude Physiology Research Centre, H N B Garwal University, Srinagar and G B Pant Institute of Himalayan Environment and Development, Sikkim Unit, Gangtok.

Sundriyal, M. and L. K. Rai (1996). Wild edible plants of Sikkim Himalaya. *Journal of Hill Research* 9: 267-278.

Sundriyal, M. and Sundriyal, R.C. (2000). Potential of wild edible plants of the Sikkim Himalaya: Conservation cencerns. *Journal of Non-Timber Forest products* 7(3/4): 253-262.

Sundriyal M, and Sundriyal, R .C. (2001). Seed germination and response of stem-cuttings to hormonal treatment in six priority wild edible fruit species of Sikkim Himalaya. *Indian Forester* 127: 695-706.

Sundriyal, M. and Sundriyal, R.C. (2003). Underutilized edible plants of the Sikkim Himalaya: Need for domestication. *Current Science* 85(6): 731-736

Sundriyal, M. and Sundriyal, R.C. (2004b). Wild edible plants of the Sikkim Himalaya: Marketing, value addition and implications for management. *Economic Botany* 58 (2): 300–315.

Sundriyal, M. and Sundriyal, R.C. (2001). Wild edible plants of Sikkim Himalaya: Nutritive values of selective species. *EconomicBotany* 55(3): 377-390.

Sundriyal, M. and Sundriyal, R.C. (2004a). Wild edible plants of Sikkim Himalaya: Nutritive values of selected species. *Economic Botany* 58 (2):286-299.

Sundriyal, M., Sundriyal, R.C. and Sharma, E. (2004). Dietary use of wild plant resources in the Sikkim Himalaya, *India Economic Botany* 58 (4): 626–638.

Sundriyal, R.C. and Sharma, E. (1995). (ed): Cultivation of Medicinal Plants and Orchids in Sikkim Himalayas. Bishan Singh Mahendra Pal Singh, Dehradun.

Sundriyal, R.C. and Sharma, E. (1996). Anthropogenic pressure on tree structure and biomass in the temperate forest of Mamlay watershed in Sikkim. *Forest Ecology and Management,* 81: 113-134.

Surendra, K. M., Silpa, R. G. and Astalakshmi, N. (2011). Screening of Aqueous and Ethanolic extracts of aerial parts of *Alternanthera sessilis* L. R.br.ex.dc for Nootropic Activity. *Journal of Pharm Science and Research* 3: 1294-7.

Suzigan, M. I., Battochio, A. P. R., Coelho, K. L. R. and Coelho, C. A. R. (2009). "An acqueous extract of *Bidens pilosa* L. protects liver

from cholestatic disease. Experimental study in young rats," *Acta Cirurgica Brasileira* 24 (5). 347–352.

Syed, M. H., Khatija, F. and Abdulrahman, Al-F. (2007). Prevalence of airborne allergenic *Amaranthus viridis* pollen in seven different regions of Saudi Arabia. *Annals of Saudi Medicine* 27(4): 259-263

Tahira, M. and Farzana, G. J. (2011). Nutritional and elemental analyses of some selected fodder species used in traditional medicine: *African Journal of Pharmacy and Pharmacology* 5 (8): 1157-1161.

Takyi, E.E.K. (1999). Children's consumption of dark green, leafy vegetables with added fat enhances serum retinol. *Journal of Nutrition* 129: 1549–54.

Tamang, J.P. (2007). Fermented foods for human life. In *Microbes for human life,* eds. Chauhan, A.K., Verma, A. and Kharakwal, H., 73-87. New Delhi: I.K.

Tamang, J. P. (2005). Food Culture of Sikkim. Sikkim Study Series volume IV. Information and Public Relations Department, Government of Sikkim, Gangtok, pp.120

Tamang, J.P. (2010a). *Himalayan Fermented Foods: Microbiology, Nutrition, and EthnicValues.* CRC Press, Taylor and Francis Group, New York, pages 295.

Tamang, J.P., Sarkar, P.K. and Hesseltine, C.W. (1988). Traditional fermented foods and beverages of Darjeeling and Sikkima review. *Journal of Science, Food and Agriculture,* 44: 375-385.

Tamboura, H.H., Bayala, B., Lompo, M., Guissou, I. P. and Sawadogo, L. (2005). Ecological distribution, morphological characteristics and acutetoxicity of aqueous extracts of *Holarrhena floribunda* (G. Don) Durand & Schinz, *Leptadenia hastata* (Pers.) Decne and *Cassia sieberiana (d c)* used by veterinary healers in Burkina Faso. *African Journal Traditional Complemetary and Alternative Medicine* 2: 13–24.

Tan, P.V., Dimo, T., Dongo, E. (2000). Effects of methanol, cyclohexane and methylene Chloride extracts of *Bidens pilosa* on various gastric ulcer models in rats. *Journal of Ethnopharmacology* 73: 415-421.

Tanaka, T. (1976). Cyclopedia of edible plant of the world. Tokyo.

Tapan, S. (2011). Determination of Nutritive Value, Mineral Contents and Antioxidant Activity of Some Wild Edible Plants from

Meghalaya State, India. *Asian Journal of Applied Sciences 4: 238-246.*

Tardío, J., Molina, M., Aceituno-Mata, L., Pardo-de-Santayana, M., Morales, R., Fernández-Ruiz V., Morales, P., García, P., Cámara, M. and Sánchez-Mata, M. C. (2011). *Montia fontana L.* (Portulacaceae), an interesting wild vegetable traditionally consumed in the Iberian Peninsula. In: *Genetic Resources and Crop Evolution* 58 (7): 1105–1118.

Tardío, J., Pascual, H. and Morales, R. (2005). Wild food plants traditionally used in the province of Madrid, Central Spain. *Economic Botany* 59: 122–136.

Tardío, J., Pardo-de-Santayana, M. and Morales, R. (2006). Ethnobotanical review of wild edible plants in Spain. *Botanical Journal of Linnean Society* 152: 27–71.

Tardío, J. (2010). Spring is coming. The gathering and consumption of wild vegetables in Spain. In M. Pardo-de-Santayana, A. Pieroni, R. Puri. Ethnobotany in the New Europe. UK: Berghahn Books, 211-237.

Tawan, C.S., Abdul Gani, B.M., Ipor, I.B. and Dewan, J. (2007). Medicinal plants of the Iban community in Sabal District, Sarawak. Proceedings of Conference on Natural resources in the Tropics: Development and Commercialization of tropical Natural resources, 2007, Faculty of Resource Science and technology, Universiti of Malaysia Sarawak, Kota Samarahan pp: 401 -408.

Tenaye, A., Geta, E. and Hebana, E. (2009). A multipurpose cabbage tree (*Moringa stenopetala*): Production, utilization and marketing in snnpr, Ethiopia. *Acta Horticulture* 806: 115-120.

The Wealth of India. (1988). *A Dictionary of Indian raw materials and industrial products.* New Delhi, India; Vol. 1. p. 221.

The Wealth of India, Raw materials, (1985). Vol 1(Revised), CSIR, New Delhi, 318-9.

Thomas, S.D. (2012). *Leptadenia hastata*: A Review of its Traditional uses and its Pharmacological Activity. *Medical Chemistry* 2:148-150.

Thomson, B. and Shaw, I.A. (2002).Comparison of Risk and Protective Factors for Colorectal Cancer in the Diet of New Zealand Maori and non- Maori. *Asian Pacific Journal of Cancer Prevention* 3: 319-324.

Tilahun, T. and Mirutse, G. (2010). Ethnobotanical study of wild edible plants in Kara and Kwego semi-pastoralist people in Lower Omo River Valley, Debub Omo Zone, SNNPR, Ethiopia. *Journal of Ethnobiology and Ethnomedicine*. 6: 23.

Trichopoulou, A. (2004). Traditional Mediterranean diet and longevity in the elderly: a review. *Public Health Nutrition* 7: 943-947.

Tukan, S.K., Takruri, H.R.M. and Al-Eisawi, D.M. (1998). The use of wild edible plants in the Jordanian diet. *International Journal of Food Sciences and Nutrition* 49: 225-235.

Ubillas, R.P., Mendez, C.D., Jolad, S.D., Luo, J., King, S.R., Carlson, T.J., and Fort, D.M. (2000). Antihyperglycemic acetylenic glucosides from*Bidens pilosa. Planta Medica* 66: 82–83.

Uddin, M.K., Juraimi, A.S., Ismail, M.R. and Brosnan, J.B. (2010) Characterizing weed populations in different turfgrass sites throughout the Klang valley of western peninsular Malaysia. *Weed Technology* 24: 173–181.

Uddin, M.K., Juraimi, A.S., Ismail, M.R., Rahim, M.A. and Radziah, O. (2009). Floristic composition of weed community in turfgrass area of West Peninsular Malaysia. *International Journal of Agriculture and Biology* 11: 13-20.

Uddin, S.J., Ferdous, M.M., Rouf, R., Alam, M.S., Sarkar, M.A.M and Shilpi, J.A. (2005). Evaluation of anti-diarrhoeal activity of *Enhydra fluctuans. Journal of Medical Sciences* 5: 324-327.

Udensi, E,A., Ijeh, I.I. and Ogbonna, U. (2002). Effect of traditional processing on the phytochemical and nutrient composition of some local Nigerian leafy vegetables. *Journal Science Technology* 8: 37-40.

Udoh, E.J. (2005). "Technical Inefficiency in Vegetable Farms of Humid Region: An analysis of Dry season vegetable farming of urban women in South South zone, Nigeria. *Journal of Agric. Soc.Sci.* 1: 80-85.

Udoh, E.J. and Etim, N.A. (2008). Measurement of Farm-Level Efficiency of waterleaf(Talinun triangulare) Production Among City Farmers in Akwa Ibom state, Nigeria. *Journal of sustainable development in agriculture and Environment* 3 (2): 47-54.

Uhegbu, F.O. (1997). Dietary secondary amines and liver hepatoma in Port Harcourt, Nigeria. Plant Foods Hum. Nutr., 51: 257-263.

UICC/WHO (2005). Global Action Against Cancer NOW. Geneva: UICC and WHO Publications Department.

Umoh, G.S. (2006). "Resource Use Efficiency in Urban Farming": An Application of Stochastic Frontier Production Function. *International Journal of Agriculture and Biology* 8 (1). 37-44.

Uwaegbute, A. C. (1989). Vegetables: Nutrition and Utilization. In: Food Crops Production. Dotan Publishers Ltd Ibadan. 39-44.

Uzo, J. O. (1989). Tropical Vegetable Production. In: Food Crops Production. Dotan Publishers Ltd Ibadan. 45-49.

Van Averbeke, W. and Juma, K.A. (2006 a). The cultivation of *Solanum retroflexum* Dun. in Vhembe, Limpopo Province, South Africa.

Van, den Bergh, M.H. (1994). *Limnocharis flava* L. Buchenau. In: Plat Resources of South east Asia 8: Vegetables , Siemonsma, J.S. and P. Kasem (Eds.). PROSAE, Bogor, Indonesia, pp: 192 - 194.

Van der Heever, E. and Venter, S.L. (2007). Nutritional and Medicinal properties of *Cloeme gynandra*. *Act Hort* 752: 127-130.

Van Wyk, B. E. (2005). *Food Plants of the World*, Portland, Timber Press, 2005.

Varma, P.N., Talwar, S.K. and Garg, G.P. (1980). "Chemical Investigation of Silybum marianum." *Planta Med.*, 38 (4), 337-338.

Venter, F. and Venter, J. (1996). Baobab In Making the most of indigenous trees. Briza publications, Pretoria, South Africa, pp. 26-27.

Verma, O.P., Kumar, S. and Chatterjee, S.N. (1982). Antifertility effects ofcommon edible Portulaca oleracea on the reproductive organs ofmale albino mice. *Indian Journal of Medical Research* 75: 301-310.

Vishwakarma, K.L. and Dubey, V. (2011). Nutritional analysis of indigenous wild edible herbs used in eastern Chhattisgarh, India Emirates Journal of Food and agriculture 23 (6): 554-560.

Visioli, F., and Galli, C. (2001). The role of antioxidants in the Mediterranean diet. *Lipids, 36*: S49-S52.

Wagner, W.L., Herbst, D.R. and Sohmer, S.H. (1999). Manual of the flowering plants of Hawaii. Revised edition. Bernice P. Bishop Museum special publication. University of Hawaii's Press/Bishop Museum Press, Honolu.

Walter, M., and Hamilton, A. (1993). *The Vital Wealth of Plants*. Gland, Switzerland: WWF- World Wide Fund for Nature.

Webb, C.J., Sykes, W.R. and Garnock-Jones, P.J. (1988). Flora of New Zealand, Volume IV: Naturalised pteridophytes, gymnosperms, dicotyledons. Botany Division, DSIR, Christchurch pp. 1365.

Wells, M.K. and Brandon, K. (1992). People and Parks: Linking protected area management with local communities. The World Bank, Washington, D.C.

Wenzel, G.E., Fontana, J.D. and Correa, J.B.C. (1990). The viscous mucilagefrom the weed *Portulaca oleracea*, L, Vol.24-25 (Heidelberg, ALLEMAGNE, Springer).

Wesche-Ebeling, P., Maiti, R., Garcia-Diaz, G., Gonzalez, D.l. and Sosa-Alvarado, F. (1995). Contribution to the botany and nutritional value of some wild *Amaranthus* species (Amaranthaceae) of Nuevo Leon, Mexico. *Economic Botany* 49: 423-30.

Whitbread, M.W. (1986). Preliminary Studies on the Utilization and Adaptation of Indigenous and Introduced Vegetable and Grain Amaranths (*Amaranthus* spp.) in the Natal and KwaZulu Midlands. M.Sc. (Agric) Dissertation. University of Natal, Pietermaritzburg.54 pp.

Whiting, S.J. and MacKenzie, M. (1998). Assessing the changing diet of Indigenous Peoples. *Nutrition Reviews*. 56: 248-250.

WHO, 1985. Energy and protein requirements: Report of a joint FAO/WHO/UNU expert consultation. Technical Series No. 724. World Health Organization, Geneva, Switzerland.

Wickens, G.E. (1980). The use of the baobab (A. digitata L) in Africa. Page xx–zz. In: LE HOUEROU, H. N. (Ed.). Browse in Africa: The current state of knowledge. ILCA, Addis Ababa, Ethiopia.

Wiersema, J.H. and León B. (1999). World Economic Plants: a standard reference, BocaRaton, CRC Press, 1999.

Winston, J.C. (1999). Health promoting properties of common herbs. *American Journal of Clinical Nutrition* 70: 491S-499S.

Wong, K.C and Tan, G.L. (1994). Steam volatile constituents of the aerial parts of *Paederia foetida* L. Alamgir J, *9*: 25-28.

Wunderlin, R.P., Hansen, B.F. and Bridges, E.L. (1996). Atlas of Florida vascular plants [CD-ROM]. Tampa: University of South Florida, Institute for Systematic Botany, Dept. of Biology.

Yadav, D. (2006). Commercial Non Timber Forest Products collected by the Bhill Tribe in Shivgarh town of Ratlam District, Madhya Pradesh. *Journal of Non -Timber Forest Products* 13 (4): 295 -295.

Yang, H.L., Chen, S.C., Chang, N.W., Chang, J.M., Lee, M.L., Tsai, P.C., Fu, H.H., Kao, W.W., Chiang, H.C., Wang, H.H. and Hseu, Y.C. (2006). Protection from oxidative damage using *Bidens pilosa* extracts in normal human erythrocytes. *Food and Chemical Toxicology* 44: 1513-1521.

Yang, J.H., Lin, H..C and Mau, J.L. (2002). Antioxidant properties of several commercial mushrooms. *Food Chemistry* 77: 229-235.

Yedjou, C., Izevbigie, E. and Tchounwou, P. (2008). Preclinical assessment of *Vernonia amygdalina* leaf extracts as DNA damaging anti-cancer agent in the management of breast cancer. *International Journal of Environmental Research and Public Health* 5: 337–341.

Yen, G.C., Chen, H.Y. and Peng, H.H. (2001). Evaluation of the cytotoxicity,mutagenicity and antimutagenicity of emerging edible plants. *Food and Chemical Toxicology* 39: 1045-1053.

Yi-Fang, C., Jie S., Xian-Hong, W.U. and Rui-Hai, L. (2002). Antioxidant and antiproliferative activities of common vegetables, Rev., *Journal of Agricultural and Food Chemistry* 50: 6910-6916.

Yiftach, V., Rivka, H., Dan, S., Leonid, M and Neta, B. (2008). The potential of milk thistle (*Silybum marianum* L.), an Israeli native, as a source of edible sprouts rich in antioxidants. *International Journal of Food Sciences and Nutrition* 59 (4): 339-46.

Yisehak, K., Belay, D. and Janssens, G. (2010). Indigenous fodder trees and shrubs: Nutritional and ecological aspects. 14th European Society of Veterinary and Comparative Nutritrition. ESVCN, Zurich, Swizerlands.

Zabihullah, Q., Rashid, A. and Akhter, N. (2006). Ethanobotnical survey in kot Manzary baba valley malakand agency, Pakistan. *Pakistan Journal of Plant Science* 12: 115-121 .

Zi, X., Mukhta, H. and Agarwal, R., (1997). Novel cancer chemo-preventative effects of a flavonoid constituent silymarin: inhibition of mRNA expression of an endogenous tumour promoter. TNF alpha. *Biochemical and Biophysical Research Communications* 239: 334-339.

Zoran, Z. K., Ljiljana, N. T.T., Biljana, M. K., Snjezana, B. M., Svetlana, S. P., Mirela, M. B., and Aleksandar, V. S. (2012). Characterization

of antioxidant and antimicrobial activities of nettle leaves (*Urtica dioica* L.) *Acta Periodica technologica* 43: 1-342.

Zubair, M., Rumpunen, K., Lindholm, C. and Nybom, H. (2008b). Differences in the amount of polyphenolic compounds in different aerial parts of *Plantago major*. World congress of medicinal and aromatic compounds (WOCMAP IV). Cape town, South Africa, Nov. 9–14.

Zubair, M., Rumpunen, K., Lindholm, C. and Nybom, H. (2010). Genetic and phytochemical variations in *Plantago major*. 28th International Horticultural congress. Lisboa, Portugal, August 22-27, 2010.